FACULTATEA DE construcții

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Printed by UTPRESS
utpress@biblio.utcluj.ro

ISBN 978-606-737-657-9

C70

Proceedings of the C70 International Conference

FACULTATEA DE construcții

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

MEMBER OF

EUT+ EUROPEAN UNIVERSITY OF TECHNOLOGY

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C70

TRADITION AND INNOVATION IN CIVIL ENGINEERING
1953 - 2023

CLUJ-NAPOCA, ROMANIA • 8-11 NOVEMBER 2023

Proceedings of the C70 International Conference

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE

TRADITION AND INNOVATION-70 YEARS OF HIGHER EDUCATION IN CIVIL ENGINEERING IN TRANSILVANIA

C70-2023

https://c70.utcluj.ro

Cluj-Napoca- Romania

8-11 November 2023

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Faculty of Civil Engineering,

Technical University of Cluj-Napoca, ROMANIA

UTPRESS
Cluj-Napoca, 2023

Editura UTPRESS
Str. Observatorului nr. 34
400775 Cluj-Napoca
Tel.: 0264-401.999
e-mail: utpress@biblio.utcluj.ro
http://biblioteca.utcluj.ro/editura

Director: Ing. Dan Colțea

Descrierea CIP a Bibliotecii Naţionale a României
Tradition and innovation-70 years of higher education in civil engineering in Transylvania - C70-2023 : Proceedings of the International Conference : 8-11 November 2023, Cluj-Napoca, Romania / edited by: Ligia Moga, Daniela Manea, Gavril Hoda, ... – Cluj-Napoca : Editura U.T. Press, 2023
ISBN 978-606-737-657-9

I. Moga, Ligia Mihaela (ed.)
II. Manea, Daniela (ed.)
III. Hoda, Gavril (ed.)

37

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Tiparul executat la Tipografia UTCN.

ISBN 978-606-737-657-9
Bun de tipar: 31.10.2023
Tiraj: 200 exemplare

International Conference
”Tradition and Innovation 70 Years of Higher Education in Civil Engineering in Transilvania”

C70-2023, 8-11 November 2023, Cluj-Napoca, Romania, https://c70.utcluj.ro/

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Sponsor Diamond al Evenimentului C70

DIFERIT SRL este o firmă cu capital privat românesc înfiinţată în anul 2001, specializată în construcția de autostrăzi, drumuri naționale, drumuri județene și comunale, drumuri urbane, alei, infrastructură rutieră rurală, platforme, trotuare, terenuri de sport, etc. Compania s-a impus pe piața construcţiilor din România prin calitatea lucrărilor executate, prin seriozitatea relațiilor cu beneficiarii și rigurozitatea cu care tratează fiecare detaliu. Strategia de abordare a DIFERIT SRL constă în realizarea lucrărilor utilizând tehnologii noi și inovatoare, care pe de o parte conduce la reducerea costurilor, simultan cu creşterea nivelului de calitate a lucrărilor şi cu reducerea duratelor de execuție, iar pe de altă parte contribuie decisiv la promovarea principiului dezvoltării durabile, cu impact favorabil asupra mediului. Succesul afacerii demarate în anul 2001 s-a datorat în special unei viziuni integratoare, o viziune orientată spre client, spre calitatea lucrărilor realizate și respectarea termenelor de execuție, aceasta fiind de altfel atitudinea care asigură succesul într-un mediu competitiv, din ce în ce mai dinamic. DIFERIT SRL are echipă de profesioniști uniți de dorința de a-și proba valoarea, care a construit în timp o companie responsabilă și de încredere. Stabilitatea, reziliența, recunoaşterea performanţei și respectul față de oameni fac din DIFERIT un angajator loial și de încredere. Grupul DIFERIT are peste 250 de angajați, mai mult de 95% cu studii superioare sau calificări speciale. DIFERIT SRL are în dotare un puternic parc auto și de utilaje specifice pentru construcții și un atelier mecanic dotat cu tot ceea ce este necesar pentru asigurarea service-ului acestora. Preocuparea managementului societății privind grija față de mediul înconjurător şi reducerea impactului acțiunilor desfăşurate de companie asupra acestuia a constituit o constantă de la înființare și până în prezent.

Sponsori Platinum ai Evenimentului C70

ACI Cluj SA este o companie de construcții cu tradiție și o experiență de peste 70 de ani pe piața din Europa si Orientul Mijlociu, a funcționat neîntrerupt în toți acești ani sub diverse forme de organizare, dar a menținut constant un portofoliu de proiecte majore, adevărate repere pentru perioadele în care au fost construite. Cu un personal bine pregătit și o echipă de specialiști în domeniul construcțiilor, compania oferă servicii complete de la proiectare și planificare la construcția efectivă și gestionarea proiectelor. Peste 95 % dintre angajatii cu studii superioare s-au instrut si format in Universitatea Tehnica din Cluj Napoca Facultatea de Constructii , ceea ce subliniaza importanta si relevanta acestei institutii de invatamant superior. Compania se remarcă prin specializarea sa în proiecte complexe și variate, oferind servicii de construcții de calitate într-o gamă largă de domenii.de activitate. ACI Cluj SA reprezintă o companie de construcții civile cu un potofoliu solid și cu o viziune de viitor axată pe calitate, inovație și sustenabilitate. Cu fiecare proiect finalizat, contribuie la dezvoltarea infrastructurii și la îmbunătățirea calității vieții la nivel național.

Gordias S.R.L., o companie înființată în 2003, se specializează în consultanță pentru managementul de proiect și dezvoltarea afacerilor în industria construcțiilor metalice. Începând cu 2006, și-a diversificat serviciile pentru a include proiectarea și s-a transformat într-un furnizor cheie de soluții integrate în construcțiile metalice. Compania este activă în organizații precum Asociația Inginerilor Constructori Proiectanți de Structuri (AICPS), IABSE (Asociația Internațională pentru Poduri și Inginerie Structurală) și grupurile tehnice de lucru ale organizației ECCS (Convenția Europeană pentru Oțel și Structuri de Construcții). Misiunea Gordias este să ajute clienții să dezvolte un spirit competitiv etic și să realizeze investiții eficiente, oferindu-le expertiza lor profesională și software performant pentru diverse soluții structurale. Viziunea lor este de a deveni lideri în serviciile de consultanță și proiectare, fundamentându-se pe profesionalism, experiență și inovație. Compania furnizează servicii de proiectare, verificare și expertiză pentru construcții industriale, zootehnice, centre comerciale, edificii sportive, construcții civile și speciale, monumente, expertize tehnice, proiecte de intervenție și consolidare, precum și proiecte de cercetare și dezvoltare. De asemenea, oferă servicii de scanare 3D și digitalizare a clădirilor, optimizând dezvoltarea proiectelor, economisind timp și bani, și asigurând calitate superioară în domeniul construcțiilor. Compania se angajează să-și îmbunătățească constant serviciile prin cercetare și producerea de articole științifice în diverse domenii legate de construcții în general.

Sponsori Gold ai Evenimentului C70

Amicii Building este o companie de top din judetul Bistrita Nasaud, specializata pe executie si proiectare constructii civile, industriale si agricole. A fost infiintata in anul 2008 si inca de la inceputuri, Amicii Building e intr-un continuu proces de a face lucrurile mai bine, mai repede, mai modern si cu mare grija fata de oameni si fata de client. Cresterea continua a companiei se bazeaza pe un management orientat spre oameni, spre relatii de tip win-win, spre progres si abordare de noi solutii tehnice combinat cu abordari de noi domenii. Astfel, ne mandrim cu o multime de proiecte de success: comerciale, rezidentiale, industriale, hoteliere si renovare de caldiri monument, iar incepand cu anul 2020 ne-am extins spre construirea de drumuri si baze sportive. Deoarece avem o echipa de specialist, bine pregatiti, oferim servicii complete: de la proiectare, consultanta, management, topografie pana la executie structuri, finisaje interioare si exterioare, renovari si amenajari exterioare. Amicii Building se angajează să contribuie la dezvoltarea sustenabilă a industriei construcțiilor, prin actualizarea constanta a tehnologiilor utilizate, prin eficienta, promptitudine, seriozitate, materiale de inalta calitate, siguranta, soluții profesionale pentru fiecare etapă a proiectelor de construcții si satisfacerea celor mai complexe cerinte ale clientilor.

KÉSZ România, o companie importantă în industria construcțiilor din România și Europa Centrală și de Est, oferă o gamă diversificată de servicii și resurse proprii pentru a satisface cerințele complexe ale acestei industrii. De la proiectare la execuție, de la instalarea sistemelor tehnologice la dezvoltarea imobilelor, KÉSZ abordează cu succes cerințele clienților actuali și viitori, atât în România, cât și în regiunea Europei Centrale și de Est. Înființată în 2001, KÉSZ România este parte a Grupului KÉSZ și se bucură de standarde înalte de lucru, management de calitate și procese de gestionare a proiectelor, asigurând astfel experiență, competență profesională, calitate și respectarea termenelor, indiferent de locația proiectelor. Misiunea KÉSZ este de a deveni o companie independentă și de succes în Europa Centrală și de Est, reprezentând valorile Grupului cu profesionalism. Prin activitățile internaționale de succes, Grupul KÉSZ a devenit, de asemenea, un investitor important pe piața din România. Cu un portofoliu extins și o abordare de înaltă calitate, KÉSZ România continuă să contribuie semnificativ la dezvoltarea industriei construcțiilor din regiune.

CON-A este una dintre cele mai mari companii de construcții din România, cu capital privat integral românesc. Fondată în martie 1990, firma s-a dezvoltat continuu și a creat un grup diversificat de firme sub umbrela CON-A. Această dezvoltare a permis abordarea cu succes a unor proiecte ambițioase, beneficiind de resursele proprii și de o echipă de peste 1000 de angajați. Grupul CON-A acoperă o gamă completă de servicii din domeniul construcțiilor, de la antreprenoriat general și proiectare până la instalații mecanice și electrice. Acest portofoliu extins este întregit de compania UNIMAT, care furnizează materiale de construcții și renovare. De asemenea, CON-A dispune de facilități proprii de producție, inclusiv fabrici de structuri metalice și elemente prefabricate din beton. Compania a luat naștere în Sibiu și s-a extins treptat, dezvoltând divizii și capacități diverse. În plus, CONDESIGN, firma de proiectare a grupului, a contribuit la optimizarea proiectelor tehnice și a oferit servicii de proiectare atât pentru proiectele CON-A, cât și pentru beneficiari externi. Prin accentul pus pe calitate, promptitudine și eficiență, CON-A a reușit să câștige încrederea în domeniul construcțiilor și să rămână un jucător important pe piața românească. Grupul de firme s-a diversificat și a evoluat constant, abordând proiecte complexe și contribuind la dezvoltarea infrastructurii și a industriei de construcții din România.

Progresul începe cu noi!

Aproape 79.000 de oameni lucrează în STRABAG, în peste 700 de locații din întreaga lume, pentru progres. Proiectele noastre sunt unice și cu o individualitate puternică, la fel ca fiecare dintre noi. De la construcții și inginerie structurală, construcții de drumuri și inginerie civilă, construcții de poduri și săpături de tuneluri, dezvoltare de proiecte, producție de materiale de construcții sau managementul clădirilor - gândim în perspectivă și ne propunem să devenim cel mai inovator și durabil grup de tehnologie în construcții din Europa. Oportunități egale de șanse, diversitatea și incluziunea sunt părți integrale a ceea ce suntem și este modul nostru de operare. Lucrăm împreună ca parteneri pentru a finaliza proiecte cu succes și pentru a crește odată cu noile provocări. Împreună realizăm lucruri mari. Construiește-ți viitorul alături de noi!

MDPI (Multidisciplinary Digital Publishing Institute) este o companie pionier în domeniul publicării articolelor științifice de tip „Open Access” care sprijină comunitățile academice încă din 1996. Având sediul principal la Basel, în Elveția, MDPI are misiunea de a avansa dialogul științific deschis în toate formele acestuia și de-a lungul tuturor domeniilor de studiu. MDPI susține cercetătorii din întreaga lume prin accesul gratuit pe care îl oferă publicului larg la publicații de ultimă oră. Orice material publicat de MDPI este partajat prin Creative Commons Atribuire 4.0 Internațional (CC BY 4.0). MDPI publică în prezent peste 400 de jurnale științifice, atingând în 2022 pragul de 1 milion de articole publicate de la înființarea companiei. În România, MDPI operează în prezent în două birouri în cele mai apreciate orașe și centre universitare din țară: Cluj-Napoca și București, înființate în 2019, respectiv 2020. La momentul actual, MDPI România are peste 400 de angajați.

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Sponsori Silver ai Evenimentului C70

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Susținători ai Evenimentului C70

În parteneriat cu:

Cercetare de excelență în domeniul inteligență artificială și date masive

Cuprins

PREFACE

Conferința internațională C70 ”Tradiție și inovare - 70 de ani de construcții în Transilvania” organizată cu acest prilej va oferi posibilitatea schimburilor de idei și cunoștințe, precum şi împărtășirea experienței în domeniul vast al construcțiilor prin prezentările şi dezbaterile ce vor avea loc în cadrul evenimentului. O vedere de ansamblu a cercetării, proiectării şi a mediului economic în domeniul construcțiilor, precum și tendințele de dezvoltare a acestora, se va obține prin alăturarea profesioniștilor din mediul academic şi a celor angrenați în activitatea practică.

În urmă cu 70 de ani, într-o frumoasă zi de toamnă, 130 de tineri studenți se îndreptau spre primele ore de curs la nou înființata Facultate de Construcții din cadrul Institutului Politehnic Cluj, întemeiat în același an, 1953. Era începutul unui drum lung: șapte decenii de învățământ universitar neîntrerupt, presărat cu rezultate remarcabile, obținute atât în pregătirea studenților, cât şi în domeniul cercetării științifice.

La început, facultatea a funcționat doar cu specializarea CCIA, apoi au apărut treptat CFDP, Instalații pentru construcții, și secția de conductori arhitecți. În anul 1993 s-a înființat și specializarea CCIA în limba engleză, în 1997, specializarea Inginerie economică, apoi Măsurători terestre și cadastru, în 2006, iar în 2008, Amenajări și Construcții Hidrotehnice, Inginerie Urbană și Dezvoltare Regională. Din 2014 facultatea are și la Baia Mare programe de studiu de licență și de masterat.

În prezent, Facultatea de Construcții din Cluj-Napoca are 2520 de studenți – înscriși la 8 programe de licență, 8 programe de masterat și la un program de doctorat, pregătirea acestora fiind asigurată de către 118 cadre didactice titulare și 57 de cadre didactice asociate, care își propun să continue dezvoltarea unui mediu de învățare, de cercetare, și de inovare, de înaltă ținută.

Azi – cu prilejul aniversării celor 7 decenii de existență neîntreruptă a Facultății de Construcții din UTCN – suntem împreună, cadre didactice, studenți, absolvenți, pentru a ne bucura cu toții în marea familie a constructorilor. Fie că activăm în învățământ sau în cercetare, în proiectare, execuție sau ofertare, ca verificatori sau ca experți, mulțumirea noastră este una pe măsura realizărilor trainice la care am contribuit, într-un fel, fiecare.

Aniversând astăzi 70 de ani de la întemeierea Facultății de Construcții din Cluj-Napoca, ne exprimăm, întâi de toate, recunoștința și respectul față de fondatorii acestei facultăți. Încrezători, ei au pus bazele unui remarcabil demers didactic universitar, așa cum avea să se dovedească pe întreg parcursul anilor care au urmat.

Recunoștința noastră se îndreaptă apoi către toți membrii corpului didactic care și-au îndeplinit cu cinste *misiunea educațională în cei 70 de ani de istorie a Facultății de Construcții*, rămânând adevărate modele pentru generațiile de absolvenți pe care le-au format și le-au inspirat.

Și, nu în ultimul rând, ne exprimăm prețuirea pentru generațiile de studenți care au făcut posibilă reușita noastră. *A avea asemenea studenți și absolvenți este pentru noi un motiv de mândrie*.

În numele actualei conduceri a Facultății de Construcții din Cluj-Napoca, îngăduiți-mi, *dragi profesori, dragi studenți și dragi absolvenți*, să vă felicit și să vă mulțumesc tuturor, *deopotrivă.*

Daniela-Lucia MANEA

This volume contains the extended abstracts of the papers presented at the 70th anniversary conference of the Faculty of Civil Engineering at the Technical University of Cluj-Napoca: *"Tradition and Innovation - 70 Years of Higher Education in Civil Engineering in Transylvania - C70"*, held in Cluj-Napoca from November 8th to 11th, 2023. The Faculty of Civil Engineering organized the conference at the Technical University of Cluj-Napoca, Romania, that attracted participants from various national and international universities and organizations whose attendance and valuable contributions to the conference sessions made this event both productive and exciting.

During the *C70 International Conference*, academics, students, researchers, and community members had the opportunity to attend several keynote lectures where the speakers shared their vision of the recent progress in research, design, and practice in the broad fields of Civil Engineering and Architecture. We are very grateful to all the experts for their keynote lectures that helped enhance the conference program.

The selected papers in this book comprise a short historic about the Faculty of Civil Engineering evolution and several excellent short scientific papers, which present advanced approaches to modern research problems in the broad fields of Civil Engineering and Architecture. The final program and the conference proceedings feature 72 successful peer-reviewed extended abstracts that are grouped in the following sections:

- *The Evolution of the Faculty of Civil Engineering;*
- *Construction Materials;*
- *Architecture, Buildings and Building Services;*
- *Structural Mechanics;*
- *Steel and Reinforced Concrete Structures;*
- *Roads, Bridges and Railways;*
- *Soil Mechanics and Foundations;*
- *Land Measurements;*
- *EUt+ Innovations in Civil Engineering.*

The Editors are very grateful to all authors for their valuable contribution and to the Members of the International Scientific Advisory Committee and other colleagues for their help in reviewing the papers published in this book.

It is also important to emphasize the possibility of publishing an extended abstract as an article in the journal 'Buildings,' with an impact factor of 3.8 and Q2 classification, in the Special Volume created in the context of the C70 Conference. The details regarding the submission and evaluation procedure are available at: https://www.mdpi.com/journal/buildings/special_issues/I4BYE42MWH. This possibility contributes to increasing the visibility of your work in the scientific community.

We warmly welcome you to the very special 70th anniversary of the Faculty of Civil Engineering from Technical University of Cluj-Napoca, and we hope to see you again in the coming years to celebrate our history as we look towards our future.

The Editors

Cluj-Napoca, November 2023

SECTION I

The EVOLUTION of the FACULTY of CIVIL ENGINEERING

Facultatea de Construcții 1953-2023

D.L. Manea, I. Marțian, H.L. Cucu, N. Ilies, N. Cobîrzan, G. Hoda, L.M. Pleșa

Tradiţia educaţiei în domeniul ingineriei civile în Cluj-Napoca începe cu anul 1920 când, pe baza Decretului Guvernamental nr. 4206 din 19 octombrie este înfiinţată ŞCOALA DE TEHNICIENI PENTRU LUCRĂRI PUBLICE, subordonată Ministerului Lucrărilor Publice şi Comunicaţiilor. Decizia de a promova acest tip de educaţie a fost făcută de către Guvernul român cu scopul de a dezvolta formarea profesională şi educaţia în limba română, după recenta unificare a Statului român (1 decembrie 1918).
Oferta educaţională a acestei şcoli s-a situat pe aceeaşi linie cu a altor centre educaţionale din România (Bucureşti, Chişinău şi Cernăuţi), fiind organizate cursuri de trei ani pentru tehnicieni în domeniul căilor de comunicaţie şi al ingineriei civile. Primul director al şcolii a fost Eugen ŢILEA, inginer şi şef al Oficiului pentru Lucrări Publice din Transilvania.
Şcoala de Tehnicieni pentru Lucrări Publice a funcţionat independent între anii 1920 şi 1930, fiind apoi înglobată în cadrul Şcolii de Conductori din Cluj. În 1936 aceasta a fost mutată definitiv la Bucureşti.

Un departament al acestei şcoli a fost lăsat să funcţioneze în continuare la Cluj schimbându-şi profilul şi denumirea în ŞCOALA DE TEHNICIENI ELECTROMECANICI (1937 - 1948). Între anii 1945 şi 1948, în cadrul acesteia a funcţionat şi ŞCOALA DE DIRIGINŢI DE ŞANTIER, care a oferit cursuri cu durata de doi ani oricărui absolvent de liceu.

Cu toate că până la acel moment nu putem vorbi despre o tradiţie în domeniul studiilor universitare de inginerie civilă la Cluj, necesităţile unei economii în plină dezvoltare, progresul tehnic, nevoia de susţine toate acestea printr-o sistematizare coerentă a zonelor urbane şi rurale, asigurarea unei infrastructuri corespunzătoare pentru industrie, agricultură, transporturi şi silvicultură, au condus la ideea de a înfiinţa o şcoală de inginerie civilă la Cluj.
În scopul de a susţine această cerere locală, pe 12 februarie 1947 a fost înaintat Ministerului Educaţiei Naţionale un memoriu, în care s-au adus argumente pentru înfiinţarea unui Institut Politehnic la Cluj.
Prin Hotărârea Consiliului de Miniștri nr. 2688 și 2727/1953, s-a înființat Institutul Politehnic din Cluj având patru facultăți: Facultatea de Mecanică (1631 de studenți), Facultatea de Tehnologie (283 de studenți), Facultatea de Mecanica Transporturilor (123 de studenți) și Facultatea de Construcții, (130 de studenți), având un număr de 2167 de studenți.
A înființa o scoală înseamnă în primul rând a-ți aminti de viitor. A înființa o scoală nu înseamnă neaparat a-i face pe oameni să citească, ci a-i face să gândească, iar fiecare se straduiește apoi să calce pe urmele celor dintâi, dar nu pentru a-i urma pe ei, cât pentru a se depăși pe sine. Astfel, o școală de inginerie ne învață că cel care gândește puțin se înșală mult, dar și faptul că trebuie să acționezi ca un om de gândire și să gândești ca un om de acțiune.
Astfel, în urmă cu 70 de ani, într-o frumoasă zi de toamnă, 130 de tineri studenți se îndreptau spre primele ore de curs la nou înființata Facultate de Construcții din cadrul Institutului Politehnic Cluj. Era începutul unui drum lung: șapte decenii de învățământ universitar neîntrerupt, presărat cu rezultate remarcabile, obținute atât în pregătirea studenților, cât și în domeniul cercetării științifice.
Activitatea didactică s-a desfășurat încă de la început în clădirea de pe strada George Barițiu nr. 25 și clădirea de pe strada C-tin. Daicoviciu nr. 15.
Clădirea aflată pe str. C-tin. Daicoviciu nr. 15 unde acum este sediul decanatului și a secretariatului a fost proiectată în perioada 1886-1887 (Figura 1), după planurile arhitecților locali, Frigyes Maetz și Remenyik Karoly, având o schema de funcționare simplă, o clădire în formă de U, ușor deformată de rabatarea spre exterior a brațului vestic, datorită aliniamentului străzii limitrofe. (Vais, 2009)


Figura 1. Strada C-tin. Daicoviciu nr. 15 - Imagini din perioada de execuție a clădirii

Din punct de vedere artistic, se caracterizează printr-un amalgam stilistic ce amplifică eclecticul soluțiilor arhitectonice adoptate, specific sfârșitului de secol XIX și începutului de secol XX. (Nistor, 1998)

Figura 2 – C-tin Daicoviciu nr. 15 – actualmente sediul decanatului și al secretariatului

Compoziția avea în axul său intrarea principală (Figura 2) și scara de onoare (Figura 3), de o parte și de alta dezvoltându-se spațiile de învățământ propriu-zise având ca destinație sediul Academiei Comerciale, înființată în 1878.

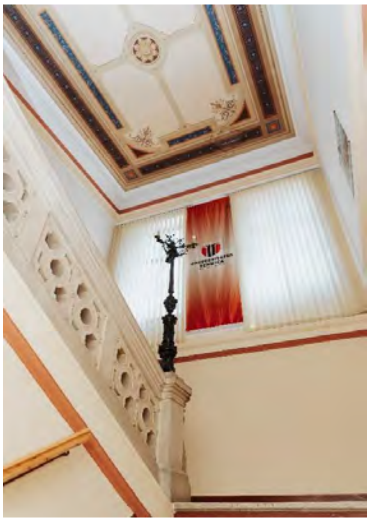


Figura 3 – Interior - C-tin Daicoviciu nr. 15

Clădirea are subsol, parter și un etaj, cu fundațiile de piatră, pereții din cărămidă, planșeele din boltișoare de cărămidă și profile metalice I20, șarpanta din lemn cu învelitoarea din tablă și țiglă.
Edificarea clădirii de pe strada George Barițiu nr. 25 s-a înscris într-o tendință impusă de avântul vieții culturale și dezvoltarea învățământului, oferind arhitecților o temă generoasă ce și-a găsit materializarea, în epocă, într-o serie de clădiri monumentale. (Nistor, 1998) Clădirea sobră a Muzeului Industriei „Francisc Iosif I” a fost ridicată între anii 1901-1903, după planurile arhitectului Pákei Lajos, în stil eclectic cu elemente neoclasice și neorenascentiste. (Vais, 2009)
Clădirea de pe strada Barițiu (fosta Malom utca = strada Morii), nr. 25, a fost pentru două decenii, unul dintre cele mai fascinante muzee din Cluj, în care publicul putea să vadă artefacte realizate în cele mai îndepărtate colțuri ale lumii, o colecție a invențiilor care au făcut mai ușoară viața oamenilor și au stimulat activitatea economică. (Vais, 2009) Muzeul Industriei se deosebea de un muzeu clasic, fiind mai degrabă un centru de inovare modern și complex, în care erau etalate cele mai recente descoperiri (mașini, utilaje, unelte) din diverse ramuri de producție sau ale artelor aplicate moderne (obiecte din lemn, metal, sticlă, textile, covoare, ceramică, mobilier, broderii, piele). Pákei Lajos a dotat muzeul cu cele mai recente obiecte de artă contemporană aplicată, iar odată cu moartea lui, survenită în anul 1921, muzeul a intrat în declin și a fost închis, în anul 1926, clădirea fiind preluată de Școala Comercială pentru fete.
Clădirile proiectate de Pákei Lajos sunt emblematice pentru Cluj, dar el a avut proiecte în toată Transilvania. Academia Comercială (azi Colegiul Economic), Hotelul New York (Continental), ansamblul de construcții din Parcul Central

(Cazinoul și fântâna arteziană din fața acestuia, Pavilionul de Patinaj – azi Restaurantul Chios), Școala Profesională a Lemnului și Metalurgiei (azi Facultatea de Electrotehnică a Universității Tehnice), Muzeul Industrial „Franz Iosif I” (azi Facultatea de Construcții a Universității Tehnice), Colegiul Unitarian, soclul Grupului Statuar Matia Corvin (Figura 4) și împrejmuirea Bisericii Sf. Mihail sunt proiectele arhitecturale care definesc azi imaginea Clujului.

Figura 4 – Clădiri emblematice proiectate de Pákei Lajos

Materialele fotografice din epocă (Figura 5) prezintă clădirea de pe strada George Barițiu 25 ca fiind o clădire paralelipipedică, relativ îngustă, sugerând că imobilul ar fi avut doar un tract de spații de expunere orientate spre nord, având subsol, parter, 2 etaje și mansardă parțială, aflată în centrul istoric al orașului, pe latura de sud a străzii George Barițiu, înglobând o porțiune din incinta de nord a fostului zid de fortificare a orașului. (Vais, 2009) Fundațiile au fost realizate din beton, pereții din cărămidă, planșeele din boltișoare de cărămidă și profile metalice I20, dar și din beton, acoperișul de tip șarpantă din lemn și învelitoare de tablă.

Figura 5 – G. Barițiu nr. 25 - Muzeul Industrial „Franz Iosif I”- azi Facultatea de Construcții

Din analiza releveelor (Figura 6) existente se poate vedea amploarea extinderii și a modificărilor survenite la clădirea originală din care s-a păstrat tractul de la stradă și fațada principală. Structura în cadre indică clar părțile adăugate: tractul sudic și 2 corpuri laterale, (Vais, 2009), lucrare la care au participat și studenții Facultății de Construcții din acea perioadă, dintre care unii au devenit apoi, cadre didactice, povestindu-le studenților din generațiile de azi, modul în care s-au desfășurat lucrările în anii ′60.

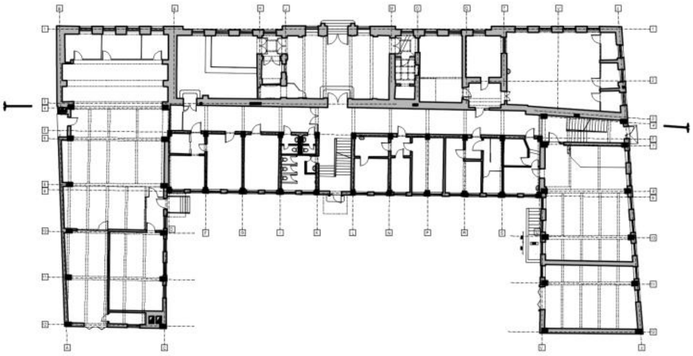


Figura 6 - Plan parter după extindere și modificare G. Barițiu nr.25

"Înainte de anii 90, Canalul Morii de pe strada G. Barițiu era descoperit, iar intrarea în clădirea Facultății de Construcții, se făcea prin acest somptuos portal. Fotografia este realizată de Rohonyi D. Iván, în 1986 cu ocazia ultimelor clipe de existență ale acestei frumoase lucrări. Tot ansamblul, clădirea, podul, portalul, au fost proiectate de arhitectul șef al orașului, Pákei Lajos (1853-1921). Prin lucrările de acoperire a Canalului Morii, podul s-a demolat, iar portalul s-a mutat la intrarea de la Universitatea Tehnică din cartierul Zorilor."

Figura 7 - Canalul Morii, portalul și podul pentru intrarea în clădirea G. Barițiu nr. 25

Limbajul decorativ utilizat de Pákei a fost unul eclectic, în care se regăseau principiile de compoziție specific neoclasicismului și neo-renașterii, oferind o imagine relativ austeră și sobră. Fațada clădirii are o intrare impozantă cu trei registre decorative suprapuse, întrerupte de pilaștri și coloane, în alternanță cu capiteluri ionice, o bogată decorație neobarocă cu motive geometrice în partea inferioară, cu ghirlande și amorași în partea superioară, dominate de frontonul central și cornișa pe console, care sporesc impresia de monumentalitate (Figura 8).

Figura 8 – Fațada clădirii G. Barițiu nr. 25

Clădirea este trecută în lucrările și albumele de artă ca un reper important și reprezentativ al arhitecturii clujene. Este de remarcat faptul că în ciuda modificărilor foarte serioase aduse clădirii, fațada principală a fost păstrată dovedindu-se respectul cuvenit față de imaginea inițială a muzeului.
În anul 1976 s-a construit "Blocul Turn", având subsol, parter și 7 etaje, (Figura 9) cu fundații de tip radier general din beton armat, planșee de tip semidală din beton armat prefabricat, diafragme din beton armat, pereții despărțitori din BCA, închiderile - pereți cortină pe schelet metalic și acoperiș de tip terasă.

Figura 9 – Blocul Turn, str. C-tin Daicoviciu nr. 15

În anul 1982 a fost data în folosință clădirea de pe strada Observatorului 72, o clădire având subsol, parter și două etaje, (Figura 10) cu fundații din beton, planșee din beton armat prefabricat, structura de rezistență - cadre din beton armat, închideri - parapeți prefabricați și profilit, iar acoperișul de tip terasă.

Figura 10 – Observatorului 72

Azi – cu prilejul aniversării celor 7 decenii de existență neîntreruptă a Facultății de Construcții din UTCN – suntem împreună, cadre didactice, studenți, absolvenți, pentru a ne bucura cu toții în marea familie a constructorilor. Fie că activăm în învățământ sau în cercetare, în proiectare, execuție sau ofertare, ca verificatori sau ca experți, mulțumirea noastră este una pe măsura realizărilor trainice la care am contribuit, într-un fel, fiecare.
Aniversând astăzi 70 de ani de la întemeierea Facultății de Construcții din Cluj-Napoca, ne exprimăm, întâi de toate, recunoștința și respectul față de fondatorii acestei facultăți. Încrezători, ei au pus bazele unui remarcabil demers didactic universitar, așa cum avea să se dovedească pe întreg parcursul anilor care au urmat.
Corpul profesoral al tinerei Facultăți de Construcții clujene a fost întărit, încă de la început, prin descinderea unor distinși specialiști în construcții de la București și Timișoara (Mihail HANGAN, Constantin AVRAM, Dan MATEESCU), conturându-se apoi un colectiv puternic mulțumită stabilirii aici a unor personalități proeminente și a recrutării cadrelor didactice din rândurile primilor absolvenți. Printre cei care au pus bazele facultății se numără profesorii: Vasile ILLE (1955) - Rezistența materialelor, Teoria elasticității și plasticității; Igor TERTEA (1956) - Beton

armat; GOBESZ Ferdinand (1956) - Statica construcțiilor; Nicolae JUNCAN (1956) - Construcții metalice și Tehnologia sudării; Viorel POP (1958) - Geotehnică și Fundații; George BÂRSAN (1959) - Mecanică teoretică, Stabilitatea și dinamica construcțiilor; Dumitru MARUSCIAC (1959) - Construcții de lemn și Agricole; Octavian BOTA (1959) - Poduri din beton armat; Alexandru NEGOIȚĂ (1961) - Clădiri civile și Inginerie antiseismică; Eugen BEIU (1963) - Tehnologia construcțiilor și Organizarea lucrărilor de construcții; Vasile IANCĂU (1963) - Desen tehnic și Geometrie descriptivă; Mircea MIHAILESCU (1964) - Construcții de beton armat și Învelitori autoportante; Onisim MITROFAN (1965) - Topografie.
Acestora li s-au alăturat Lazăr IACOB, Mircea BENEA, Gheorghe ȚANU, Ioan MORUȘCA, Alexandru CĂTĂRIG, Terente HOSSU, Dumitru MUGIOIU, Emil COMȘA, Traian ONEȚ, Gheorghe BADEA, Vasile MITREA, Cornel BIA, Anton IONESCU, Ioan OLARIU, Ioan POP, Augustin POPA, Pavel ALEXA și încă alții, care au primenit permanent, facultatea. Să nu-i uităm nici pe matematicienii, fizicienii și chimiștii, care au asigurat bazele înțelegerii disciplinelor inginerești: Aurel COȚIU, Gheorghe IONESCU, Hortenzia ROȘCĂU, Nicolaie LUNGU; NAGY Ladislau, Olivia POP; Liviu LITERAT.

Câteva repere temporale importante din istoria Facultății de Construcții din Cluj-Napoca:

- 1953 - Se înființează "Institutul Politehnic din Cluj" din care face parte şi Facultatea de Construcţii, cu specializarea: "Construcţii Civile, Industriale şi Agricole (CCIA)";
- 1970 - Se înfiinţează secţia de "Conductori Arhitecţi";
- 1971 - Se înfiinţează: "Căi ferate, Drumuri şi Poduri (CFDP)" - ingineri zi,
  - "Instalaţii în Construcţii" - subingineri zi şi subingineri seral;
  - "Construcții Civile, industrial agricole"- subingineri zi și subingineri seral;
- 1977 - Se înfiinţează secţia "Instalaţii în construcţii" - ingineri zi şi ingineri seral;
- 1992 - Schimbarea denumirii "Institutul Politehnic din Cluj" în "Universitatea Tehnică din Cluj-Napoca", din care face parte şi Facultatea de Construcţii şi Instalaţii;
- 1993 - Se înfiinţează "Civil Engineering" - cursuri zi;
  - Colegiul Universitar Tehnic, Economic şi de Administraţie - cursuri zi;
- 1995 - Se înfiinţează "Instalaţii şi Echipamente pentru Protecţia Atmosferei" - cursuri zi;
- 1997 - Se înfiinţează "Inginerie economică" - cursuri zi;
- 2005 - "Facultatea de Construcţii" devine "Facultatea de Construcţii şi Instalaţii";
- 2006 - Se înfiinţează domeniul de licență "Inginerie Geodezică", cu specializarea "Măsurători terestre şi Cadastru (MTC)";
- 2007 - Se revine la denumirea de "Facultatea de Construcţii", prin înfiinţarea "Facultăţii de Instalaţii";
- 2008 - Înființarea în cadrul domeniului Inginerie civilă a specializărilor :
  - "Amenajări și Construcții Hidrotehnice"
  - "Inginerie Urbană și Dezvoltare Regională";
- 2014 - CCIA și MTC de la Baia Mare, licență și master PASLM trec la Facultatea de Construcții prin desființarea FRMM (Facultatea de Resurse Minerale și Mediu), CUNBM;
- 2023 - înființarea domeniului de master Inginerie geodezică cu noul program "Topografie Digitală în Construcții și Cadastru".

Recunoștința noastră se îndreaptă către decanii Facultății de Construcții care și-au îndeplinit cu cinste misiunea managerială în cei 70 de ani de istorie:

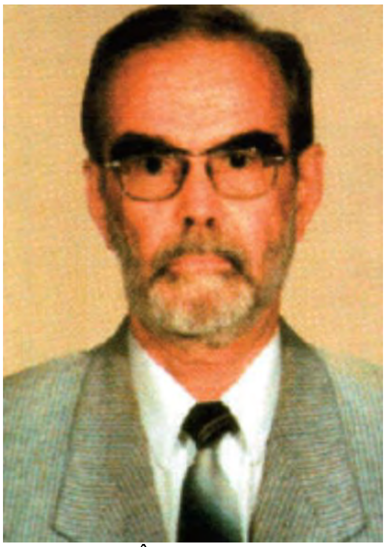

Mihai TRIPA (1953-1958)


Ștefan IACOB (1958-1961)


Nicolae JUNCAN
(1961-1962; 1971-1972)


Alexandru NEGOIȚĂ (1962-1971)


Viorel POP (1972-1976)


George BÂRSAN (1976-1984)


Traian ONEȚ (1984-1989)


Alexandru CĂTĂRIG (1989-1990)


Cornel BIA (1990)


Anton IONESCU (1990-1996)


Ioan POP (1996-2004)


Horia ANDREICA (2004-2008)


Mihai ILIESCU (2008-2012)


Nicolae CHIRA (2012-2020)


Daniela Lucia MANEA
(2020 – prezent)

Începând cu anul 1960 decanii au fost ajutați de către prodecani și secretari științifici: GOBESZ Ferdinand, Vasile ILLE, Viorel POP, Vasile MITREA, Emil COMȘA, Igor TERTEA, Octavian BOTA, Traian ONEȚ, Marieta BEURAN, Julietta DOMȘA, Anton IONESCU, Adrian CHISĂLIȚĂ, Eugen PANȚEL, Tudor POPOVICI, Viorel DRAGOȘ, Carmen CHIRA, Daniela Lucia MANEA, Anca Gabriela POPA, Nicolae CHIRA, Cristina CÂMPIAN, Gavril HODA, Nicoleta COBÎRZAN, Ștefan GUȚIU, Vasile FĂRCAȘ, Nicoleta ILIEȘ, Hortensiu Liviu CUCU.

Din anul 1962 și până astăzi au fost investiți și au activat în funcții de prorectori ai Universității Tehnice următoarele cadre didactice ale Facultății de Construcții: Nicolae JUNCAN, Vasile ILLE, Alexandru CĂTĂRIG, George BÂRSAN, Viorel POP, Adrian CHISĂLIȚĂ, Mihai ILIESCU, Mircea PETRINA, Daniela Lucia MANEA, Hortensiu Liviu CUCU și Ștefan GUȚIU.

Președintele Senatului UTCN în perioada 2012-2016 a fost Mihai ILIESCU, iar Anca Gabriela POPA ocupă funcția de vicepreședinte a Senatului din 2012 până în prezent.

Activitatea de cercetare și proiectare realizată de către cadrele didactice din Facultatea de Construcții a fost apreciată - de-a lungul timpului - prin numeroase premii și distincții, printre care:

- Mircea MIHAILESCU (1957 - Premiul „Aurel Vlaicu” al Academiei Române);
- Mircea MIHAILESCU, Octavian BOTA, Cornel BIA, Adrian POCANSCHI și BUCUR Ildikó (1968 - Premiul Ministerului Educației și Învățământului);
- Ioan OLARIU (1992 - Premiul „Anghel Saligny” al Academiei Române);
- Cornelia MĂGUREANU (2003 - Premiul „Anghel Saligny” al Academiei Române);
- Florian ROMAN (2022 - Premiul „Anghel Saligny” al Academiei Române).

Distinșii noștri înaintași și actualii colegi au fost și sunt afiliați unor asociații și societății profesionale naționale și internaționale aducându-și o valoroasă contribuție la implementarea unor programe mondiale de cercetare și proiectare ridicând prestigiul Facultății de Construcții și al Universității Tehnice din Cluj-Napoca la cote înalte, garanție a scrutării viitorului, fără umbră de îndoială. Dintre acestea pot fi amintite: RILEM - International Union of Laboratories and Experts in Construction Materials, Systems and Structures, FIB - Fédération Internationale du Béton - International Federation for Structural Concrete, AGIR- Asociația Generală a Inginerilor din România, AIIRO-Asociația Inginerilor de Instalații din România, AMIER- Asociatia Managerilor și a inginerilor economiști din România, AICPS - Asociația Inginerilor Constructori Proiectanți de Structuri, IABSE - International Association for Bride and Structural Engineering, International Federation of Surveyors: FIG, PIARC (World Road Association), ACI - American Concrete Institute, ISSMGE - International Society for Soil Mechanics and Geotechnical Engineering, SRGF - Societatea Română de Geotehnică și Fundații; IFE - The Institution of Fire Engineers, IASS - International Association for Shell and Spatial Structures, OPSEC – Organizația Profesională a Specialiștilor în Energetica Clădirilor, ANEVAR - Asociația Națională a Evaluatorilor Autorizați din România, Comisia națională de comportare in SITU a Construcțiilor, The World Corrosion Organization, ELGIP-European Large Geotechical Institute Platfrom, ITE - Institute of Transportation Engineers, ISGG - International Society for Geometry and Graphics, APDP- Asociația Profesională Drumuri și Poduri.

Până în prezent, au fost laureate cu titlul de „Doctor Honoris Causa” al Universității Tehnice din Cluj-Napoca numeroase personalități propuse și susținute de către Facultatea de Construcții:

- Prof. Dan MATEESCU de la Universitatea Politehnica din Timișoara (16.02.1995);

- Prof. Mircea SOARE de la Universitatea Tehnică de Construcții din București;
- Prof. Alexandu NEGOIȚĂ de la Universitatea Tehnică Gheorghe Asachi din Iași (24.02.1997);
- Prof. Ioannis VAYAS de la National Technical University of Atena (02.07.1997);
- Prof. Mircea MIHAILESCU de la Universitatea Tehnică din Cluj-Napoca (29.03.2001);
- Prof. Dan DUBINĂ de la Universitatea Politehnica Timişoara (17.03.2005);
- Prof. Laurie BOSWELL de la City University of London (30.05.2006);
- Prof. Dumitru MARUSCEAC de la Universitatea Tehnică din Cluj-Napoca (27.09.2007);
- Prof. Igor TERTEA de la Universitatea Tehnică din Cluj-Napoca (22.01.2008);
- Prof. Victor GIONCU de la Universitatea Politehnica Timişoara (08.11.2010);
- Prof. Alex Horia BĂRBAT de la Technical University of Catalonia Barcelona (30.09.2013);
- Prof. Petru PETRINA de la Cornell University (23.05.2014);
- Prof. Heinz BRANDL de la Vienna University of Technology (27.09.2018);
- Prof. Lyesse LALOUI de la Ecole Polytechnique Federale de Lausanne (9.11.2022).

Istoria Facultății de Construcții începe cu 130 de studenți înscriși în anul universitar 1953-1954, la singura specializare, Construcții Civile, Industriale și Agricole, ingineri - zi (5 ani), numărul anual al studenților şcolarizaţi aflându-se într-o continuă creştere în urma apariţiei unor specializări noi, dar şi a şcolarizării studenților străini. In anul universitar 1977-1978 erau înmatriculați 2600 de studenți dintre care 363 erau studenți străini. Un număr maxim de 3688 studenți s-a atins în anul universitar 2008-2009, iar în prezent Facultatea de Construcții are înmatriculați 2392 de studenți la licență și masterat și 128 la doctorat (49 în stagiu, 26 în perioada de prelungire și 53 perioada de grație). În Figura 11 este prezentată evoluția numărului de studenții ai Facultății de Construcții în cei 70 de ani.

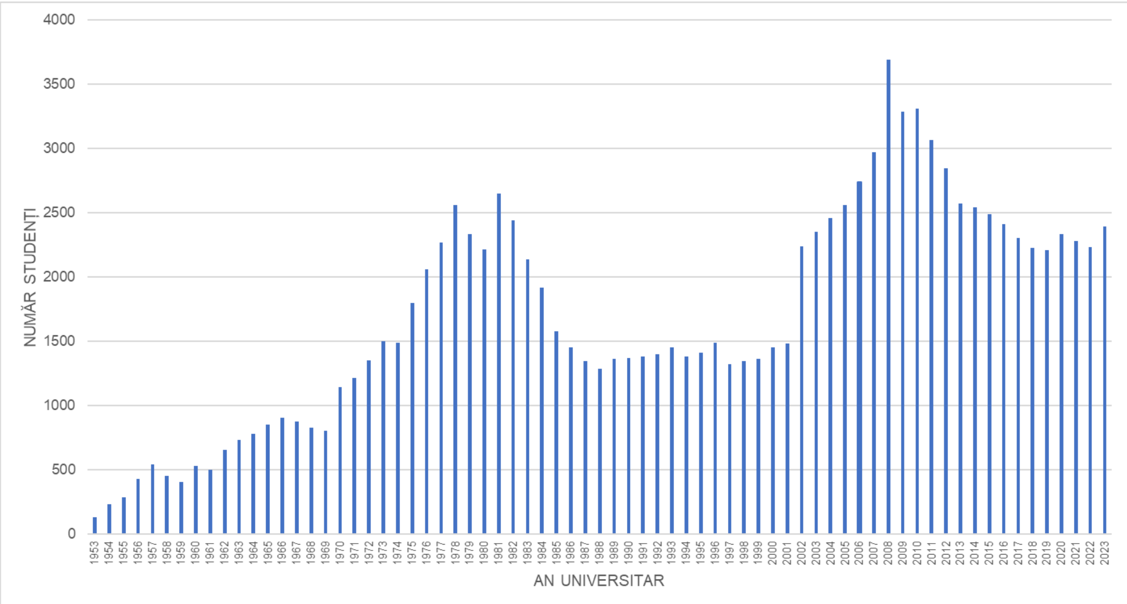


Figura 11 – Evoluția numărului de studenți ai Facultății de Construcții, 1953-2023

În cei 70 de ani de existență neîntreruptă, Facultatea de Construcții a avut 20.984 de absolvenți ai cursurilor de zi și seral, ingineri și subingineri, conductori arhitecți, absolvenți ai colegiului universitar, absolvenți ai studiilor aprofundate, absolvenți ai studiilor de licență și masterat, atât din țară cât și din 26 de țări ale Europei, Asiei, Africii și Americii. Figura 12 prezintă evoluția absolvenților Facultății de Construcții în perioada 1958-2023.

Interesante sunt mărturiile absolvenților din Vietnam - 48 de absolvenți ai Facultății de Construcții din perioada (1968-1982) - "După absolvire, studenții s-au întors în Vietnam, au lucrat în multe domenii și au contribuit la cauza reconstrucției și dezvoltării țării. Timpul a trecut atât de repede, absolvenții de atunci sunt toți bătrâni acum, cel mai tânăr are 66 de ani. Ne-am pensionat, am devenit bunice și bunici. Viața a trecut prin multe suișuri și coborâșuri, acum sunt multe lucruri pe care le-am uitat dar nu vom uita niciodată zilele când noi am trăit în Cluj-Napoca și am studiat la Institutul Politehnic Cluj-Napoca. O perioadă de viață care a lăsat în fiecare dintre inimile noastre amintiri și impresii profunde pe care timpul nu le poate șterge. Profesorii și oamenii din institut ne-au iubit mult și au avut grijă de noi ca de copiii și pe frații mai mici. Profesorii MUGIOIU, BÂRSAN, BEIU, COMŞA, ILLE, MIHAILESCU, TERTEA, PETRINA, COCHECI … vă păstram veșnic în sufletele noastre. Cu colegii din școala, noi am petrecut o perioadă studențească frumoasă, de neuitat. Mulți dintre colegi au devenit prieteni ai noștri dintre care unii ca niște frați astfel încât, oricât de departe am fi, nu-i vom uita niciodată. In ultimii zece ani, mulți absolvenți vietnamezi s-au întors să viziteze orașul Cluj-Napoca și vechiul lor institut. Cei care nu pot încă să se întoarcă, visează întotdeauna să se întoarcă în acel loc măcar o dată. Pentru a deveni oamenii care suntem astăzi, suntem extrem de recunoscători profesorilor, personalului și colegilor români ai Universității Tehnice din Cluj-Napoca. Vă mulțumim din suflet tuturor. Mulțumim poporului român, mulțumim țării românești. Cu ocazia împlinirii a 70 de ani de la înființare, dorim Facultății de Construcții, precum și Universității, din ce în ce mai multă dezvoltare. Dorim tuturor profesorilor, personalului și colegilor din universitate, multă sănătate, bucurii și multe realizări.″

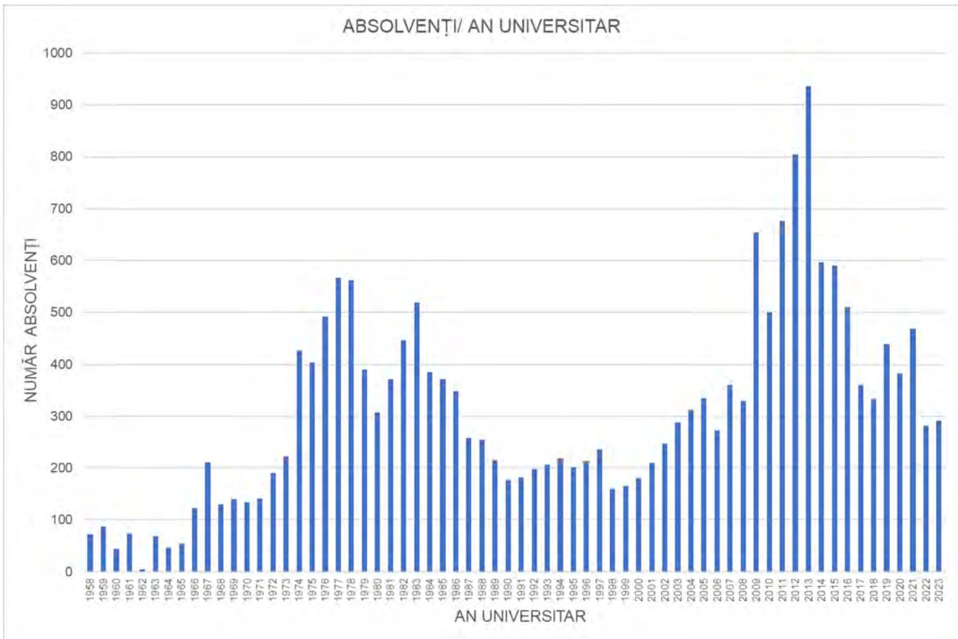


Figura 12 – Evoluția numărului de absolvenți ai Facultății de Construcții în perioada 1958-2023

Într-o instituție în care învățătura, educația și cercetarea erau și sunt venerate, cu toate vitregiile politice efemere, încă de la început au fost cadre didactice care au dobândit dreptul de a conduce pregătirea în vederea obținerii titlului de „doctor inginer". Figura 13 prezintă numărul anual al tezelor de doctorat susținute în perioada 1969-2023. Începând cu anul 1969 și până în prezent au avut loc 400 de susțineri de teze de doctorat sub coordonarea următorilor profesori: Alexandru NEGOIȚĂ, Mircea MIHĂILESCU, Vasile ILLE, Igor TERTEA, GOBESZ Ferdinand, Nicolae JUNCAN, Ioan POP, Dumitru MARUSCIAC, Anton IONESCU, Traian ONEȚ, Vasile PĂCURAR, Iacob LAZĂR, Alexandru Teofil CĂTĂRIG, Augustin POPA, Gheorghe BADEA, Terente HOSSU, Cornel Traian BIA, Octavian Ioan BOTA, Florin Radu POP, George Mihail BÂRSAN, Mihai ILIESCU, Gavril KOLLO, Cornelia MĂGUREANU, Iacob BORȘ, Mariana BRUMARU, Horia Aurel ANDREICA, Viorel MAIER, KISS Zoltan Iosif, Călin Grigore Radu MIRCEA, Ildiko BUCUR, Eugen PANȚEL, Pavel ALEXA, Mircea PETRINA, Balint Gyorgy SZABO, Daniela Lucia MANEA, Adrian CHISĂLIȚĂ, Adrian Mircea IOANI, Tudor POPOVICI, Ludovic Gheorghe KOPENETZ, Cosmin CHIOREAN, Mihai NEDELCU, Ioan AȘCHILEAN. Domeniul Inginerie Civilă și Instalații din cadrul „Școlii doctorale" a fost coordonat succesiv de către Adrian Ioani, Kiss Zoltan și Mihai Nedelcu.

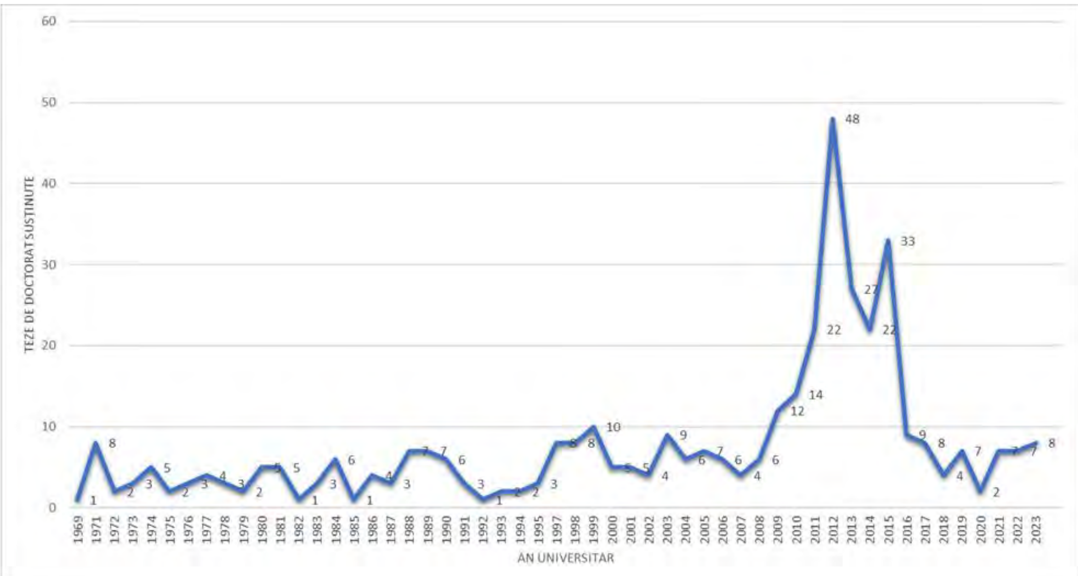


Figura 13 – Numărul tezelor de doctorat susținute în Facultatea de Construcții în perioada 1969 - 2023

Facultatea de Construcții, azi, este o instituție de învățământ superior cu tradiție, care s-a impus pe piața pregătirii forței de muncă înalt calificată din România și din străinătate și care trebuie să-și întrețină și dezvolte acest renume, în contextul în care evoluțiile viitoare vor fi marcate de intensificări ale mediului concurențial și al lărgirii bazei competiționale, iar ritmurile accelerate de evoluție în domeniul cercetării și inovării vor impune o rată înaltă de schimbare anuală a cunoștințelor.
Încurajarea parteneriatului între mediul universitar și cel antreprenorial este un prim pas către integrarea europeană, mai ales prin intermediul trinomului educație-cercetare-inovare, unde competențele educaționale trebuie să fie dobândite și apreciate prin implementarea Învățământului Centrat pe Student.
Învățământului universitar, cea mai importantă structură a societății cunoașterii, prin componentele sale de formare și de cercetare științifică, îi revine sarcina de a asigura resursa de bază, singura capabilă să genereze creația științifică necesară inovării și înnobilării activității umane, să asigure o dezvoltare durabilă și să creeze noi resurse necesare atingerii acestor obiective.
Misiunea Facultății de Construcții a fost definită cu ocazia sărbătoririi semicentenarului, prin trei funcții ce caracterizează conceptul de universitate modernă:
- Educație la cele mai înalte standarde calitative;
- Cercetare și dezvoltare în concordanță cu standardele internaționale;
- Legătura cu societatea prin crearea de cunoștințe, formarea de personal calificat, transferul și aplicarea cunoștințelor.

Corpul Didactic

Dinamica funcțiilor didactice în Facultatea de Construcții în perioada 2019-2023 este prezentată în Figura 14. În anul universitar 2023-2024, în statele de funcții sunt **191** posturi didactice, **118** dintre acestea fiind ocupate (61,7%) și restul de **73** (38,3%) vacante, iar distribuția pe funcțiile didactice este următoarea:
- 7 profesori
- 28 conferențiari
- 65 șefi de lucrări
- 11 asistenți
- 7 asistenți pe perioadă determinată

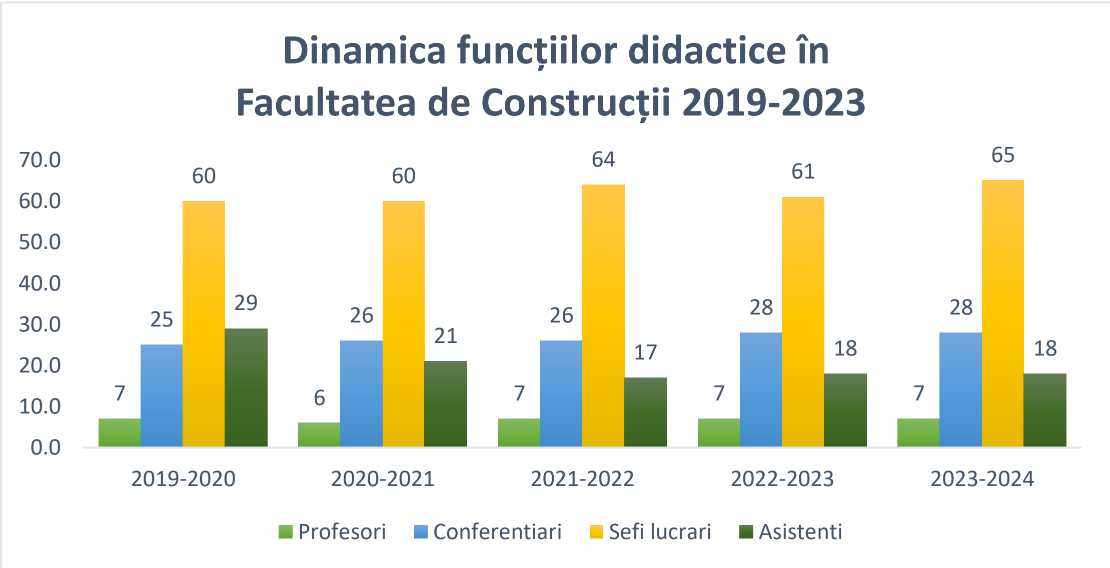


Figura 14 – Dinamica funcțiilor didactice în Facultatea de Construcții 2019-2023

Corpul didactic este organizat în cinci departamente, conduse de către directori:
1. CCM - Construcții Civile și Management (Conf. dr. ing. Claudiu ACIU);
2. CFDP - Căi Ferate, Drumuri și Poduri (Ș. l. dr. ing. Mihai DRAGOMIR);
3. MECON - Mecanica construcțiilor (Conf. dr. ing. Anca POPA);
4. MTC - Măsurători Terestre și Cadastru (Conf. dr. ing. Sanda NAȘ);
5. STR - Structuri (Conf. dr. ing. Attila PUSKAS).

Repartizarea cadrelor didactice pe departamente este prezentată în Figura 15:

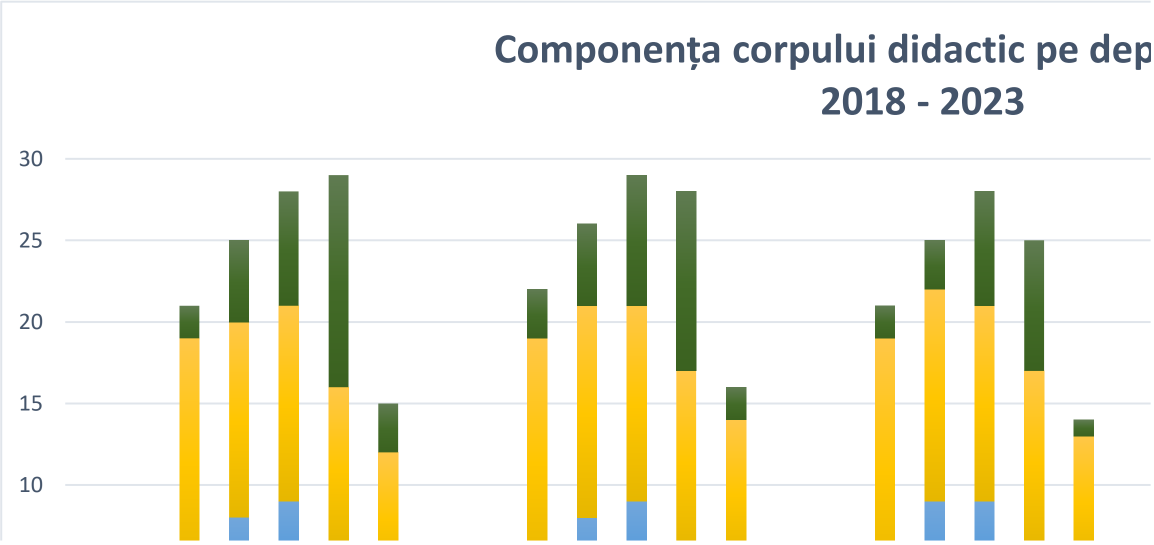


Figura 15 – Repartizarea cadrelor didactice pe departamente în perioada 2018-2023

Conducerea Facultății de Construcții este asigurată de către Prof. dr. ing. Daniela Lucia MANEA - decan și prodecanii Conf. dr. ing. Nicoleta ILIEȘ - didactic, Conf. dr. ing. Nicoleta COBÎRZAN - relații internaționale și imagine, Conf. dr. ing. Gavril HODA - cercetare - dotare și ing. Liliana IACOB, secretar-șef.

Departamentul CCM – Construcții Civile și Management
Director departament: Conf.dr.ing. Claudiu ACIU


Departamentul CFDP – Căi Ferate, Drumuri și Poduri
Director departament: Șef lucrări dr. ing. Mihai Liviu DRAGOMIR

Departamentul MECON – Mecanica Construcțiilor
Director departament: Conf.dr.ing. Anca Gabriela POPA

Departamentul MTC – Măsurători Terestre și Cadastru
Director departament: Conf.dr.ing. Sanda Mărioara NAȘ

Departamentul STR – Structuri
Director departament: Conf.dr.ing. Puskas Attila


Secretariatul facultății este coordonat de ing. Liliana Mariana Iacob în calitate de secretar șef al facultății și Alexandra Matiş, Cozmina Ploscar, Anca Sita şi Olimpia Suciu. În calitate de administrator facultate este Sorina Georgiu.

OFERTA EDUCAȚIONALĂ
În prezent, Facultatea de Construcții din Cluj-Napoca are 2520 de studenți - înscriși la 8 programe de licență, 8 programe de masterat și la un program de doctorat, pregătirea acestora fiind asigurată de către 118 cadre didactice titulare și 57 de cadre didactice asociate care își propun să continue dezvoltarea unui mediu de învățare, de cercetare și de inovare, de înaltă ținută. La licență și masterat, în anul universitar 2023-2024 sunt înmatriculați 2392 de studenți (Figura 16).

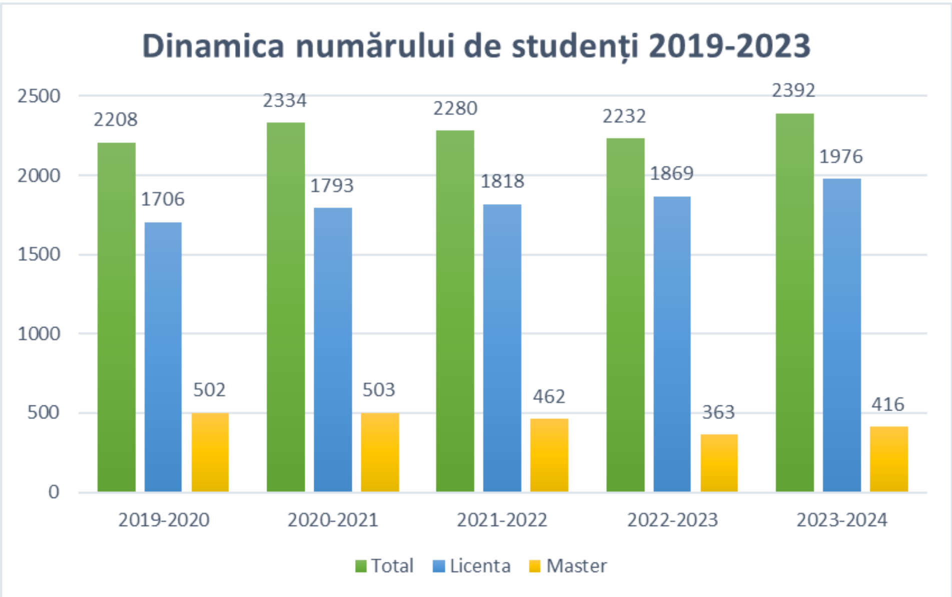


Figura 16 – Dinamica numărului de studenți în perioada 2019-2023

STUDII DE LICENȚĂ – 4 ani, se desfășoară pe trei domenii:
1. Domeniul **Inginerie civilă**:
- Construcții Civile Industriale și Agricole – Cluj-Napoca (RO/EN) și Baia Mare (RO);
- Căi Ferate, Drumuri și Poduri;
- Amenajări și Construcții Hidrotehnice;
- Inginerie Urbană și Dezvoltare Regională.
2. Domeniul **Inginerie și Management:**
- Inginerie și Management în Construcții;
3. Domeniul **Inginerie Geodezică:**
- Măsurători Terestre și Cadastru.

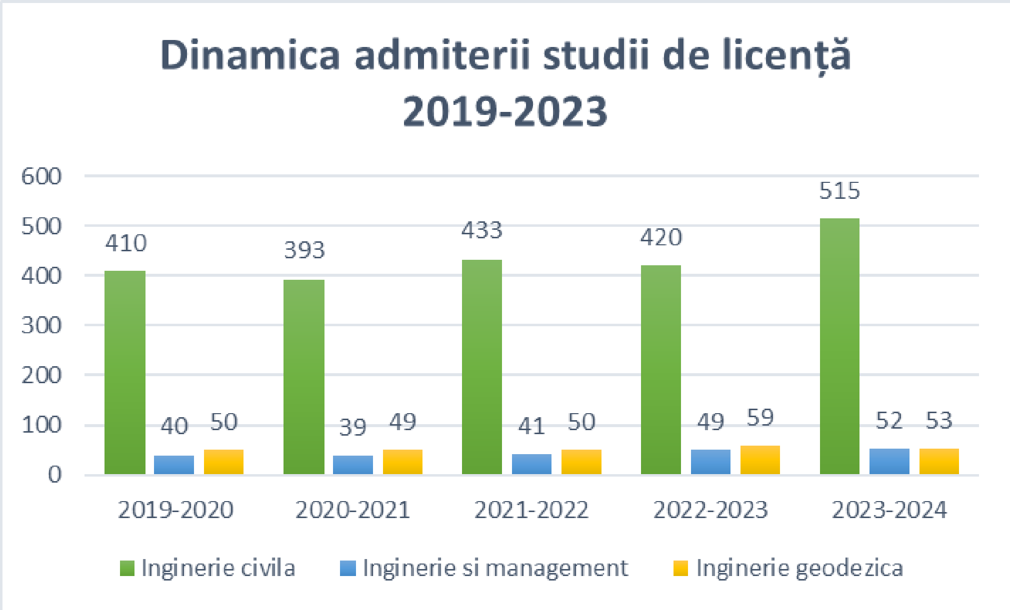


Figura 17 – Dinamica admiterii la studii de licență în perioada 2019-2023

STUDII DE MASTER – 2 ani, se desfășoară pe trei domenii:

1. Domeniul **Inginerie civilă și Instalații**:
- Construcții Durabile din Beton;
- Clădiri Verzi;
- Inginerie Geotehnică;
- Ingineria Infrastructurii Transporturilor;
- Inginerie Structurală;
- Proiectarea Avansată a Structurilor din Lemn și Metal;
2. Domeniul **Inginerie și Management:**
- Managementul Proiectelor și Evaluarea Proprietății;
3. Domeniul **Inginerie Geodezică:**
- Topografie Digitală în Construcții și Cadastru.

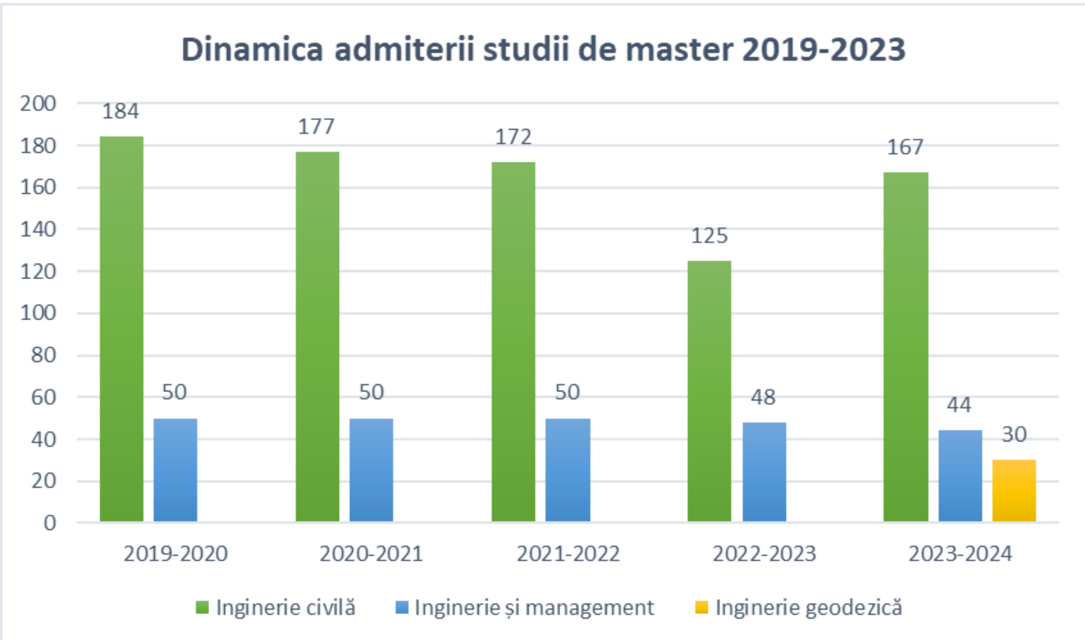


Figura 18 – Dinamica admiterii la studii de masterat în perioada 2019-2023

STUDIILE DE DOCTORAT

Studiile de doctorat se desfășoară pe durata a 4 ani, în domeniul Inginerie Civilă și Instalații, având 11 conducători de doctorat și 128 de doctoranzi înmatriculați în anul universitar 2023-2024.

RELAŢII INTERNAŢIONALE ŞI INTERNAŢIONALIZARE
La Facultatea de Construcții sunt înmatriculați atât la licență cât și master studenți internaționali din: Republica Moldova, Republica Federală Germana, Italia, Israel, Regatul Hasemit al Iordaniei, Palestina, Chile, Ucraina, Canada, Congo.

EUT+, European University of Technology - consorțiu de 8 universități europene partenere angajate într-un proces intens de armonizare academică și de cercetare.
Facultatea de Construcții a făcut parte din primul val de facultăți dispuse să își armonizeze curricula academică cu cea a universităților partenere pentru programul de licență Civil Engineering, semestrele 3 și 4. La nivel de master, datorită diversității foarte mari a specializărilor, s-a convenit în prima faza ca studenții să opteze pentru semestrul rezervat disertației, care nu mai conține alte cursuri.
Clusterul de lucru este alcătuit din 5 universități: Technological University Dublin; Cyprus University of Technology; Technical University of Cartagena; Darmstadt University of Applied Sciences și UTCN.
După efectuarea a cel puțin un semestru de mobilitate în aceste condiții la nivel de licență și master, studenții vor obține un certificat european recunoscut EUT+.

ERASMUS+
Mobilități Outgoing, studenți: Cracow University of Technology - Polonia, Budapest University of Technology and Economics - Ungaria, Kaldy Basement Ltd - Anglia, Bayer Construct ZRT - Ungaria, Universita Degli Studi di Bergamo, Budapest University of Technology and Economics, Cracow University of Technology, Polytechnic University of Catalonia, University of Liege.
Mobilitați Incoming, studenți: INSA Strasbourg- Franţa, HEI, une école d'Yncréa Hauts-de-France, Institut National des Sciences Appliquées de Rennes – Franţa, Universidad de Zaragoza, Universidad de Córdoba - Spania, Université de Technologie de Troyes - Franţa, University of A Coruña - Spania, Institut National des Sciences Appliquées Strasbourg - Franta, Universidad Politécnica de Cartagena - Spania, mobilități de staff: University of Technology of Troyes, Technical University of Sofia - Bulgaria, Iordania, Arabia Saudită, Vietnam, Nepal.

CERCETARE
În Facultatea de Construcții este promovată cercetarea fundamentală, cercetarea aplicativă și inovativă având ca principale teme de cercetare din domeniul Ingineriei Civile, Ingineriei și managementului în construcții și Ingineriei geodezice. La nivelul facultății își desfășoară activitatea următoarele grupuri de cercetare:
- Modelare Computațională și Simulare Avansată în Ingineria Structurală și Geotehnică, în cadrul Departamentului de Mecanica Construcțiilor;
- Grup de Cercetare în Materiale de Construcții în cadrul Departamentului de Construcții Civile și Management;
- Grup de Cercetare în Domeniul Ingineriei Podurilor în cadrul Departamentului Căi Ferate, Drumuri și Poduri;
- Grup de Cercetare în Domeniul Sistemelor de Transport în cadrul Departamentului Căi Ferate, Drumuri și Poduri;
- Grup de Cercetare în Dezvoltare Tehnologică și Inovare în Domeniul Ingineriei Civile și a Serviciilor pentru Clădiri în cadrul Departamentului de Construcții Civile și Management;
- Colectiv de Cercetare în Fizica și Protecţia Clădirilor. The Research Collective in Physics and Protection of Buildings - RCPPB https://eertis.eu/erlb-2300-000a-5509 .

Activitatea de cercetare desfășurată în cadrul facultății, se materializează prin publicații științifice (în reviste de specialitate sau volume ale unor conferințe), contracte de cercetare/proiectare.

RESURSE SI UTILITĂȚI
Activitatea didactică și de cercetare a cadrelor didactice din cadrul Facultății de Construcții se desfășoară în spații care în ultimii ani au fost reabilitate, modernizate și dotate cu aparatură modernă, cu sisteme All-In-One, proiectoare, camere web pentru conferințe, table interactive și tablete grafice.
Printre sălile modernizate, se regăsesc:
- Aula Tertea - utilizată pentru susținerea tezelor de doctorat, evenimente festive;
- 6 amfiteatre reabilitate, modernizate și dotate cu aparatură modernă;
- 8 laboratoare de calcul dotate cu rețele de calculatoare și programe de calcul/proiectare performante;
- 30 săli pentru desfășurarea activităților practice;
- Laboratorul Central autorizat ISC cu 14 profiluri de încercări;
- Hala de încercări pentru structuri industriale și materiale pentru drumuri.

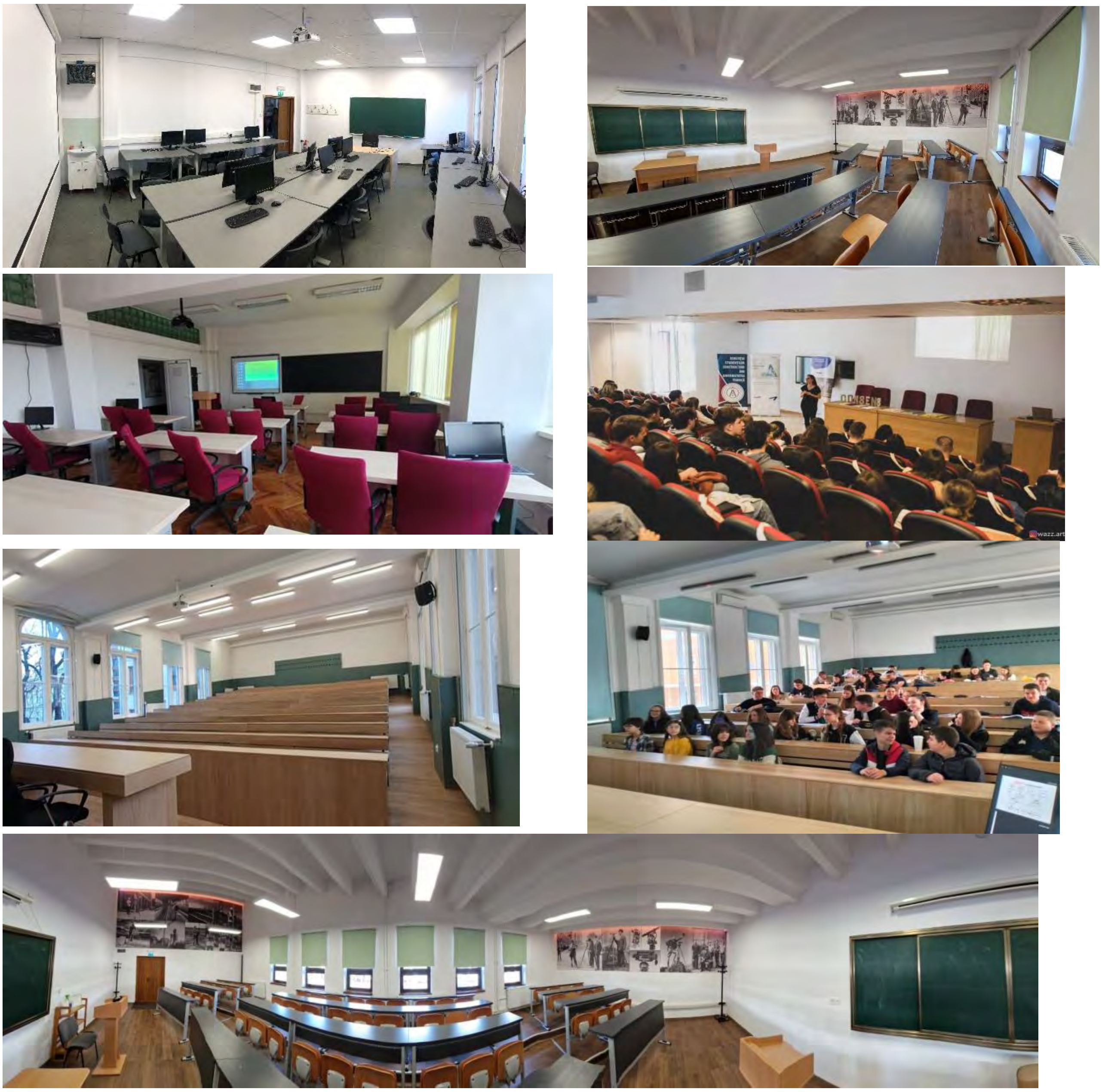


Figura 19 - Spațiile de învățământ reabilitate și modernizate

Studenții beneficiază de servicii de masă, peste 800 locuri de cazare în Căminele II și III din Complex Observator, respectiv 2B din Complex Mărăști, teren de sport modern în Campus Observator, acces la Bazinul Olimpic al Universității.

ACTIVITĂȚI EXTRACURRICULARE STUDENȚEȘTI

Studenții Facultății de Construcții sunt încurajați să participe la activități extracurriculare, în scopul îmbunătățirii competențelor profesionale și transversale necesare în vederea creșterii performanțelor academice și dezvoltării unei cariere de succes.
Conducerea Facultății de Construcții, promovează implicarea în activități de cercetare și dezvoltare tehnologică la cele trei cicluri de studii (licență, masterat și doctorat), rezultatele obținute fiind diseminate în cadrul simpozioanelor studențești, al conferințelor naționale sau internaționale și publicate ca lucrări științifice în jurnale de specialitate.
Rezultatele remarcabile înregistrate în ultimii ani de studenții facultății noastre la concursurile internaționale (*Seismic Design Competition, World Champion in Spaghetti Bridge Building, Beton Kenu*) și naționale (*Concursul Profesional Științific Studențesc de Rezistența Materialelor „C. C. Teodorescu”*) evidențiază dorința de aprofundare a cunoștințelor, potențialul creativ, motivația și buna pregătire a studenților dar și colaborarea strânsă între studenți și cadrele didactice coordonatoare.

CONCURSURI INTERNAȚIONALE

Seismic Design Competition (SDC) este un concurs de inginerie seismică, organizat în Statele Unite ale Americii, în cadrul conferinței de inginerie seismică “Earthquake Engineering Research Institute – EERI”, care are ca obiectiv proiectarea și realizarea unei structuri din lemn de balsa rezistentă la cutremure simulate cu ajutorul platformelor seismice (https://sdc.utcluj.ro/ro/) .
Studenții Facultății de Construcții din cadrul Universității Tehnice din Cluj-Napoca au participat la acest concurs începând cu anul 2011, reușind să se claseze de 6 ori pe locul întâi (anii 2014, 2015, 2016, 2020, 2022 și 2023).
Este un concurs care reunește anual studenți pasionați de domeniul ingineriei seismice de la universități prestigioase din lume: University of Buffalo; Cornell University; University of California, Los Angeles; University of Massachusetts, Amherst; University of California, Berkeley; University of Memphis; Purdue University; University of Nevada, Reno; University of British Columbia; New York University; University of California, San Diego; The University of Texas at Austin; University of Toronto; etc.
Coordonatori echipe UTCN SDC: Ș. l. dr. ing. Ovidiu PRODAN, Ș. l. dr. ing. Bianca MARTON și Ș. l. dr. arh. Paul MOLDOVAN.

Figura 20 - Echipa SDC-UTCN San Francisco, California SUA, 2023 – locul I

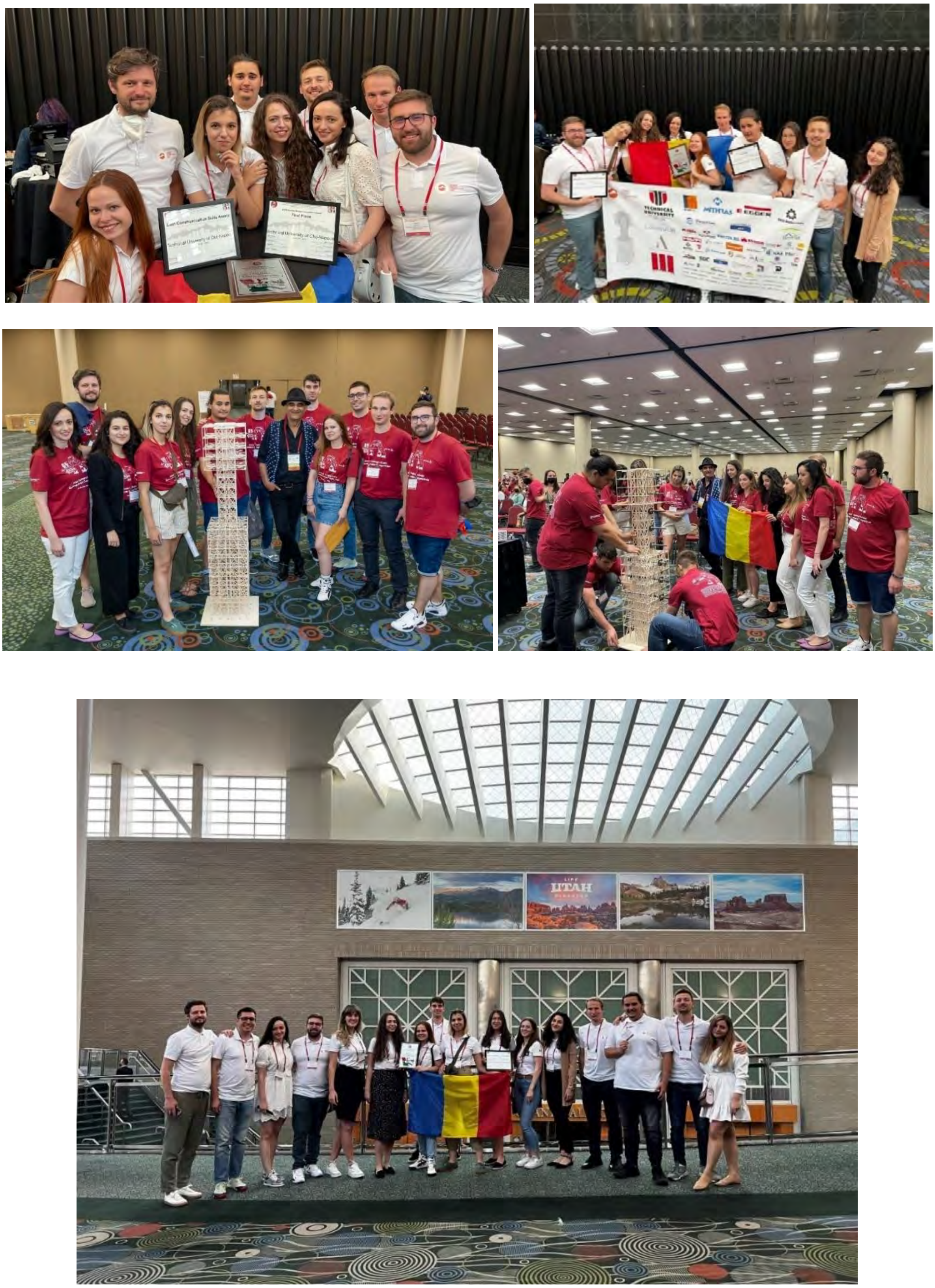


Figura 21 - Echipa SDC-UTCN Salt Lake City, Utah - SUA, 2022 – locul I

Figura 22 - Echipa SDC-UTCN San Diego, California SUA, 2020 – locul I

World Champion in Spaghetti Bridge Building (***RECCS)*** este o competiție internațională organizată de Universitatea Óbuda din Budapesta (www.reccs.hu; http://reccs.uni-obuda.hu/en) la care studenții Facultății de Construcții au participat și au fost premiați începând cu anul 2011.
Obiectivul concursului constă în proiectarea și realizarea unor structuri din paste făinoase cu caracteristici (înălțime, deschidere, greutate) definite prin regulamentul competiției și testarea structurilor la încărcări progresive până la cedare.
La secțiunea ‚Bridge', studenții Facultății de Construcții s-au clasat de 4 ori pe locul I (anii 2012, 2014, 2016, 2018).
Coordonatori echipe: Conf.dr.ing. GOBESZ Zsongor, Asist. dr. ing. Ioana MARCHIȘ, S.l dr.ing. Marius BURU

Figura 23 - Echipa UTCN - locul III la categoria ”Bridge”, 2019

In anul 2022, la Faza locală a concursului de poduri din paste făinoase Spaghetti Bridge Building organizată în cadrul simpozionului SNCSS, s-au prezentat șase echipe (Figura 24) cu studenți ai Facultății de Construcții, coordonați de Șef lucrări dr. ing. Cristian MOJOLIC și Șef lucrări dr.ing. Adrian MARCHIȘ.

Figura 24 - Echipele participante la Faza locală a concursului de poduri din paste făinoase Spaghetti Bridge Building, 2022

Devenită tradițională după ce a fost lansată în anul 2012, la inițiativa Budapest University of Technology and Economic şi MAPEI Hungary, competiția ***"Beton Kenu (Concrete Canoe)"*** (http://www.betonkenu.hu/) susține spiritul de competiție al studenților pasionați de beton și de utilizarea acestuia la fabricarea de canoe. Elementele esențiale care asigură crearea unei ambarcațiuni competitive (designul, ingeniozitatea, tehnologia de realizare, greutatea și viteza de deplasare) au stat la baza evaluării structurilor realizate. Este un concurs la care studenții Facultății de Construcții au participat alături de studenți din alte țări (Ungaria, Cehia, Ucraina), clasându-se pe podium în anii 2018 și 2019.
Coordonator: Prof. dr. ing. Călin MIRCEA

Figura 25 – Imagini de la competiția "Beton Kenu (Concrete Canoe)"

CONCURSURI NAȚIONALE

Concursul Profesional Științific Studențesc de Rezistența Materialelor „C. C. Teodorescu" este unul dintre cele mai longevive concursuri naționale la care studenții facultății au participat, intrând în competiție cu studenți din alte centre universitare din țară: Iaşi, Bucureşti, Constanța, Braşov şi Timişoara.
Studenții Facultății de Construcții au obținut premiul I la edițiile: XXXV, XXXVI, XXXVII și XXXVIII.
Pregătirea studenților s-a desfășurat cu sprijinul Prof. dr.ing. Adrian IOANI, Prof.dr.ing. Ironim MARTIAN, Conf. dr.ing. Liviu CUCU, Conf. dr.ing. Anca POPA, Şef lucrări dr. ing. Mircea BOTEZ și Şef lucrări dr. ing. Marius BURU.

Figura 26 – Studenții premiați la concursul Profesional Științific Studențesc de Rezistența Materialelor „C. C. Teodorescu”

Sesiunea Națională de Comunicări Științifice Studențești (SNCSS) este un eveniment organizat de către Facultatea de Construcții și Asociația Studenților Constructori din Universitatea Tehnică din Cluj-Napoca (*ASCUT*) în colaborare cu Facultatea de Instalații și Facultatea de Arhitectură.

Reunește anual un număr de peste 150 de studenți, cadre didactice, reprezentanți din sectorul economic și cuprinde prezentări și dezbateri ale lucrărilor științifice, workshop-uri tematice si vizite tehnice organizate în parteneriat cu firme de profil din țară.

Este un simpozion dedicat studenților de la cele 3 cicluri de studii, care a reușit prin cele XIX ediții organizate până în prezent să atragă un număr mare de studenți pasionați de cercetare, atât din cadrul UTCN cât și din alte centrele universitare din țară (Iași, București,Timișoara, Constanța, Oradea, Brașov).

Figura 27 - SNCSS, 2019

Figura 28 - SNCSS 2022

Figura 29 - SNCSS 2023

ORGANIZAȚII STUDENȚEȘTI

Studenții sunt încurajați să se implice în activități de voluntariat, să se înscrie și participe la evenimentele tradiționale organizate de către studenți, pentru studenți, prin organizațiile:

- **ASCUT - Asociația Studenților Constructori din Universitatea Tehnică**
- **OSUT - Organizația Studenților din Universitatea Tehnică din Cluj-Napoca**
- **BEST - Board of European Students of Technology**.

Activități ASCUT
CONSENS

Figura 30 – Proiect ASCUT – CONSENS, CONAliada

SNCSS

Figura 31 – Proiect ASCUT - SNCSS

OSUT - Organizația Studenților din Universitatea Tehnică din Cluj-Napoca
Debattle

Figura 32 – Proiect OSUT - Debattle

Engineering Summer University

Figura 33 – Proiect OSUT - Engineering Summer University

Crosul UT

Figura 34 – Proiect OSUT - Crosul UT

Facultatea de Construcții, a reușit să se plaseze în elita școlilor superioare de construcții, fapt validat de relațiile privilegiate pe care le are cu universități şi facultăți de același profil din numeroase ţări: Franţa, Italia, Portugalia, Belgia, Grecia, Ungaria, Irlanda, Germania, Spania, Bulgaria şi altele.

În încheiere, recunoștința noastră se îndreaptă către toți membrii corpului profesoral care și-au îndeplinit cu cinste misiunea educațională în cei 70 de ani de istorie a Facultății de Construcții, rămânând adevărate modele pentru generațiile de absolvenți pe care le-au format și le-au inspirat.

Și, nu în ultimul rând, ne exprimăm prețuirea pentru generațiile de studenți care au făcut posibilă reușita noastră. A avea asemenea studenți și absolvenți este pentru noi un motiv de mândrie.

Vivat academia, Vivat profesores!

VIVAT, CRESCAT, FLOREAT Facultatea de Construcții!

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CLUJ+-+Academia+-+animata+-+1909.jpg (500×314) (bp.blogspot.com).
FOTO Clujul în 3000 de fotografii vechi. Povestea inginerului care readuce la viaţă trecutul oraşului | adevarul.ro.
Pákei Lajos - cel mai important arhitect al Clujului (clujwebstory.ro).
Povestea frumosului portal din Zorilor, de la intrarea în clădirea Universității Tehnice - FOTO - Știri de Cluj (stiridecluj.ro)

SECTION II

CONSTRUCTION MATERIALS

Ceramic Waste Brick Replacement of Aggregates in Eco-Efficient Plastering Mortars

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3 Institute for Research in Chemistry Raluca Ripan ICCRR, Babes Bolyai University, 30 Fantanele Str., Cluj-Napoca, Romania,

Summary: *Brick waste is one of the most common construction and demolition types of waste. To extend its life cycle and to prevent further exploitation of raw materials, 3 new plastering mortars with ceramic brick waste were created. The results were promising. The mechanical strength of the mortars increases at a replacement percentage of 15%. Further research is suggested testing the durability of the mortars and adding additives to improve the strength.*

Keywords: brick waste mortars, locally sourced materials, sustainable waste management, construction and demolition waste

1. Introduction

In eco-efficient plastering mortars, a part of the cement or of the aggregates has been replaced with construction and demolition waste (CDW). Research shows that the life cycle assessment (LCA) of these mortars is only improved if the waste transport and processing energy consumption is reduced to the minimum. Studies testing plastering mortars with ceramics waste have shown positive results. In cases where the waste granulation was < 150 μm, mechanical strength was greatly improved.

2. Materials

This study proposes 3 eco-efficient mortars where the aggregates were partially replaced with ceramic waste from bricks (“ACR”) 15% - ACR15, 30% - ACR30, 45% - ACR45. Four sorts of different sizes were used: 0-0.5 mm, 0.5-1 mm, 1-2 mm, 2-4 mm for natural aggregates, as well as for the brick waste. The waste processing procedures were maintained at the minimum: the brick waste was only crushed and sieved. The natural aggregates and the brick waste were procured from local sources. The utilised cement was Portland Structo 42.5 R. The water originated from the municipal drinkable water supply of Cluj-Napoca. The physical-mechanical characteristics of the ACR mortars were compared to the CS IV reference mortar. The modern electronic microscopy methods of SEM and EDX were used, to observe the micro-morphology of the materials. The Laboratory of the Construction Faculty in Cluj-Napoca was the processing site of the ceramic waste and of performing the physical-mechanical determinations in accordance with the standard SR EN 1015:1-21. The storage temperature of the samples kept before each determination was according to the standard: 20ºC ± 2ºC and relative humidity of 65%±5%. Determination of flexural strength was performed using prism shaped samples of size 160x40x40 mm, as per the standard SR EN 1015, using an automated machine A/0700/478. On the two ruptured sample ends, the determination of compressive strength was performed using a hydraulic press Tecnotest It. These determinations were performed at 3, 7, 14, and 28 days. On the 28th day, adherence to the support layer was determined and recorded with a digital dynamometer Controls 58-C0215/T. The morphology of the mortars was observed with SEM and EDX analyses. The SEM was a JEOL JSM 5600 LV (Tokyo, Japan) and for EDX the Oxford Instrument (High Wycombe, UK) detector UltimMAX64 and AZtech software (v. 4.2) was utilised.

3. Results and Discussion

All mortars corresponded to the SR EN 1015 standard requirements.

- Determination of flexural strength

On the 28th day, ACR15 recorded a flexural strength +11% higher than CS IV, ACR30 and ACR45 had flexural strength values -17% lower than CS IV. This signifies that replacing 15% of natural aggregates with ceramic brick improves the flexural strength. Above this percentage, the impact is negative, but the values do not decrease between 30% and 45% replacement levels.

- Determination of compressive strength

On the 28th day, ACR15 had a compressive strength +3% higher than CS IV, ACR30 had a value -14% lower than CS IV and ACR45 values were -23% lower than CS IV. This signifies that replacing natural aggregates with concrete waste affects compressive strength negatively, lowering it by an average of about -15% at 30-45% replacement.

- Determination of adhesion to the support layer

The values were on average lower than CS IV by 45% in the case of ACR15, by 29% in the case of ACR30, and by 55% in the case of ACR45 (Figure 1), which is consistent with other studies on mortars with CDW. However, they all corresponded to the requirements of the standard SR EN 1015. This signifies that they are technically viable.

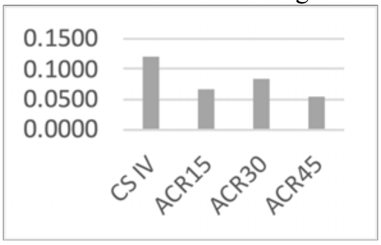
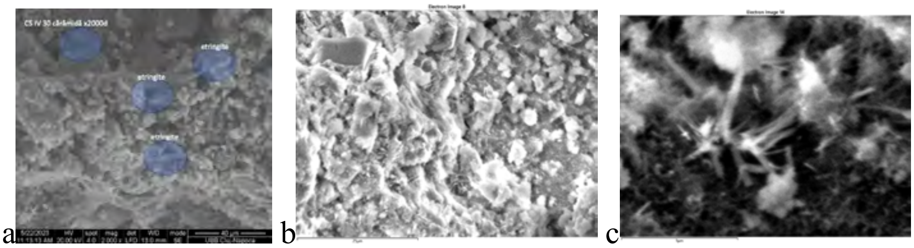


Figure 1. Average values of the adherence strength test of CS IV and ACR mortars, the four recipes are represented on the y axis

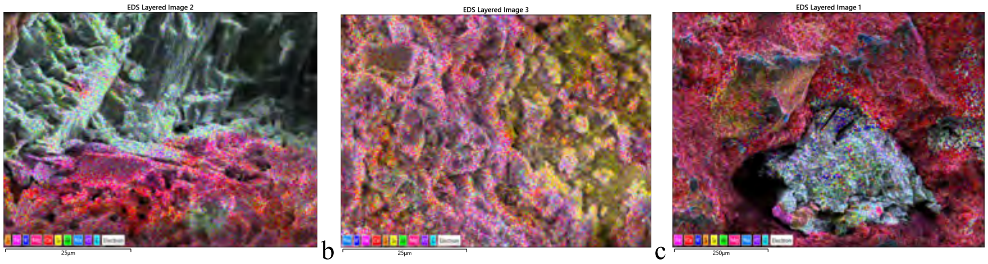
- The optical microscopy method - SEM and EDX

Mineralogical compounds and aluminium oxides ($Ca_5Al_6O_{14}$) as well as hydrated calcium silicates ($Ca_2SiO_4 \cdot 3H_2O$, $CaO \cdot SiO_2 \cdot H_2O$ and $Ca_2SiO_4 \cdot H_2O$) were visible through SEM and EDX analyses, increasing mechanical strength.
The results indicate that using ceramic waste from bricks to replace aggregates in plastering mortars is viable, and that a 15% replacement has beneficial effects on mechanical strength. Other studies showed that 30% or even 40-50% of the aggregates can be replaced with ceramic waste. (Raini, et al., 2020) In a review of studies from 2002-2022, Garg & Shrivastava (2023) found that up to 100% of the natural aggregates can be replaced with brick ceramics, if utilised as fine aggregate. However, in this study, the size of the aggregates was coarse and no additives were utilised, and thus, the maximum percentage of replacement with improved proprieties was 15%. SEM and EDX analyses showed chemical reactions taking place in the mortar, with the presence of etringite needles (Figure 2) and the binding matrix, as the mechanical resistance was increasing (Figure 3).



a b c

Figure 2. SEM images of the brick replacement mortar ACR, a. ACR30 x2000 – etringite clusters marked with blue; b. ACR15 x2000; c. ACR45 x10000



a b c

Figure 3. EDX images of the brick replacement mortar ACR, a. ACR15 x2000; b. ACR30 x2000, c. ACR15 x150

4. Conclusions

Using brick waste as a substitute for aggregates in plastering mortars is a viable solution, due to the porosity of the material, which acts as a filler. Confirming the viability of these recipes with minimal transport and energy use is essential for producing mortars that not only utilise CDW, but also have a lower negative impact on the environment. This paper has demonstrated that ASR15 is a promising mortar to develop into a commercial product, due to its good physical-mechanical performance. Further research could assess the durability of the mortars over a longer time.

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Acknowledgment: This paper was financially supported by the Project "Network of excellence in applied research and innovation for doctoral and postdoctoral programs/InoHubDoc", project co-funded by the EU Social Fund financing agreement no. POCU/993/6/13/153437.

Replacing Aggregates in Plastering Mortars with Locally Sourced Concrete Waste

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Summary: *Concrete is utilised at scale and leads to large quantities of concrete waste. Extending the lifecycle of construction materials and creating new materials with a lower life cycle impact is a target imposed by sustainability norms. In this paper three plastering mortars with 15%, 30%, and 45% aggregate replacement with concrete waste are tested. The results show that up to 15% replacement, performance is not affected significantly, and the recipe is viable.*

Keywords: concrete waste; plastering mortars; sustainable waste management; construction and demolition waste.

1. Introduction

The construction industry is one of the most polluting ones, so interest in developing alternatives for reducing, reusing, and recycling building materials has grown in recent years. Recycling aggregates from construction and demolition waste (CDW) could reduce carbon emissions by 65% and non-renewable energy consumption by 58%. Concrete is one of the most prevalent materials in both construction and demolition and is responsible for over 8% of global carbon emissions. Production of concrete has tripled since the 1990s, from 1.10 billion tonnes to 3.27 billion tonnes, and is expected to reach 4.83 billion tonnes in 2030. (Wang, et al. 2021) In order to use this material in a sustainable way, three mortar recipes have been developed in which natural aggregates have been replaced with concrete waste in 15%, 30%, and 45% proportions. Mortars with concrete waste have been researched extensively. (Garg & Shrivastava, 2023) However, studies have shown that mortars with CDW have a lower negative environmental impact only if the CDW are sourced from a short distance and energy consumption with materials processing is reduced to the minimum. (Farinha, et al., 2021) The aim of this research is to create plastering mortars with partial replacement of aggregates with concrete, sourced from a local concrete aggregates recycling plant. The new mortars were titled using the acronym ABR, followed by the number indicating the percentage of aggregate replacement – 15% (ABR15), 30% (ABR30), 45% (ABR45). Specific determinations in fresh and hardened state, required by the standard SR EN 1015: 1-21, were performed on the CS IV reference mortar and the ABR mortars. In this paper, the results obtained from the tests in hardened state will be presented: determination of flexural and compresive strength at 3, 7, 14, 28 days, determination of adhestion to the support layer at 28 days, and modern method analyses of optical microscopy SEM.

2. Materials

Mortars are composite materials containing binder, aggregates, water, and possibly additives. The concrete was crushed and sorted in fractions at the Laboratory of the Construction Faculty in Cluj-Napoca, Romania. This is also where and the physical-mechanical determinations were performed. The cement utilised was the Portland Structo 42.5 R. The determination of the water quantity and of the plug time was performed before applying it into the recipes. The natural aggregates were sourced locally, from Gilau, Cluj. They were grinded and divided into 4 sorts: 0-0.5 mm; 0.5-1 mm; 1-2 mm; 2-4 mm. The concrete waste was sourced from a local concrete recycling plant in Cluj-Napoca. They were grinded and divided into 4 sorts of the same size as the natural aggregates. The water used for the recipes was drinkable water, sourced from the municipal supply of Cluj-Napoca. Flexural and compressive strength were determined at the four time intervals mentioned in Section 1. Flexural strength was determined using an automated machine A/0700/478, on prism shaped samples of size 160x40x40 mm in which the mortar was poured, and which were evened with the vibrating table. Compressive strength was determined by using a hydraulic press Tecnotest It, on the ruptured ends, after the flexural strength had been determined. Adherence to the support layer was determined by pouring fresh mortar on a brick, with a thickness of 10±1 mm. After 28 days, the determination was performed with a digital dynamometer Controls 58-C0215/T. The optical microscopy method - SEM is a modern method through which the morphology and topography of the mortars were observed. The device used for SEM was the JEOL JSM 5600 LV (Tokyo, Japan) electron microscope.

3. Results and Discussion

The flexural strength was determined at different intervals. All mortars corresponded to the SR EN 1015 standard requirements. At 28 days, ABR15 had a flexural strength 2% lower than CS IV, while ABR30 and ABR45 had flexural strength values 3% lower than CS IV. This signifies that replacing natural aggregates with concrete waste does not impact the flexural strength negatively, even at a level of 45% of replacement. The compressive strength was determined at the same four intervals. All mortars corresponded to the SR EN 1015 standard requirements. At 28 days, ABR15 had a flexural strength 3% lower than CS IV, ABR30 and ABR45 had flexural strength values 16% and 12% lower than CS IV. This signifies that replacing natural aggregates with concrete waste affects compressive strength negatively, decreasing it by an average of about 15% between 30-45% replacement. Adherence to the brick support layer corresponded to the SR EN 1015 standard. All samples broke in the mortar. In all the cases, the average value was lower than CS IV by 48% and 47% in the case of ABR15 and ABR30, and by 85% in the case of ABR45. This result is consistent with other studies of mortars with CDW. (Figure 1.)

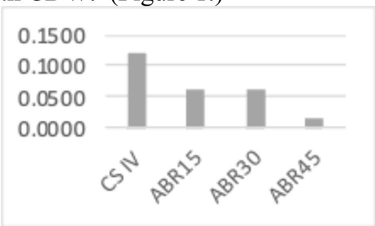

Figure 1. Average values of the adherence strength test of CS IV and ABR mortars, the four recipes are on the y axis

The SEM analysis showed the formation of etringites at the interface between the concrete waste and the cement, which is important for increasing mechanical strength. Also, the high porosity and the presence of nucleation sites was visible (Figure 2.).

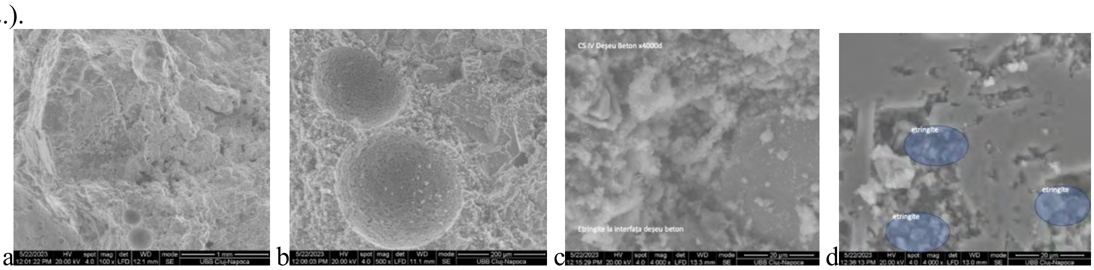

Figure 2. SEM images of mortars with concrete waste, a. x100; b. x500; c. x4000, d. x4000 with ettringite clusters marked in blue

The results indicate that replacing agregates in plastering mortars with concrete waste is viable, with performance values similar to standard mortars, and lower environmental impact, as the concrete is reused and the mortar production requires less natural resources. The results indicate that for a replacement level of up to 15%, there is no significant negative effect on mechanical strength proprieties, the mortars being very similar to CS IV. This is due to a filling effect that concrete aggregates have. Future research would be required, in order to assess the durability of the ABR mortars over a longer time. Also, improving adhesion to the support layer by adding additives could be tested, since this was the only mechanical characteristic that scored lower than the reference mortar, in all of the recipes.

4. Conclusions

Mortars in which a part of the aggregates is replaced by concrete waste are more eco-efficient than the conventional mortars, if the transport and processing required for the waste is kept to the minimum. This research confirms that plasters mortars with concrete waste have similar performance to the reference mortar. This study proves that it would be possible to introduce more circularity in construction and demolition waste management. By utilising concrete from a local recycling plant as well as aggregates of local provenance, the environmental footprint of mortars is reduced, and the lifecycle of concrete is extended by giving it a new use. A recommendation would be to create regional integrated CDW management systems, where industrial symbiosis can occur by circulating waste as resource and economic good.

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Acknowledgment: This paper was financially supported by the Project “Network of excellence in applied research and innovation for doctoral and postdoctoral programs/InoHubDoc”, project co-funded by the EU Social Fund financing agreement no. POCU/993/6/13/153437.

C70 International Conference
"Tradition and Innovation - 70 Years of Constructions in Transilvania"

Assessment of Internal Pore Structure of Self Compacting Concrete by Means of Computed Tomography and Image Analysis

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Summary: *The study presents the obtained results from the assessment of the internal pore structure of self-compacting concrete using computed tomography and image analysis. The procedure is non-invasive but requires specialized equipment. The obtained results show a non-uniform pore distribution along the height of the specimen. The total porosity is mainly influenced by small pores, with a diameter of up to 1.5 mm.*

Keywords: self-compacting concrete; pore structure; computed tomography; image analysis.

1. Introduction

The pore structure is a very important parameter that influences both strength and durability of cement based material and should be, therefore, correctly assessed. Recent studies showed that the permeability and strength of cement pastes are governed by pore size distribution rather than porosity as a total value (Gong, 2023). One of the most used methods for assessing the pore size distribution is mercury intrusion porosimetry. However, it involves careful sample preparation since it is based on high pressure injection of mercury into the sample. Even though the total porosity may be correctly assessed, the pore size distribution varied significantly compared to other methods. Another technique for assessing the pore structure of porous media is the low-field nuclear magnetic resonance relaxometry (Toma, 2023). This method exploits the difference in relaxation times between the liquid molecules filling the pores and the surface of the pores. The main advantages of this technique is that it is completely non-invasive and does not require any special sample preparation. X-ray computed tomography is also a non-destructive measurement method that can be used to directly measure the three-dimensional distribution of multi-scale pores in solid materials. It provides great convenience for the pore characterization of porous materials such as concrete (Guo, 2021; Tkac, 2022).
The pore structure of self-compacting concrete (SCC) has only been recently recognized as an influencing parameter. This was due mainly to the fact that, usually, SCC was characterized as a high-performance concrete with increased fluidity which did not need any vibration during casting (Ling, 2018). Hence, the research efforts on its pore structure came after its defining properties such as the ones mentioned above. The present paper brings its contribution to assessing the pore structure of SCC by means of computed tomography coupled with image analysis. The findings are in line with previously reported results in the scientific literature related to normal or high strength concrete.

2. Methods

The SCC mix considered in this study is shown in Table 1 (Stratulat, 2020). Cylindrical specimens, having the dimension of 100 mm × 200 mm, were cast and stored in laboratory conditions.

Table 1 Mix proportion of SCC concrete

Cement CEM I 42.5R	Water	w/c	Limestone filler	Aggregates		
				Sand 0-4 mm	4-8 mm	8-16 mm
[kg/m^3]	[liters]		[kg/m^3]	[kg/m^3]	[kg/m^3]	[kg/m^3]
320	170	0.53	160	814	203	678

Three such samples were scanned using an industrial CT in order to assess the internal pore structure. The samples were chosen randomly. The obtained 3D images were post-processed in order to determine the total internal porosity and pore size distribution. The obtained CT files were investigated by using MyVGL software. A 3D reconstruction image of the cylindrical specimen is shown in Figure 1. The transparency was adjusted so that to render evident the internal voids and pores. The 3D model of the cylinder, Figure 2a, was subsequently sliced at 10 mm intervals along its height, Figure 2b. The obtained slices were then imported into an image analysis software that enabled the identification of the voids by means of subsequent image processing techniques aimed at increasing the contrast between the volume occupied by the material and the pores, as shown in Figure 2c.

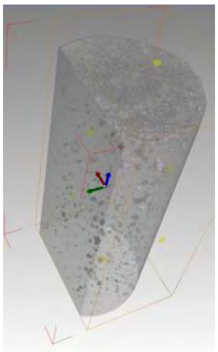
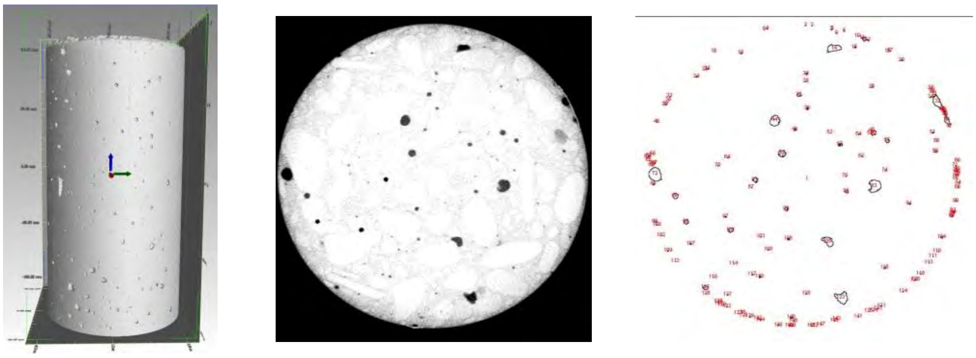


Figure 1. 3D model reconstruction



a) 3D solid model b) cross-section image c) voids / pores identification

Figure 2. Post-processing steps

3. Results and Discussions

Figure 3 presents the porosity distribution along the height of the specimen, Figure 2a, computed as the ratio between the total areas of the dark spots, Figure 2b, and the measured visible area of the cross-section. It can be observed that the distribution of the pores was not uniform along the height of the specimen.

The pores were grouped into different intervals based on their size (diameter). For an easier assessment, the pores were assumed to be spherical, although their real shape was, sometimes, significantly different, as seen in Figure 2c. The obtained results are shown in Figure 4. It can be seen that almost 90% of the identified pores had a diameter smaller than 1.5 mm, proving, once more, the good self-compacting characteristic of SCC.

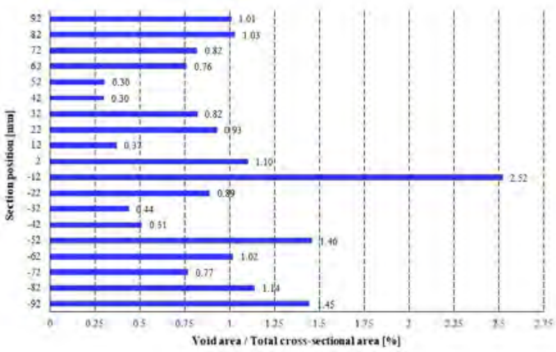


Figure 3. Distribution of porosity

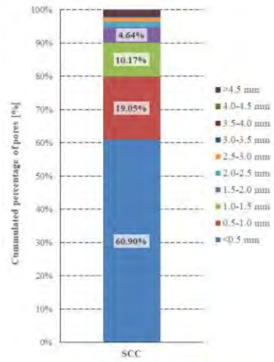


Figure 4. Distribution of pore diameters

4. Conclusions

The paper presents an alternative method to assess the internal pore structure of self-compacting concrete based on x-ray computed tomography and image analysis. The obtained results in terms of pare distribution, based on diameter, shows that 90% of the pores have a diameter less than 1.5 mm. The assessment method should be further improved for faster image analysis and pore identification. The main limitation of the study resides in the fact that it can be applied only to small sized specimens. However, it can offer a good prediction on the mechanical and durability properties of the investigated material.

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Abrasion performance of ceramic waste plaster mortars

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Summary: *Ceramic wastes are a source of waste studied by engineering scientists in order to obtain new construction materials. This extended abstract presents the possibility of using ceramic waste plaster mortars as a specific paving material. The recipes were tested by the abrasion method to determine wear resistance. The results obtained at 28 days show improved performance in terms of abrasion resistance of the waste ceramic mortars.*

Keywords: mortars; ceramic waste; abrasion.

1. Introduction

According to studies, ceramic waste has been used to produce construction materials such as concrete, mortar and concrete blocks (Shanmugam et al. 2020; Kadhim et al. 2022; Ghernouti et al. 2016). The reuse of ceramic waste in different recipes is a solution to improve the technical and economic performance of building materials as well as to improve the ecological aspect of the environment, (Riaz et al. 2019; Pinchi, 2019). As far as the present experimental program is concerned, it is proposed to use up to 35% of ceramic waste in order to obtain materials whose abrasion performance is in accordance with the standards in force. The amount of waste used in the recipes, ranges from 0 to 539.35 kg/m^3 of mortar.

2. Materials

The proposed materials are according to the CSIV standard plaster mortar recipe. The CSIV recipe is made of classic materials such as Portland cement 52.5 R, sand (sort 0-4.00) mm and water. Portland cement and sand have been partially replaced by various amounts of ceramic waste. The description of the recipes and the percentage of waste used in them is presented in Table 1.

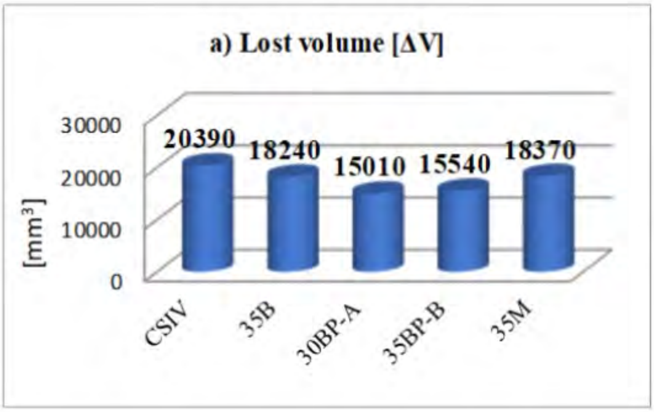
Tabel 1. Studied recipes

Recipes	Notation
Plastering mortar recipe with 0% ceramic waste	CSIV
Plaster mortar recipe with 35% brick waste as aggregate replacement.	35B
Plaster mortar recipe with 30% waste brick powder as cement substitute.	30BP-A
Plaster mortar recipe with 20% waste brick as aggregate substitute and 15% waste brick powder as cement substitute.	35BP-B(15PB+20B)
Plaster mortar recipe with 35% brick masonry waste as aggregate replacement.	35M

The experimental program presents the determination of the physical-mechanical characteristics of ceramic waste plaster mortars, in particular the wear resistance by abrasion, (ASRO, 2015). Samples of 7 cm size, kept under optimal conditions, dried at a temperature of (105 ± 5) ºC until a constant mass is obtained were tested in 16 cycles of 22 rotations, with a constantly applied force of (294 ± 3) N. The result obtained is the volume lost after abrasion testing (ΔV), (ASRO, 2015).

3. Results and Discussion

The ΔV of the waste ceramic mortar samples respectively of the CSIV standard mortar in comparison with the apparent density in hardened tested at 28 days after casting is presented in Figure 1.a) and Figure 1.b). We observe that the mortar sample whose value of apparent density is the highest, presents the lowest values of volume lost through testing.



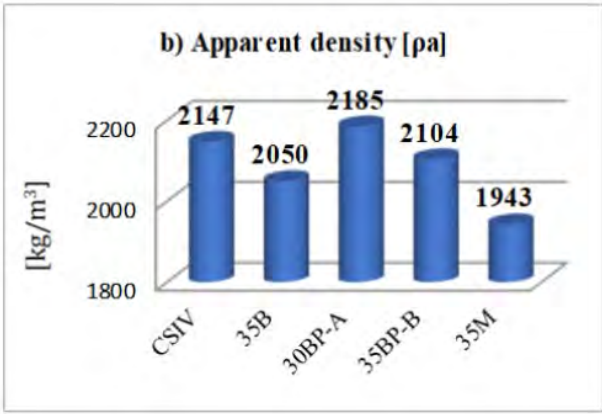


Figure 1: a) Lost volume; b) Apparent density in hardened state

From Figure 1.a) the sample with the lowest volume of material lost is the sample in which 30% brick powder (30BP-A) was used for partial replacement of 52.5R Portland cement.
In Figure 1.b) it can be seen that the lowest value of apparent density, in the case of mortars with ceramic waste, is for mortar 35M. This sample, in which brick masonry waste was used in the composition, has 23% more lost mass volume compared to 30BP-A mortar. The abrasion resistance class of the tested mortar recipes are presented in Table 2, (ASRO, 2006).

Tabel 2. The abrasion resistance class

Samples	CSIV	35B	30BP-A	35BP-B	35M
Lost volume ΔV [mm^3]	20390	18240	15010	15540	18370
Mark	F	H	I	I	H
Abrasion resistance class	1	3	4	4	3

4. Conclusions

The mortar mixtures with ceramic waste mortars showed lower material volume losses than the CSIV mortar recipe. The composition of the 35B and 35M mortar samples whose volume loss is ≤ 20000 mm^3 / 5000 mm^3, were classified as wear resistance class 3, mark H.
Also, for mortars 30BP-A and 35BP-B, whose volume loss is ≤ 18000 mm^3 / 5000 mm^3, the abrasion resistance is class 4, mark I.
According to the results, CSIV plaster mortar does not show any measured performance in terms of wear resistance classification because the volume of lost material is above the standard value of 20000 mm^3/5000mm^3. The best performing recipes in terms of abrasion resistance are recipes with waste brick powder. The 30BP-A mortar has 35% higher abrasion resistance compared to the CSIV standard mortar.

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Identification of the structure of mortars at the microscopic level based on SEM and EDX investigations

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Summary: *In order to investigate the structure of plaster mortars at a microscopic level based on electron microscopy (SEM) and X-ray diffraction (EDX) investigations, research was carried out in the Materials Science and Engineering Department for the three plaster mortar recipes: CSIV, CSIV 10C and CSIV 20P.*

Keywords: SEM and EDX investigations; plaster mortars; nanostructures; waste paints.

1. Introduction

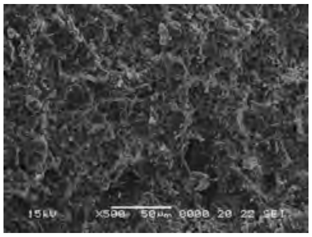
The SEM and EDX investigations, which aim to identify the structure of the materials, represent a complementary component of the applied research.
This fundamental research aims to explain the behavior over time of the physical-mechanical characteristics (especially the compressive strength and the bending tensile strength), highlighting the structural changes that occur at 3, 7 and 28 days, determined by the presence of the mineralogical compounds of the cement and especially their hydration processes that evolve over time, even after 28 days. (Siomin, 2022)
Through SEM, the identification of hydrated mineralogical compounds (ettringite, portlandite, tobermorite) is carried out, and through EDX, the chemical elements in each material will be identified .
Through both methods of investigation, the contribution brought by the presence of used paint will be highlighted for all the materials proven to be the best performers, CSIV 10C (Plaster mortar recipe in which 10% of the cement has been replaced with waste paint and CSIV 20P (Plaster mortar in which 20% of the water has been replaced by waste paint) compared to CSIV (Plaster mortar recipe).
Scanning electron microscopy (SEM) is a type of microscope that uses a focused electron beam to scan the surface of a sample/sample creating a high-resolution image. SEM technology can produce images that can display information about the composition and surface topography of a material.
Given the importance of microscopy in both science and industry, the sample can be mapped using SEM, as a multitude of necessary information about the sample can be obtained under the microscope up to a resolution of 300,000x.
The EDX detector detects X-rays that are produced by the plaster mortar when electrons interact with its surface during the SEM scan. EDX analyzes X-rays and therefore can identify all other elements in the mortar sample except for only 3 chemical elements: hydrogen, helium and lithium. The elements in the sample can be distinguished from each other because each element has its own X-ray spectrum that it emits after interacting with electrons. (Siomin, 2022)

2. Methods

Using SEM electron microscopy, detailed and magnified images of plaster mortar samples were rendered by scanning a focused electron beam.
Using an electron emitter that accelerates the microscope, electrons passing through a series of lenses and apertures create a focused beam that then interacts with the surface of a sample.
To prepare the sample, it was necessary to carbonize it with a carbon filament, using a Dentom Vacuum Desk V device.
The sample is positioned on a holder in the microscope chamber before a vacuum is created in the chamber by a series of pumps. The vacuum level depends on the type of microscope. Some microscopes are designed to operate in low vacuum environments, meaning this chamber does not need to be evacuated.
Scanning coils control the position of the electron beam above the objective lens. These coils allow the beam to be scanned over the surface of the sample and the information collected over a well-defined area. The interaction between the sample and the electron creates a number of signals in the form of secondary electrons, backscattered electrons and characteristic X-rays which are then picked up by the detectors.
At the same time, the electron microscope was equipped with an Oxford Ultim Max 65 detector to detect the X-rays that are produced by the material, respectively the plaster mortar, when electrons interact with its surface. With this detector it was possible to analyze at the nanostructure level for the identification of chemical elements. (Siomin, 2022)

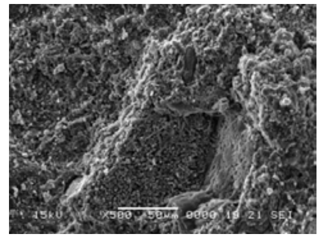
3. Results and Discussion

Using the electron microscope for SEM-type investigations, the samples were analyzed from the nanostructure point of view at different resolutions: 100x, 500x, 2,000x, 5,000x and 10,000x (Figure 1, Figure 2, Figure 3).



(Siomin, 2022)

Figure 1: Structure of CSIV plaster mortar at 500x resolution



(Siomin,2022)

Figure 2: Structure of CSIV 10Cplaster mortar at 500x resolution

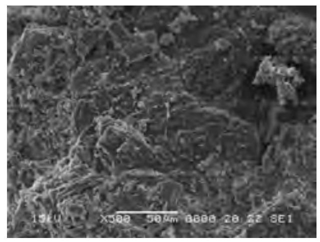


Figure 3: Structure of CSIV 20P plaster mortar at 500x resolution (Siomin, 2022)

With the help of electronic SEM microscopy, it was possible to observe that the structure in the case of the best performing mortar recipe, namely the CSIV 10C recipe, is much more compact, standardizing the structure of this mortar (Figure 2).

At the same time, in the case of the CSIV 20P plaster mortar recipe (Figure 3), a structure with alveoli is observed, being more compact than the CSIV base recipe.

Following the analysis of the samples from the point of view of X-ray diffraction (EDX), in the case of CSIV 10C and CSIV 20P plaster mortar recipes, a decrease in the chemical element Oxygen in the structure of the sample (Table 1), which indicates an increase in the compactness of the material, which implicitly leads to the waterproofing of the structure. (Siomin, 2022)

Table 1. Reduction of the amount of oxygen in the structure of CSIV 10C and CSIV 20P plaster mortar recipes compared to CSIV (Siomin, 2022)

Plaster Mortar Recipes	Oxygen percentage (%)
CSIV	44.00
CSIV 10C	35.80
CSIV 20P	34.50

4. Conclusions

Following the analysis of the structure of the plaster mortars: CSIV, CSIV 10C and CSIV 20P, based on SEM and EDX investigations, it can be observed that the structure appears more compact, and the used paint has the role of blurring, uniforming and waterproofing of the CSIV 10C mortar.

The hydration products (ettringite, portlandite, tobermorite) are identified under their characteristic shape (acicular shape, hexagonal shape and prismatic shape).

Following the analysis of the samples from the point of view of X-ray diffraction (EDX), in the case of the CSIV 10C and CSIV 20P plaster mortar recipes, a decrease in the chemical element Oxygen by 8.2% and 9.5%, respectively, is found, which which indicates an increase in the compactness of the material, which implicitly leads to the waterproofing of the structure of these plaster mortars, and the changes determined by the presence of paint do not present high values and do not cause any kind of risks. (Siomin, 2022)

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Increasing the performance of mortars with glass wastes aggregates with plasticiser additives

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Summary: *The use of waste glass in the production of plastering mortars is currently being very carefully studied. In this context, this paper proposes new plastering mortars in which the aggregate is partially replaced by glass waste up to 25%. Four types of plastering mortars have been studied, in which the improvement of the workability of the mortars by using a plasticizer additive in different percentages: 0.2%, 0.5% and 0.9% of the cement mass. After analysing the results obtained, it was found that the mortar made with waste glass and with an additive of 0.2% behaved best in terms of physical-mechanical characteristics and workability.*

Keywords: plastering mortars; additives plasticizers; workability; glass wastes; physical-mechanical characteristics.

1. Introduction

It is well known that large quantities of waste and by-products from various manufacturing processes are becoming an increasingly serious threat to the planet's ecological balance. Using them to produce new products that prove their usefulness is a partial solution to environmental problems. It is also known that for every tonne of glass recycled, more than a tonne of raw materials is conserved: 604.5 kg of sand, 197 kg of caustic soda, 197 kg of lime and 69 kg of additives, (Meyer et al., 1999) according to and (Molnar et al., 2010). The use of waste glass in Portland cement-based mortars and concretes has attracted a great deal of international interest. These wastes can replace natural resources, through reuse, either as an aggregate replacement or as a cement replacement. The use of broken glass as an aggregate in concrete has some negative properties; however, there is a practical application where glass can be used as a 100% aggregate. The main problems that arise when using glass as an aggregate in Portland cement concrete are expansion and cracking caused by glass aggregates. Among the materials made with glass could be listed the following: concrete made from processed glass, concrete glass blocks for masonry, paving products made from coloured glass concrete, decorative-architectural applications and uses, glasphalts, bitublock, foam glass granulate. In recent years, an increase in the amount of glass waste has been observed, both due to industrialisation and to rising living standards. Unfortunately, most of this glass waste is more likely to be abandoned or thrown away than recycled.

2. Materials

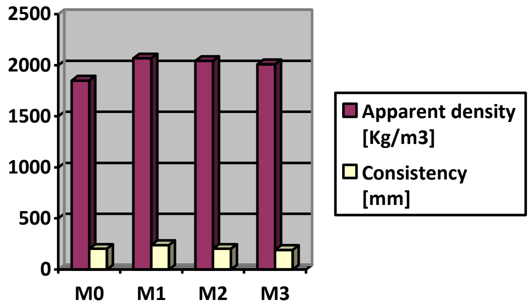
Considering these aspects, regarding the reuse of waste in the construction field, the objective of the experimental research was to make plaster mortars with waste glass, so that they keep their physical-mechanical characteristics within the limits imposed by the standards in force. A plasticiser additive was also used to improve the workability of glass mortars, as it is known that, in any form of use of glass in concrete or mortars, it reduces their workability. Four types of CS IV plaster mortar recipes (M0 – standard mortar with no glass waste and no plasticizing additive, M1 – 0.2% plasticizing additive, M2 – 0.5% plasticizing additive, M3 – 0.9% plasticizing additive), were developed in the experimental programme. In M1, M2 and M3 recipes of mortars the same proportion of 25% glass waste were kept as a sand substitute. To improve the workability of the mortar, a plasticizer was used as an additive in different percentages.
The materials used in the experimental program are the following: 1. Cement - Portland cement - CEM II B/LL 42.5, according to (SR EN 197-1, 2011); 2. Aggregates - river sand with grain size between 0/4 mm; 3. Water - drinking water from Cluj city, Romania; 4. Glass waste - coloured glass waste (the glass waste was crushed to (0-4) mm grading) (Figure 1); 5. Plasticizing additive - water-reducing plasticizing additive, polycarboxylate type (it is known that the presence, in any form, of glass in a concrete mixture reduces its workability). The additive has the trade name Sika Plastiment BV 440.

Figure 1: Glass waste

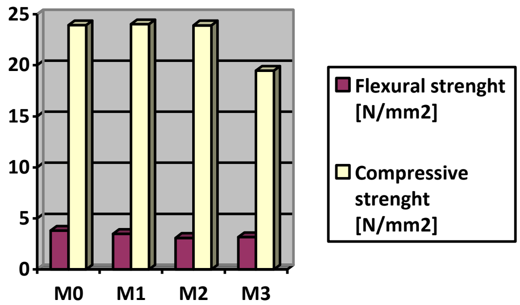
The experimental programme involved the study of glass mortars in both fresh and hardened states. In terms of the properties of the fresh mortar, the apparent density and consistency of the glass mortar were investigated. The properties of waste glass mortar in the hardened state were also studied: flexural strength and compressive strength.

3. Results and Discussion

The analyses of the physical-mechanical properties were carried out according to the standards in force. The study of the mortars in hardened state was carried out at 7, 14 and 28 days. In the graphs below are presented the results obtained on the mortars analysed both in fresh and hardened state obtained at 28 days.



a. Properties of fresh mortar



b. Properties of hardened mortars tested at 28 day

Figure 2: Average values obtained for fresh and hardened state of tested mortars (a.)(b.)

According to the graph above (Figure 2), it can be seen that standard M0 mortar has a lower density than mortars made with waste glass. Also, M1 mortar has the highest apparent density value of fresh mortar. As the percentage of plasticiser additive increases, the bulk density value decreases. Increasing the plasticizer percentage resulted in a reduction in the consistency of the waste glass mortars, thus the M3 mortar had the lowest consistency value. According to the standard, depending on the spreading value obtained, M0, M1 and M2 mortars are classified as fluid mortars (> 200 mm) and M3 type mortar is classified as plastic mortars (between 140 mm and 200 mm). The flexural strength increases with time, so the highest values are obtained at 28 days. According to the graph above it can be seen that the highest value was obtained for the standard mortar. Among the mortars made with waste glass, the highest value was obtained for mortar M1 - 3.5 N/mm2, followed by mortar M2. The compressive strength values increase with time, so the highest values are obtained for M1 mortar. From the graph it can be seen that M1, M2 and M3 have close values (Figure 2). It should be noted that the use of the plasticiser additive does not significantly influence the compressive strength values.

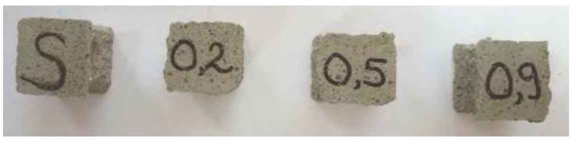


Figure 3: Standard mortar and mortars with glass wastes after tested at 28 days at compressive strength

Figure 3 shows the rupture mode of the samples tested at 28 days at compressive strength.

4. Conclusions

In terms of physical-mechanical characteristics, M1 type mortar has the best behaviour over time. The use of waste glass has led to a reduction in mechanical strength compared to standard mortar. Also, in the case of mortars made with waste glass with plasticizer additive, the compressive strengths decrease as the percentage of additive increases, thus R1 mortar with 25% waste glass has the highest value of compressive strength throughout the mortar age evolution. The study shows that all the strengths obtained for all the plaster mortaring made with waste glass and plasticiser additive, according to the results obtained, have values that comply with the current regulations, regardless of the percentage of plasticizer additive used.

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SEM and EDX study of a paper ash based mortar recipe

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Summary: *Sustainable development applied from the perspective of reducing cement used in mortar recipes by replacing it with waste proved to be an ambitious plan but with exceptional results. Cement is the predominant raw material in construction works, and its production is a major pollution factor. Paper, also, is a mass-used material, which generates huge amounts of cellulosic waste. These two issues are combined in this study which aims to create a sustainable mortar, with a low cement content, which incorporates a large amount of cellulosic waste and which has physical and mechanical properties comparable or superior to the standard recipe.*

Keywords: paper ash; cement; mortar; sustainable development; green mortar.

1. Introduction

In the context of sustainable development and the environmental problems facing humanity in the 21st century, but also with a special focus on the sustainable development objectives set for the next decade, 2020-2030, the importance of the development of alternative binders and innovative construction materials and ecological, is a duty that humanity and the research collective must assume. Therefore, the purpose of this study was to create an overall picture of the problem we face both as inhabitants of the Earth and as civil engineers.
In this study, two mortar recipes were analyzed. A standard masonry mortar recipe and a recipe in which 15% of the cement quantity was replaced with paper ash. These were analyzed in stages through the fresh mortar, such as the apparent density in the fresh state, the consistency, and the evolution of the water-cement ratio. In the hardened state, the mortar was subjected to a new series of tests, determining the hardened mortar's physical characteristics, such as the density at standard time intervals and the determination of water absorption by mass and volume. The tests to determine the mechanical characteristics significantly contribute to outlining a profile in terms of strength and durability In-depth studies with modern equipment were carried out to analyze the chemical composition and structure of the mortar at the nanometric level. SEM or Scanning electron microscope and EDX or X-ray spectroscopy technologies provided an analysis from another perspective on the studied samples. These modern techniques have supported results originally obtained through standard tests while also obtaining an insight into the physicochemical processes in the mortar mass, which underlie the evolution of the strength and durability of the hardened mortar.

2. Methods

SEM is a surface scanning technology of a material at the nanometer level. This technology uses electron beams instead of visible light like the conventional microscope so that it obtains a faithful image of the sample to be studied, with better resolutions. EDX is one of the interactions that offers information about the chemical compounds in the studied sample. Each atom has a unique number of electrons that have specific positions under normal conditions. When an exchange of electrons occurs in the studied sample, energy is released in the form of an X-ray. The energy of the generated X-ray is unique to each type of atom, it depends on the atomic number, which is a unique property of each element in the periodic table. To better understand the results offered by this technology, is useful to review the chemical composition of cement.
Portland cement contains 4 main compounds: tri-calcium silicate (Aelite), di-calcium silicate (Belite), tri-calcium aluminate (Celite) and a tetra-calcium alumina-ferrite (Felite). Hydration of cement compounds occurs in three stages. In the first phase, portlandite, or calcium hydroxide, is formed on the surface of the cement granules in contact with water. It is formed by the reaction of silicates, aelite and belite in the first hours. Belite is associated with late mechanical strengths or contributes to structure formation later in the evolution of the sample over time. Aelite, on the other hand, prematurely contributes to the creation of the structure, because it has an increased reactivity in contact with water, caused by the higher calcium content. In the second stage, through the continuous reaction of aelite and belite, lamellae of C-S-H, or hydrated calcium silicate, are formed. They occupy a volume of 50-60% of the cement paste in the solid phase. In the third phase of hydration, the pores are closed by short fibers or lamellae of hydrated calcium silicates. This extends over several days to several months and determines the complete hydration of the cement paste. This phase is characterized by the formation of ettringite and tobermorite, as a reaction of celite. Ettringite is observed in the form of long crystals, which form interconnected acicular formations. Tobermorite is identified as rounded blades/discs.

3. Results and Discussion

Observing paper ash mortar at 2000x magnification in Figure 1A, the presence of ettringite crystals is easy to spot, in extended and dense formations, unlike the standard recipe where only C-S-H and CH formations are visible – calcium hydroxide lamellae (Figure 1B). At a 10,000 times magnification, clear differences are observed. The paper ash mortar recipe (Figure 1C) reveals extended and dense formations of ettringite, closing the pores through a complex network of long and dense crystals compared to the standard recipe (Figure 1D). The effect of this type of structure formed by adding ash to the base composition is reflected in the compressive strength results.

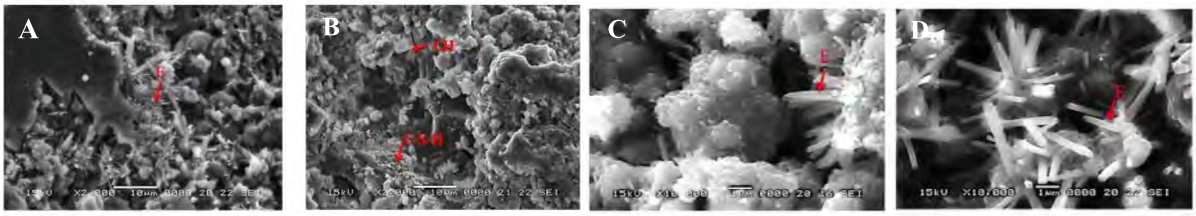

Figure 1: Crystalline formations present in the paper ash mortar - A and the standard mortar - B, at x2000 magnification and Crystalline ettringite formations present in paper ash mortar - C and standard mortar– D, at 10,000x magnification

Measurements made on images generated by SEM technology calculate an average of 1.64 microns in length of the ettringite crystals for the standard mortar. They are identified in pores but are found in relatively low numbers. In contrast, in the case of the paper ash recipe, an increase in the density of ettringite needles in the porous structure of the mortar is clearly observed. These crystalline formations, form complex nets, almost completely fill the pores, thus reducing the porosity of the material, behavior observed in previous studies of porosity. The average crystal length is 2.83 microns, 72% longer than the standard recipe. All these aspects result in superior mechanical resistance of paper ash mortars. In particular, the bending strength has a net superior result compared to the basic recipe.

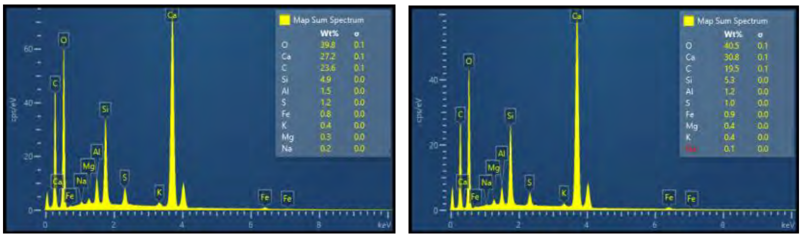

Figure 2: EDX analysis - chemical composition of the paper ash mortar - left and the standard mortar– right

Analyzing the chemical composition of the mortar with the addition of paper ash (Figure 2-right), no large differences are observed compared to the basic recipe (Figure 2-left), which indicates that the ash worked with the cement, participating in the hydration process. This proves the pozzolanic effect of the paper ash, similar to that of Portland cement. A lower oxygen content is observed in the paper ash mortar, which can be translated into reduced porosity.

4. Conclusions

The analysis of the samples through SEM and X-ray diffraction, comes to support and clarify aspects related to hardened mortar behavior under the action of mechanical tests. The evolution at the nanocrystalline level is clearly differentiated by the presence of ash in the mortar. Ash excites the formation of ettringite filaments that plug the pores, resulting in a denser and stiffer structure.

In conclusion, the entire research process can be summarized briefly and concisely by the following statement: Waste Cellulosic Ash (RPA) is an adequate substitute for cement in mortar recipes in percentages up to 15%.

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Recycling Metallurgical Wastes in the Composition of Ecological Mortars

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Summary: *Industrial pollution from metallurgical waste accumulation negatively affects the environment, impacting soil, air, and water. Effective waste management is crucial for safeguarding these environmental factors and conserving natural resources. This study examines the recycling potential of sludge generated during the chemical pickling of steel pipes and of steel mill scale to create environmentally friendly mortars. Experimental results reveal that as the proportion of mill scale in mortars increases, compressive and flexural strengths decrease compared to standard samples. Additionally, the article investigates the use of sludge as a pozzolanic material, providing a valuable solution for repurposing waste generated by steel pipe pickling.*

Keywords: waste management; metallurgical waste; sludge; steel mill scale; building materials; ecological mortar.

1. Introduction

The metallurgical sector stands as one of the foremost contributors to waste production. Within this industry, various waste types are generated, including sintering dust and sludge from sintering processes, dust and sludge from blast furnace operations, dust and sludge from steelmaking in converters, dust from electric arc furnace steel production, slags from blast furnaces and steelmaking, ceramic residues, and sludges resulting from the wet dedusting of burned gases and melting losses (Ilutiu-Varvara et al., 2022).
Annually, approximately 13.5 million tons of mill scales are produced globally (Gaballah et al., 2013).
The practice of depositing metallurgical waste in slag dumps presents the risk of contaminating all environmental elements: air, water, and soil. This method also results in the removal of land areas from circulation, degradation of soil quality, negative impacts on human health, and the permanent depletion of natural resources contained within the composition of metallurgical waste (Ilutiu-Varvara et al., 2022).
The primary objective of this study was to explore the utilization of sludge as a potential additive to ordinary Portland cement, with the aim of creating an environmentally sustainable cement. This approach leverages the waste generated from the pickling of steel pipes, which, until now, had amassed significant volumes without a designated purpose.
The paper's objectives encompass also several aspects: establishing the mortars recipes by determining the optimal proportion of steel mill scale to replace sand in mortar compositions; identifying a method for recycling steel mill scales in mortar compositions to promote sustainability in manufacturing; conducting physical and mechanical assessments of the mortars; creating new building materials through the recycling of industrial waste from the steelmaking sector; and enhancing the management of industrial waste within the steelmaking industry (Ilutiu-Varvara et al., 2020).

2. Materials

The materials used for the experimental part were Portland cement CEM I 52.5 R, sand (2 mm), steel mill scales derived from the steel rolling process, sludge generated during the chemical pickling of steel pipes and water. Of all the materials utilized, only the steel mill scales and the sludge resulting from the chemical pickling of steel pipes demanded specific preparation. The other materials were acquired commercially and did not necessitate any specific preparation.
The steel mill scales and the sludge samples were collected from a metallurgical facility located in Salaj County, Romania, renowned for producing various domestic steel brands. This facility specializes in manufacturing cold-drawn pipes from hot-rolled tubes, which undergo a sulfuric acid pickling process before final production. The waste produced during pickling is subjected to heavy metal precipitation, flocculation, sedimentation, and deposition. Each of these stages occurs in separate containers and necessitates several pH adjustments, along with the addition of coagulants and lime. This intricate process results in the substantial generation of sludge (Aciu et al., 2021).
To ensure representative sampling across the entire production process, weekly samples were collected over twelve weeks, subsequently combined to create a uniform sludge sample.
To prepare the steel mill scale and the sludge samples, they were first dried in an oven at 105ºC and subsequently ground using ball milling to achieve a fine granulation.
Following grinding, the samples were sieved using a 0.125 mm mesh.
The experimental studies were performed in the Civil Engineering Faculty's Building Materials Laboratory from the Technical University of Cluj-Napoca.
The chemical characterization of the steel mill scale samples can be found in the work authored by Ilutiu-Varvara et al.

(2017). The sand in the mortar compositions was replaced with steel mill scales in varying proportions for three different recipes: the first adhering to the standard mortar recipe, and the other two substituting steel mill scales for sand at 10% and 20%, respectively (Ilutiu-Varvara et al., 2020).
The chemical analysis of the sludge samples arising from the chemical pickling of steel pipes is detailed in the study conducted by Aciu et al. (2021). In the composition of standard mortar cement is replaced by 10%, 20%, 30% and 40% steel sludge.

3. Results and Discussion

Following the study performed on the production of ecological mortars based on sludge resulting from the chemical pickling of steel pipes, it can be seen that the sludge particles have a significantly larger specific surface area, nearly three times that of cement particles (Aciu et al., 2021).
The chemical composition of steel sludge contains approximately 11 times more amorphous phase compared to cement. Cement is primarily composed of 79.2% calcium silicate, while steel sludge lacks silica, preventing it from being a pozzolanic material. Steel sludge fails to meet the ASTM C618 (2019) requirement for pozzolanic materials, with a sum of oxides ($SiO_2 + Al_2O_3 + Fe_2O_3$) amounting to only 17.22% (Aciu et al., 2021).
Compressive strength in mortars prepared with sludge as a cement substitute tends to increase over time, even after 28 days. A higher proportion of cement replacement by sludge results in decreased compressive strength, with the mixture in which 10% of the cement was replaced exhibiting the highest strength. Consequently, it can be concluded that the steel sludge studied lacks pozzolanic properties (Aciu et al., 2021).
The steel sludge could be recycled for the creation of red ceramics such as bricks and roofing tiles (Vieira et al., 2006), or as a substitute aggregate in the production of mortar or concrete (Alwaeli et al., 2020). This approach not only decreases the need for extracting natural resources but also addresses waste disposal challenges, ultimately helping to protect the environment.
The study conducted on the development of ecological mortars based on steel mill scales showed that the optimal proportion of these waste materials in the mortar recipe is around maximum 10% (Ilutiu-Varvara et al., 2020).
Increasing the proportion of mill scale, substituting sand, results in lower compressive and flexural strengths compared to standard samples. The steel mill scale-replaced sand mortars exhibit reduced density (10%) and a significant decrease in the water absorption coefficient (20%) after 28 days, a favourable characteristic in humid environments. Recycling oily mill scale in mortar compositions contributes to sustainable manufacturing through raw material conservation (Ilutiu-Varvara et al., 2020).

4. Conclusions

This research underscores the potential for resolving significant waste management issues through recycling, leading to the creation of new construction materials. It establishes the technological steps for mortar production, outlining the optimal preparation of waste materials and formulating eco-friendly mortar recipes via waste recycling. The experimental findings demonstrate the feasibility of using metallurgical waste, specifically steel mill scales, in mortar compositions. Increasing the proportion of mill scale, substituting sand, results in lower compressive and flexural strengths compared to standard samples. The studied steel sludge lacks pozzolanic properties so it cannot be used as an addition to ordinary Portland cement to create a more sustainable and durable cementitious material.

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Recycling of construction and demolition waste as a substitute for cement in obtaining mortars

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Summary: *Construction and demolition waste represents to the half of total amount of municipal solid waste generated in European countries, occupy a large space in the landfill and cause the environmental pollution which has become a serious problem in the world. The development of recycling and reusing routes of the construction and demolition waste is an attractive direction that is accompanied by the reduction of the pollution problems. The purpose of this study is to prepare new products using the construction and demolition waste by the incorporation into glasses by a new, simple, low cost and environmentally friendly method and to investigate their mechanical properties in view to applications in the field of origin.*

Keywords: construction waste; recycling; glasses; iron; ash; strength.

1. Introduction

Today construction and demolition waste are serious problem in the world because they represent the largest amount of municipal solid waste, are illegally dumped in urban areas, nearby rivers, roads and other unprepared places having a substantial environmental and economic impact that leads to financial problems for the community and public administration. In recent years, governments have approved new policies on waste and recycling responsibilities. As a result, the situation in big cities is changing with the implementation of recycling facilities because it reduces the consumption of natural resources, but currently only a small part of this waste is recovered. [1] Th main directive of the European Union regarding the waste management consists of the development of recycling technologies and new products which will be reduced the volume of the construction and demolition waste. [2] The construction and demolition waste are consisted of mortar, ceramics, concrete, rocks, natural gravel, masonry, sand, wood, soil, etc. and depend on the characteristics of each construction. [2] The aim of this study is to obtain new products for the construction industry from construction and demolition waste. The mechanical strengths of the prepared composites will be also determined.

2. Methods

The broken and crushed glass waste was placed in a porcelain capsule and was mixed with a NaOH solution at 50ºC. The capsule with the mixture was placed on a magnetic stirrer. After 15 minutes a HCl solution was added and after that construction and demolition waste. The used waste are iron, cash iron, lead or ash powders. The temperature was gradually raised to 100 ºC for 10 minutes and then, at 300ºC (depending on the nature of the C&D waste).

A standard mortar recipe was made by the substitution of a percentage of 2.5% composite in the cement mass. The mechanical characteristics of the composite - mortar were studied by the determination of tensile strength by bending and determination of compression strength. The results were compared with the results of a standard mortar recipe subjected to the same determinations.

The values were obtained by testing the 40x40x160 mm prisms with the Fruhling-Michaelis apparatus in the case of determining the resistance to stretching by bending and the hydraulic press to determine the resistance to compression. For the compression testing of the mortars, the remaining ends of the specimens left after they were broken during the bending test were used. The formula used to calculate the strength was [3-8]:

$$f_{yd} = 3/2 \times F \times l/a^3 \ [N/mm^2], \quad f_{ck} = F/A \ [N/mm^2],$$

where:
fyd-bending strength,
F-force applied by the apparatus to break the prism,
l-distance between the bearings of the apparatus,
a-length of side of the prism,
fck-compressive strength,
F-force applied by the apparatus to break the prism,
A-area of prism section.

3. Results and Discussion

The average values of bending strength of the standard mortar and the composite - mortar (obtained by the replacing a percentage of 2.5% composite in the cement mass) are shown in Figure 1a. Our data show that the resistance is not affected by the doping with composite and the difference at 28 days is imperceptibly.

In the case of compressive strength, it can be seen in Figure 1b that the strength can increase for the mortar prepared with the composite containing glass and iron in the first 3 days compared to the standard mortar recipe. However, at 28 days the two mortars do not have significant differences in strength values.

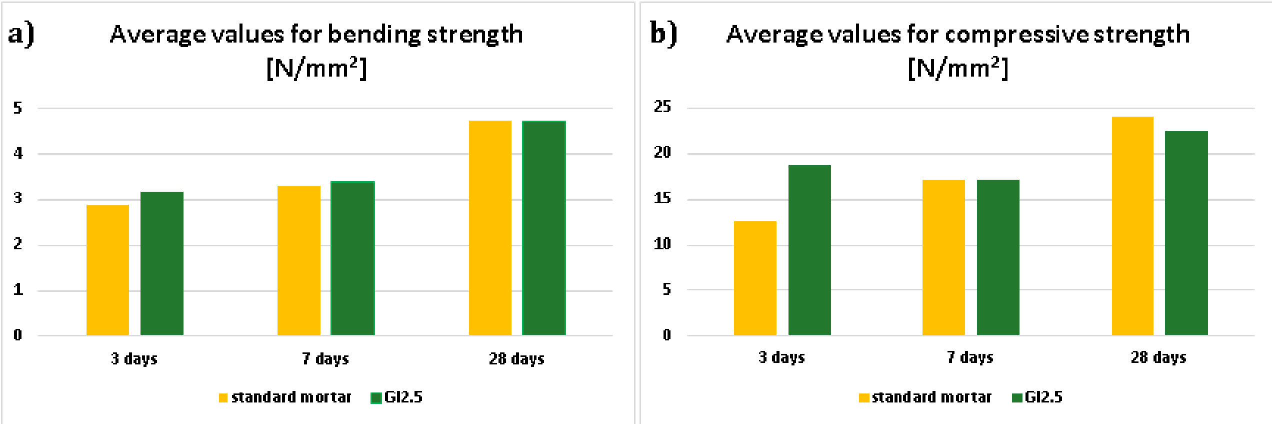

Figure 1: a) Bending strength results, b) Compressive strength results.

According to SR EN 1015, the minimum average value was 4.5 – 7 N / mm^2, and by analysing the results, the compressive strength was higher for all the samples studied and continued to attain higher values until the 28th day, when the composite - mortars were attained 22.53 N / mm^2. These results are encouraging for the development of new composite - mortars in which waste could replace a part of the cement.[3], [4]

4. Conclusions

Some composite – mortar recipes were prepared and tested to obtain their resistance values. The analysis of the bending and compressive strengths data indicates that the partial replacement of the cement with 2.5 % composite provided from construction and demolition waste does not significantly affect the physical and mechanical properties of the mortar. In a realistic and economic approximation, the reusing of construction and demolition waste as new raw materials in the field of origin would reduce the construction price and have an important impact in the society.

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Restoration methods for preserving the load-bearing structures of Romanesque monuments

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Summary: *The preservation of the Romanesque heritage in Transylvania requires a detailed assessment and minimal structural intervention, underlining the need for public awareness to protect these structures from historical threats. The establishment of a comprehensive guide to the conservation of Romanesque monuments, including theoretical studies, deterioration analysis and intervention strategies based on case studies, is crucial for the preservation and rehabilitation of these structures in Romania. This study analyses rock samples from Romanesque churches, identifying the source of the volcanic tuff and providing insights into the properties of building stone.*

Keywords: restoration; Romanesque monuments; load-bearing structures; mortar; X-ray diffraction.

1. Introduction

The conservation of the cultural heritage, particularly the Romanesque structures in Transylvania, requires comprehensive diagnosis and minimal structural intervention, emphasising the importance of raising awareness among residents and tourists in order to safeguard their historical, aesthetic, and architectural significance in the face of threats posed by events such as those of 1914-1989. It is essential to establish a guide to the protection of Romanesque monuments, which should include a comprehensive theoretical study, classification, and analysis of the causes of deterioration, focusing on architectural and structural aspects and the stages of intervention through case studies.

Protecting Romania's Romanesque heritage involves maintenance and structural rehabilitation interventions led by experts to address both the physical and moral wear of the constructions and their components, emphasizing material quality and adaptation to current operational conditions (Akcay, C., Sayin, B., Yildizlar, B., 2017; Apostolopoulou M., et al., 2017; Drdácký M., et al., 2003).

Professor Szabo Ballint (Szabó B., et al, 2003) identifies key negative influences on Romanesque structures, including issues with floor slabs, insufficient infrastructure rigidity, asymmetries in plan rigidities, low load-bearing capacity of support structures, incorrect conformation regarding diaphragm-type elements, and reduced seismic conformation. Degradation in Romanesque structures, caused by factors like water infiltration, lack of treatments for wood and metal, and variations in humidity, necessitates a holistic approach considering material characteristics, construction procedures, and historical context (Maravelaki P.-N., Bakolas A., Moropoulou A., 2003; Mertens G., Elsen J., 2006; Moropoulou A.; Bakolas A.; Bisbikou K., 1195; Olaru D., Mitroi C., 2001; Secco M., et al., 2019; Sitzia F., 2019).

This study focuses on the durability, behaviour over time, and material composition of medieval constructions, particularly load-bearing structures in Romanesque architecture. Chemical analyses, mineralogical studies, and physical-mechanical assessments of masonry mortars from two Romanian Romanesque churches in Cluj County reveal insights into historical production and provide crucial data for restoration efforts.

2. Methods

The research on the design and analysis of Romanesque architectural elements, in particular stone and masonry mortar, was divided into several phases, including the analysis of the materials of the load-bearing structure and the study of proposed materials for innovative mortar compositions. The experimental phase involved the characterisation of the preliminary performance of micro-concrete, covering aspects such as density, water absorption, mechanical properties, self-healing capacity, and mineralogical structure using X-ray diffraction.

3. Results and Discussion

The research involved X-ray diffraction analysis of rock and mortar samples (Figure 1 a and b) from Romanesque churches in Nima and Orman, Cluj County. The results revealed minerals typically found in volcanic tuff, such as zeolites, muscovite, clinoptilolite, quartz and calcite. By identifying a nearby quarry as the source of the volcanic tuff used in the construction, the study shed light on the mineralogical composition and potential physical-mechanical properties of the building stones.

The results of the analysis of the mortar paste, consisting of cement and lime paste, show remarkable trends: as the proportion of Portland cement (CEM I 42.5 R) in the paste increases and the lime paste content decreases, both the initial and final setting times of the paste show a significant increase. In addition, the amount of water required for the paste mix increased as the amount of Portland cement increased and the amount of lime paste decreased, indicating a direct relationship between these components and the water requirements of the mixes. The results provide insight into the complex interplay of these materials in the mortar paste, which is crucial to understanding its setting characteristics.

a)

b)

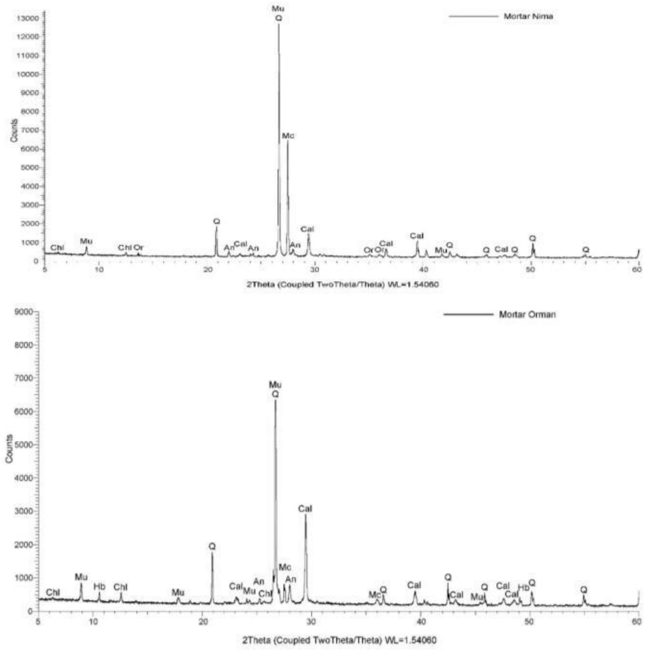

Figure 1 The X-ray diffraction spectrum of the masonry mortar samples from the church of a) Nima and b) Orman, Cluj-Napoca.

4. Conclusions

The analysis reveals an 80% compositional compatibility or similarity among the studied samples. Notable differences include the presence of synthetic rutile (titanium white) in the mortar sampled from the Nima church, while calcite is found in varying quantities in both mortar and plaster samples. Portlandite, a product of lime hydration, is present in different proportions across the samples, and the conclusion suggests a complex but interconnected mineralogical composition.

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C70 International Conference
"Tradition and Innovation - 70 Years of Constructions in Transilvania"

Concrete with E-Waste as a substitute for aggregate

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Summary: *The electronics industry is undergoing a significant expansion process, thereby generating a massive amount of waste. The main goal of this work is to identify a viable solution that contributes to reducing the impact on the environment, both in the electronics industry and in the construction industry. The valorization of electronic waste as aggregate replacement in concrete in this study can lead to the decrease in the use of natural resources and to the reduction of the electronic waste that remains unrecycled, a major issue in the electronics industry.*

Keywords: Concrete; Electronic Waste; Pollution; Compression Strength; Splitting Tensile Strength.

1. Introduction

Pollution represents the contamination of the surrounding environment with various materials that affect the quality of life, health, or the natural functions of ecosystems. It occurs when nature cannot decompose certain materials, and the process of contamination can range from a few days to several thousand years. Environmental pollution began to manifest itself with the onset of the industrial revolution in the 19th century and has since continued to grow, becoming a significant public health issue in our modern days (Riet, 2021). The electronic industry is currently experiencing rapid expansion, recording the most significant growth within the industrial sector, and generating substantial quantities of electronic waste globally. In the search for alternatives for reusing electronic waste, a viable option to replace traditional aggregates in various applications was taken into consideration. This study focused on using electronic waste as an alternative to traditional aggregates by replacing 10% of the aggregate size range of 4 – 8 mm in a C16/20 class concrete mix. The research goal was to evaluate the mechanical properties and durability of the modified concrete mix (concrete with e-waste content) compared to the standard concrete mix (control) through laboratory tests. The current study is part of a more extensive research program (Georgeoi, 2023).

2. Materials

In this study, the following steps were followed: material selection, batching of materials according to the designed concrete composition, casting of specimens, and testing of the specimens at the age of 14 days to obtain comparative data.

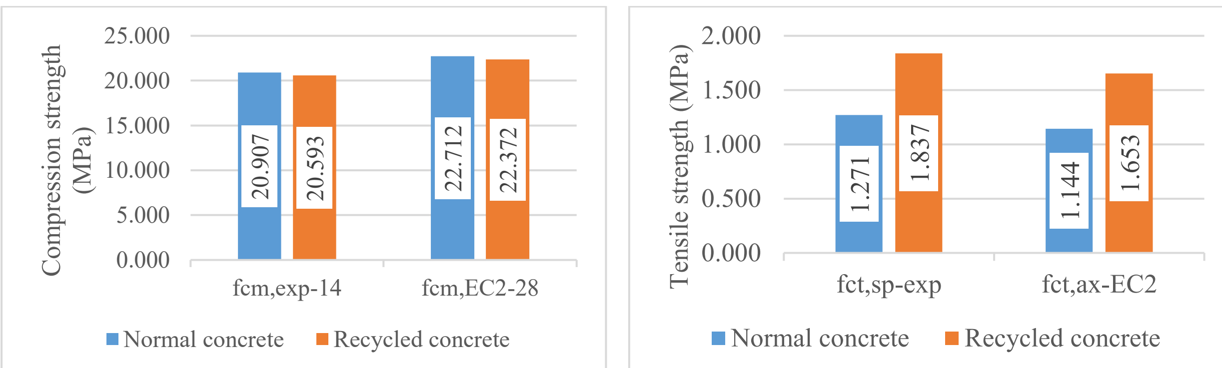
(a) (b) (c)
Figure 1: (a) GRP 6.90 mm in diameter; (b) specimens after casting; (c) compression test set-up

For the normal concrete composition, we used CEM I 52.5R cement in amount of 360 kg/m^3, river aggregate sizes 0 - 4 mm in amount of 844.20 kg/m^3, 4 - 8 mm in amount of 281.40 kg/m^3, and 8 - 16 mm in amount of 750.40 kg/m^3, water 165.60 kg/m^3 and superplasticizer in quantity of 3.60 kg/m^3. For the recycled concrete with E-Waste, we used the same amounts of components, except for the 4 - 8 mm aggregates of which 28.14 kg/m^3 were replaced with Glass Reinforced Plastic (GRP) cable pieces measuring approximately 30 - 40 mm. The rigid cables waste was provided by Prysmian Group, Romania in 500 mm length bars. Their cross section can be seen in Figure 1(a). The specimens consisted of 3 cubes of 150 × 150 × 150 mm for compression testing, and 3 cubes of 100 × 100 × 100 mm for splitting tensile testing. The same specimens were prepared for the recycled concrete and for the normal concrete, as can be seen in Figure 1(b). After demolding, the specimens were cured in water until the age of testing. Figure 1(c) presents the set-up test for compression.

3. Results and Discussion

To assess the compressive strength of concrete at t = 28 days, the following equation was used: $f_{cm}(t) = \beta_{cc}(t) \times f_{cm}$ ASRO (2004), whereas $\beta_{cc}(t) = \exp\{s[1 - (28 / t)^{1/2}]\}$ is equal to 0.9205, $f_{cm}(t)$ is the compression strength at a certain time t in MPa, and f_{cm} is the compression strength at 28 days. The results show that the replacement of the aggregates did not have any significant effect on the compression strength of the recycled concrete as seen in Figure 2(a).

The splitting tensile strength was assessed according to ASRO (2010), as follows: $f_{ct,sp} = (2 \times F) / (\pi \times L \times d)$, whereas F is the applied force at failure in N and L and d are the specimen cross section dimensions in mm. The estimated axial strength is $0.9 \times f_{ct,sp}$, according to ASRO (2004). The presence of the GRP cables as aggregates confers the concrete higher splitting tensile strengths with as much as 45% compared to the normal concrete as seen in Figure 2(b).



(a) (b)

Figure 2: (a) Compression strength; (b) Tensile strength

Furthermore, the experimental values in both compression and tensing are all in the close range of ±1 MPa, which proves a good predictability of the concrete composition and clear benefits for using E-Waste as a replacement of aggregates. However, this hypothesis will be verified in future research by testing more specimens and applying statistical means for a more accurate prediction of the concrete's mechanical properties.

4. Conclusions

The use of Glass Reinforced Plastic (GRP) as a partial replacement for traditional aggregates in concrete composition offers several advantages, including reducing the demand on natural resources and the potential for recycling electronic waste. The results of this study show that although the compression strength of both normal concrete and recycled concrete is in the same close range, an increase in the tensile splitting strength can be observed in concrete with GRP content. In terms of producing the concrete, the advantages of incorporating GRP cables are the ease of dosing and mixing. The disadvantages include the need for difficult and labor-intensive cutting of the cable to a size of 30-40 mm. For large quantities of concrete, the process of cutting must be done at industrial level, ultimately raising the costs for recycling. So far, recycled concrete with GRP cables content proves to be suitable for multiple applications in the construction industry, such as industrial and residential floors, slabs on the ground or various types of foundations.

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Preliminary aspects of a research on decarbonization by means of carbon dioxide storage in concrete and implementation of artificial intelligence in the full process

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Summary: *The EU construction sector must prioritize environmentally friendly products with minimal carbon dioxide emissions. In Romania, CO_2 emissions peaked at 289.3 million tonnes in 1989 and hit a low of 74.14 million tonnes in 2020, covering the period from 1980 to 2021. Concrete, a globally prevalent building material, is a major contributor to carbon dioxide emissions, and the study explores reducing emissions by utilizing the natural carbonation process to store significant amounts of carbon dioxide in concrete structures.*

Keywords: carbonation; plain concrete; capture of carbon dioxide; storage of carbon dioxide; environmental conservation.

1. Introduction

The concept of decarbonization, tracing its origins to the industrialization era, has gained prominence due to its role in addressing global warming. While promising long-term profitability, achieving decarbonization presents a challenge requiring substantial short-term investments. The European Union's construction sector prioritizes environmentally friendly products, aiming to minimize carbon dioxide emissions. Romania's CO_2 emissions peaked at 289.3 million tons in 1989, reached a low of 74.14 million tons in 2020, with a slight increase to 79.33 million tons in 2021, indicating a stable plateau around 75-80 million tons annually (Li, et al., 2022; Hason, et al., 2020; Bakhyar, et al., 2017; Matar and Elshurafa, 2017; Poudyal and Adhikari, 2021). The carbonation of reinforced concrete structures, triggered by atmospheric carbon dioxide entering pores, reduces their service life by transforming calcium hydroxide into calcium carbonate. This chemical process decreases concrete alkalinity, lowering the pH and initiating corrosion of reinforcement. The reaction of hydrated calcium silicate with CO_2 further forms calcium carbonate, influencing the material's durability. (Grubb et al., 2017).
Concrete carbonation rate increases with exposure environment temperature and humidity and is largely dependent on the mix composition (e.g., water/cement ratio, admixtures such as fly ash and slag). To enhance the durability of reinforced concrete elements and combat carbonation, recommendations include using low-permeability concrete mixes, ensuring sufficient cover layer thickness for steel rebars, and incorporating corrosion inhibitors. Innovatively, leveraging the natural carbonation process to store more carbon in concrete has emerged as a promising avenue for reducing the overall carbon footprint in construction, presenting a swiftly implementable opportunity following brief but intensive research. (Hamada et al., 2022; Chen et al., 2018; Wang, et al., 2018; Huang, et al., 2019; Guo, et al., 2019; Liu, et al., 2020; Li, et al., 2018; Zhan, Poon, and Shi, 2013, Zhan, et al., 2016).

2. Methods

The specificity of the research topic determined the choice of scientific methods. The research focused on the reduction of CO_2 emissions by using the natural carbonation process to store big quantities of carbon dioxide in concrete structures, utilizing analytical, comparative, and forecasting methods. Analytical methods assessed the process itself and the currently available technologies, comparative analysis evaluated the current use of such techniques in Romania, and forecasting provided insights into potential use of such techniques for further research.

3. Results and Discussion

Research by major building materials manufacturers aims to reduce CO_2 emissions and increase the durability of structures made from normal concrete. Approaches identified include the use of CO_2 for the curing process of precast concrete elements immediately after production and the incorporation of CO_2 into the concrete mix during the production of precast elements (Liu et al., 2022). In ordinary concrete production, managing carbonation involves accelerated exposure for faster hardening and surface treatment for enhanced durability and resistance in precast elements.
The carbonation of concrete with CO_2 in autoclaves involves several stages: ensuring the enclosure's tightness through visual and technological inspection, introducing gaseous CO_2 to initiate carbonation, monitoring environmental conditions during the process, and evaluating precast concrete elements post-carbonation for quality control. The duration of carbonation varies based on the product's size and desired carbonation level, lasting from hours to days, with subsequent testing and examination to assess depth and uniformity. The technological process of carbonation for precast

concrete considers three levels: low for aesthetic effects (2-5% CO_2), medium to enhance physical and mechanical properties (5-10% CO_2), and high for specific pH and improved chemical resistance (10-20% CO_2). The active research in CO_2 capture and storage in concrete structures emphasizes the need to enhance the efficiency of capture technologies, particularly in Portland cement production, and explore innovative approaches for sustainability. Efficient CO_2 storage in concrete demands optimized carbonation processes and comprehensive life cycle assessments for environmental comparison and decision-making.

Collaborative research aims to leverage AI in diverse research aspects, including design optimization, quality control, and supply chain optimization, along with exploring novel applications for composite reinforced concrete elements, presenting a promising avenue for reducing CO_2 emissions. The goal is to make substantial progress in the field of carbon dioxide storage in concrete structures and contribute to mitigating the environmental impact of CO_2 emissions.

4. Conclusions

Research on capturing and storing CO_2 in concrete is crucial for mitigating climate change, particularly in industries like cement production. This research seeks to make concrete more environmentally friendly, offering advancements that contribute to sustainable and low-carbon construction practices. The potential of concrete as a carbon sink, along with the economic and regulatory incentives for sustainability, drives innovation with broader applications in various sectors, addressing the global challenge of reducing carbon emissions.

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Asphalt mixtures used in base layers using steel slag waste

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Summary: *The production of new construction materials is often closely related to the desire to recycle waste generated from production processes. This involves using recycled materials or by products resulting from production to create new construction materials. The field of road infrastructure development entails the extensive and diverse use of construction materials. Consequently, through waste recycling, it is possible to substitute a substantial volume of construction materials while concurrently reducing a commensurate volume of waste. In the context of this research, the optimal variant will be determined through mathematical modelling of the primary physico-mechanical characteristics of asphalt mixtures used in base layers, which are constructed using steel slag aggregates.*

Keywords: aggregates; recycling, steel industry; asphalt mixtures; Civil Engineering.

1. Introduction

The steel industry is one of the industrial sectors characterized by substantial consumption of natural resources and energy, while also being a waste generator. Due to their potential for valorization, these wastes can be transformed into byproducts. Therefore, the management of steel industry waste is one of the significant issues in domestic environmental protection policies (Iriciuc, 2019)
The utilization of aggregates obtained from steel slag waste in asphalt mixtures is of paramount importance from both an economic and ecological perspective. These aggregates represent a valuable recyclable resource that helps reduce dependence on virgin materials and mitigate adverse effects on the surrounding environment.
From an economic standpoint, the use of steel slag as aggregates in asphalt offers significant advantages. It reduces the costs associated with the extraction and transportation of natural materials, leading to substantial savings. Additionally, it assists in the management and reduction of industrial waste deposits, potentially decreasing disposal costs.
From an ecological perspective, recycling steel slag in asphalt mixtures reduces the negative impact on the environment. It contributes to the conservation of natural resources by avoiding additional extraction of materials from nature and lowering carbon dioxide emissions during material production and transportation (Iriciuc et al. 2023).
The utilization of steel slag aggregates in asphalt mixtures represents a sustainable solution with significant economic and environmental benefits, promoting environmentally responsible construction practices.
That is why, together with researchers in the field, they have constantly tried to develop new cost-effective methods of both construction and maintenance works to improve structural sustainability as much as possible (Scutaru et al. 2019).

2. Laboratory tests

The aggregates used in the preparation of asphalt mixtures are natural and artificial aggregates according to ASRO SR EN 13043-2003.The following sorts of aggregates were required to produce these asphalt mix recipes:

- crushed slag aggregates 0-4 mm
- crushed slag aggregates 4-8 mm
- crushed slag aggregates 8-16 mm
- crushed slag aggregates 16-22.4 mm
- natural sand 0-4 mm
- filler

The test sieves used for determining the grain size of natural and artificial aggregates comply with ASRO SR EN 933-2-2020.
Taking into account the granularity of each aggregate, as determined through laboratory sieving, the aggregate percentages for the production of AC 22.4 base 50/70 asphalt recipes with steel slag aggregates have been established, according to table 1.

Table 1. Determination of the mineralogical composition of asphalt mix AC 22.4 base 50/70 with steel slag aggregates

Aggregates	%	Retained fraction (%)						
		22.4	16	8	4	2	0.125	0.063
slag aggregates 16 – 22.4	26.00	0.39	20.15	5.42	0.03	0.00	0.02	0.00
slag aggregates 8 – 16	25.00	0.00	0.70	19.78	4.48	0.03	0.00	0.00
slag aggregates 4 – 8	23.00	0.00	0.00	2.05	16.51	3.59	0.60	0.09
slag aggregates 0 – 4	14.00	0.00	0.00	0.00	0.13	3.85	6.74	0.23
natural sand 0 - 4	8.00	0.00	0.00	0.00	0.07	2.20	5.06	0.06
filler	4.00	0.00	0.00	0.00	0.00	0.00	0.31	2.87
total retained	100.00	0.39	20.85	27.24	21.21	9.66	12.73	3.25
total passing		99.61	78.76	51.52	30.31	20.64	7.91	4.66
limits	min	90	70	38	27	19	3	2
	max	100	86	58	43	34	8	5

Following the determination of the particle size distribution of aggregates obtained from steel slag, four asphalt mixture recipes were developed with the following bitumen percentages: 4.00%, 4.25%, 4.50%, and 4.75%. For each specific bitumen dosage, six separate Marshall specimens were fabricated. These specimens underwent a series of physico-mechanical tests, including the determination of bulk density, water absorption, Marshall stability, and flow characteristics. The determination of the asphalt mixture bulk density was achieved by measuring the apparent volumetric mass of the specimen after compaction. To assess water absorption, the quantity of water absorbed by the accessible voids on the exterior of a specimen from the asphalt mixture was determined, while it was kept in water under vacuum conditions using a vacuum desiccator. The determination of Marshall stability, flow, and the S/I ratio was carried out with the assistance of a Marshall press. All these measurements were conducted in the road laboratory of the Faculty of Civil Engineering and Installations in Iași. The test results were then subjected to a mathematical analysis using CurveExpert Professional software to determine the optimal bitumen percentage for each formulation.

3. Mathematical interpretation of the results

Interpreting the results obtained from the determination of physico-mechanical characteristics using mathematical functions, the following observations were made:

1. The maximum value of bulk density corresponds to a bitumen dosage of 4.5%.
2. It is found that with the increase in the percentage of bitumen, the water absorption value decreases. The influence of steelmaking aggregates in relation to steelmaking slag aggregates on water absorption is lower, and for bitumen dosages higher than 4.5%, water absorption is insignificant (Iriciuc et al. 2023).
3. The optimal range for the bitumen percentage required to achieve Marshall Stability values in accordance with ASRO SR EN 12697-34:2020 falls between 4.25% and 4.50%, as observed in road engineering terminology.
4. The optimum range of the percentage of bitumen required to obtain Marshall flow values according to ASRO SR EN 12697-34:2020 is between 4.25% and 4.50%.
5. the optimum range of bitumen percentage required to obtain S/I Marshall Ratio values according to ASRO SR EN 12697-34:2020 is between 4.50% and 4.75%.

4. Conclusions

In asphalt mixtures containing steel slag aggregates, the upper limit of bitumen content is influenced by the degree of coverage of these aggregates by bitumen. This coverage degree depends on how effectively bitumen adheres to these aggregates. To enhance the adhesion of bitumen to these aggregates, modified bitumens can be employed.

The advantage of modelling results using mathematical analysis programs is significant, allowing for the optimization of bitumen content based on the predictability provided by polynomial functions, both in calculations and graphical representations. The use of steel slag aggregates brings numerous technical and economic benefits, benefiting both road operators and material manufacturers. These advantages include the diversification of road construction materials, cost reduction through shorter transportation distances and local material utilization.

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Comparative study on asphalt mixtures prepared with Reclaimed Asphalt Pavement

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Summary: *The purpose of this study is to comparatively analyse the laboratory performance of four AC16 asphalt mixtures: a reference mix, as well as three mixes prepared with variable RAP content: 10 %, 20 % and 30 %, respectively. The basic physio-mechanical parameters (water absorption, stability, flow and density), as well as dynamic tests, were performed on all mixes in a certified laboratory. Controlling the recycled materials' homogeneity and careful monitoring their reusage can lead to asphalt mixtures with optimal properties and extended lifespan.*

Keywords: reclaimed asphalt pavement; recycling; asphalt mixture; laboratory tests.

1. Introduction

Reclaimed asphalt pavement (RAP) is recycled asphalt that has been removed from an existing roadway. The existing asphalt pavement is collected and then transported to a dedicated facility, where it is crushed in order to be used either as new aggregate in hot mix asphalt or as base or subbase granular material.
Road recycling technologies have successfully been used across the world, proving its competitive advantage in various road building conditions.
The technical state of a road is highly influenced by several main factors, including: traffic, climate conditions, road building technologies and materials, as well as maintenance quality and frequency. Asphalt degradation accelerates after a few years of service, however resurfacing or recycling works usually prove to be a technically and economically feasible method to extend the pavement lifespan.
These procedures also represent an environmentally-friendly alternative to building new road structures from scratch. Millions of tons of asphalt pavement are reclaimed every year. Being recyclable materials, they can be reused. In a circular economy, recyclable materials such as RAP can be injected into the economy as secondary raw materials. Furthermore, because of increasing material and technological costs in the last few years, as well as increasing environmental awareness, RAP has gained extended popularity and has been frequently used as aggregate and binder substitute in recycled asphalt pavements, as well as in other civil engineering applications.
The purpose of this study is to comparatively analyse the laboratory performance of four AC16 asphalt mixtures: a reference mix, as well as three mixes prepared with variable RAP content: 10 %, 20 % and 30 %, respectively. The basic physio-mechanical parameters, as well as dynamic tests, were performed on all mixes in a certified laboratory (Alexan and Cadar, 2022).

2. Materials

Asphalt mixture design is a procedure which consists of selecting an appropriate mix of natural aggregates, bitumen and other materials (where applicable), in order to obtain an appropriate composite material, which would exhibit acceptable performance and durability in service.
The mixes that were prepared in tested in this study (Alexan and Cadar, 2022) are presented in Table 1:

Table 1. Tested asphalt mixtures

Mix #	Denomination	RAP %
0 (reference)	AC16 rul 50/70	-
1	AC16 rul 50/70	10
2	AC16 rul 50/70	20
3	AC16 rul 50/70	30

The RAP used in this study was recovered using a Bomag BM1200/35 equipment. The RAP mixture was transported to the recycling station, where it was stored for no more than 20 days, at external temperatures not exceeding 25 °C (Alexan and Cadar, 2022). Afterwards, it was crushed to a maximum grain size of 16 mm (Figure 1).
RAP bitumen softening point was determined to be 83.4 °C, exceeding the 80 °C threshold (DD509, 2003), thus the RAP was considered a natural aggregate mix, ignoring the existing bitumen content.
RAP grain size was analysed before establishing the recycled mixtures' recipes.

The reference mix was prepared using natural fine and coarse aggregates, as well as a 50/70 bitumen with a dosage of 5.7 % (SR EN 13108-1, AND 605). Mix #1, containing 10 % RAP, was prepared by adding the RAP content instead of coarse aggregates (4/8 and 8/16 mm). Fine aggregate content remained unchanged (Alexan and Cadar, 2022).

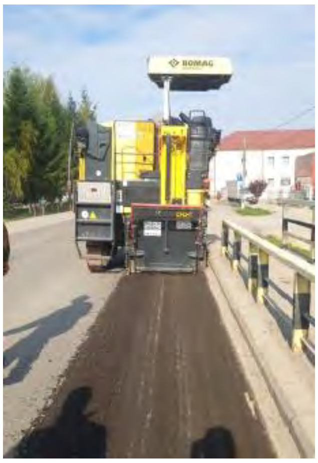

Figure 1: Reclaiming asphalt pavement and sample preparation

In the case of mixes #2 and #3, the fine aggregate content was also reduced, since the RAP content increased significantly.

3. Results and Discussion

Relevant tests were performed on all designed asphalt mixtures in a certified laboratory.
Tests on both the reference mix (#0), as well as on the other three mixtures, included: water absorption, stability, flow and density.
The flow test results on mixtures including RAP have shown that only mix #1 (with 10 % RAP content) falls between the allowable flow values (AND 605, 2016). Compared to the reference mix, adding 10 % RAP led to a slightly less dense material, with similar physio-mechanical parameters.
In the case of mix #2 (20 % RAP), flow tests provided the only unsatisfactory values, whereas for mix #3 (30 % RAP) water absorption and stability/flow ratio fell below acceptable values.
Considering these preliminary results, only the reference mix and mix #1 were then subjected to dynamic tests.
Void content for mix #1 was 37 % of the reference mix void content (1.0 % compared to 2.7 %). Furthermore, stiffness modulus fell 18 %, from 7 922 MPa (reference mix #0) to 6 521 MPa (mix #1). Adding RAP also led to a significant decrease in the resistance to permanent deformation, however the obtained values were acceptable (Alexan and Cadar, 2022).

4. Conclusions

A comparative study on four AC16 asphalt mixtures prepared using variable RAP dosage has confirmed that recyclable materials such as RAP can be injected into the economy as secondary raw materials.. Although the tests performed on the reference mix provided the best results and more balanced values, it was confirmed that controlling the recycled materials’ homogeneity and careful monitoring their reusage can lead to asphalt mixtures with optimal properties and extended lifespan. Furthermore, because of increasing material and technological costs in the last few years, as well as increasing environmental awareness, RAP has gained extended popularity and has been frequently used as aggregate and binder substitute in recycled asphalt pavements.

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Using GGBS and ACBFS blast furnace slag in road concrete mixture design

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Summary: *Incorporating blast furnace slag into road concrete can be a cost-effective way to completely remove byproducts from the cast iron production process. This work focuses on determining optimal proportions of granulated and ground slag (GGBS) as a supplementary cementitious material (SCM) and air-cooled slag aggregate (ACBFS) as a replacement for natural sand, so that the 90-day curing performance of road concrete is similar to that of control concrete. The results of this research represent important environmental benefits that comply with European circular economy regulations.*

Keywords: environmentally friendly road concrete; granulated and ground blast furnace slag (GGBS); air cooled blast furnace slag (ACBFS) aggregate; durability; hydration activity index (HAI).

1. Introduction

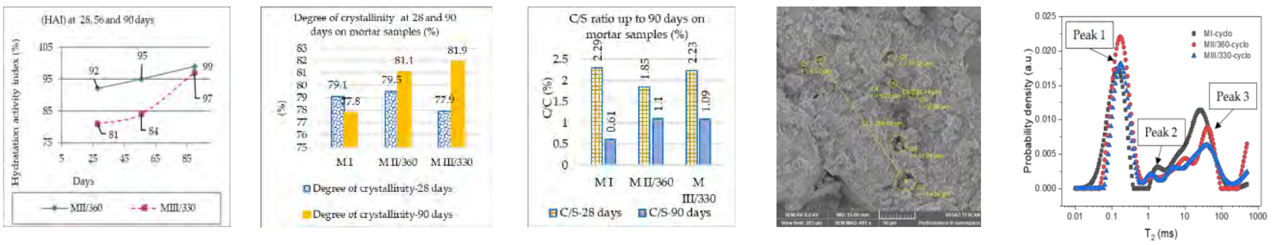
Especially in recent years, the replacement of cement with GGBS slag and natural sand with ACBFS aggregates in the concrete composition has been studied by many researchers. But concrete compositions with high proportions of incorporated blast furnace slag affect the mechanical and durability properties through the interaction with cement and water depending on the curing times. The aim of this work is to determine the optimal proportions of slag incorporated into road concrete and to show the potential role of GGBS and ACBFS slag in the composition of road concrete after a longer curing period (after 90 days). In addition, to minimize the costs associated with grinding GGBS, the hydration activity index (HAI) of GGBS slag, surface morphology and mineral components were analysed by X-ray diffraction of mortar mixtures, scanning electron microscopy (SEM) and energy dispersion spectrometry (EDX), and porosity by nuclear magnetic resonance imaging (NMR).

2. Materials

In this experiment, a mixture of standard mortar M I with 100% Portland cement and two mortar mixtures with 50% GGBS M II/360 and M III/330 were prepared, the specific surface area of which differed from 360 m^2/kg and 330 m^2/kg, respectively. We then proceeded with three road concrete mixes, one reference (S0/0) and two in which 15% GGBS blast furnace slag with a specific surface area equal to cement and 25% or 50% ACBFS slag aggregates crushed to a size (0/4) mm (S15/25 and S15/50) were constantly incorporated.

3. Results and Discussion

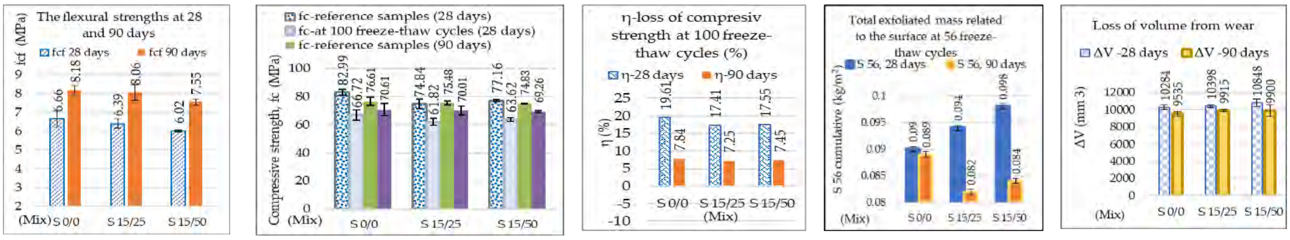
At 90 days of age, the HAI index (Figure 1(a)) for mortar with 50% GGBS reached a value equivalent to strength class 100 according to ASTM C989.The results show that replacing cement with 50%GGBS increases crystallinity at 90 days while the degree of crystallinity decreases for standard mortar (Figure 1(b)), depending on the degree of reaction of the binder Differences in the C/S ratio can be seen in Figure 1(c), the values differentiate hydrated calcium silicate (C-S-H) into different phases. The presence of (C-S-H) in slag samples at 90 days contributed significantly to increasing the compressive strength, which was close to the strength of the standard mortar.



(a) (b) (c) (d) (e)

Figure 1: (a) the HAI index; (b) Degree of crystallinity; (c) C/S ratio for mortar samples; (d) SEM images of M III/330; (e) distribution of T_2 relaxation times in cyclohexane-saturated samples at 90 days.

The pores (radii > several m) in Figure 1(d) slag mortar measured by SEM have larger dimensions and are at larger distances compared to the standard sample. The lower capillary porosity in slag samples compared to the standard sample is confirmed by MRI measurements, the area (Peak 3) in Figure 1(e) is smaller than the area of the standard MI mortar.
The flexural strengths of slag concrete S 15/25 and S 15/50 reached values of >5.5 MPa, at the age of 28 days corresponding to the requirements for the very heavy traffic class BcR 5.0 (Figure 2(a)).



(a) (b) (c) (d) (e)

Figure 2: (a) Bending strength; (b) Compressive strength; (c) Loss of compressive strength at 100 freeze-thaw cycles; (d) Total exfoliated mass at 56 freeze-dezght cycles; (e) Loss of volume from mechanical wear

The loss of compressive strength Figure 2(c) and loss of exfoliated mass after repeated freeze-thaw cycles (Figure 2(d)) is lower for slag concrete compared to reference concrete. The volume loss due to wear showed slight increase, especially for S15/50 slag concrete (Figure 2(e)). The higher water absorption coefficient of slag aggregates compared to natural sand reduced the performance of the S15/50 composite. The results obtained in Figure 3(a) show that slag concretes exhibit increased resistance to chlorine ion penetration and similar behaviour against carbonation-induced corrosion compared to conventional concrete (Figure 3(b)).

(a) (b)

Figure 3: (a) Penetration depth Xd and migration coefficient Dx (10-12 m^2/s) of chlorine ions; (b) Carbonation progress one hour after spraying phenolphthalein solution.

The results of this research are presented in detail in scientific articles published by the authors Nicula et al. (2023).

4. Conclusions

The hydration reactions of the GGBS slag as a cement substitute continued over a longer curing period, therefore the reference age of 90 days is the correct option for slag concretes. The study confirms similar performance when the substitution of Portland cement is 15% GGBS and natural sand is 25%ACBFS. In addition, the use of GGBS slag with a specific surface area equivalent to that of Portland cement results in environmentally friendly road concrete with low production costs.

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SECTION III

ARCHITECTURE,

BUILDINGS

and

BUILDING SERVICES

A cultural approach to sustainability, Space – structure and the urban artifact

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Summary: *This paper aims to raise questions regarding the present trend of discussing sustainability of the built environment primarily from a technical point of view. As the consumption of energy becomes a more acute problem this paper takes clues from the theory of urban artifact developed by Aldo Rossi, linking the cultural value of a building to its embodied carbon footprint.*

Keywords: programmatic indeterminacy; space-structure; urban artifact; sustainable design; sustainability and culture.

1. Background and research questions

Nowadays it seems sustainability in the built environment becomes more and more a technical issue disregarding the impact cultural aspects inseparable from construction such as history and type had. Lechner (2015) states sustainable design can be arranged in a three-tier approach each with a particular contribution to energy savings. The first tier corresponds to heat retention, heat rejection, heat avoidance and can be responsible for minimizing as much as 60% of energy consumption while the building is in use. The second tier of passive systems can further reduce energy consumption by up to 20%. The third tier of the mechanical equipment is responsible for the energy consumption reduction of 5%. The point Lechner makes it that by simple designing a construction considering the location, orientation, form, colour, insulation, construction materials, air tightness (first tier) and the integration of passive solar or cooling systems (second tier) without mechanical equipment as much as 80% of energy consumption can be reduced compared to a conventional building.
The construction industry is responsible for around 48% of energy consumption worldwide. While 40% of the energy is consumed when operating the buildings, the remaining 8% are consumed in the construction process and roughly represent the embodied carbon footprint of the building.
Following the economic model developed by Georgescu-Roegen (1971) which states that keeping materials in a system as long as possible is a way to slow the degradation of natural resources, Bo Andersen (2019) links this strategy with the antique theme of durability as presented by Vitruvius. The longevity of buildings becomes in this manner an embedded quality with a great potential for further reducing the energy consumption generated by the built environment.
To ensure the durability of a building we must also address how durability manifested by the structural qualities can foster different uses over a long period of time by allowing programmatic adaptability. This theme is further developed by presenting two recent projects by Studio Muoto: The Innovation Hall in Montpellier (2017-2022) and Atelier Médicis (2022) and connecting them to Aldo Rossi’s theory of urban artifact.

2. A space – structure urban artifact

The studied projects present a similar strategy of producing space, both rooted in the space-structure archetype. Space-structure is omnipresent in the history of architecture, apart from the Baroque period. Its general characteristic is the indissociability between the structure and the image of the produced space with structure becoming the main element that defines space (von Meiss, 2015). Both the Innovation Hall in Montpellier and the Atelier Médicis host very dynamic programs (one being a business center and the other an artist workshop and performance space), with unforeseeable future requirements so they naturally must be adaptable, but the originality of these projects resides not in the object but rather in using typology as the animating force of design. The projects present us not with a spatialization of function but rather with a structure that becomes a frame for functional dynamics. Indeed, to evaluate the potential of a construction to become an urban artifact the form must be independent of the function, allowing for multiple functions over time (Rossi, 1982).
The Innovation Hall in Montpellier adapts its plan following the shape of the parcel available, proposing a trapeze construction with one side forming a small curvature, giving the façade a sense of richness and marking the main entrance in the building (figure 1). This gesture is important as the arrangement of the interior is not disturbed by it, leaving on all sides the space near the façade free. The building consists of a large box with a series of inner cores of different sizes and functions arranged as a chessboard pattern. This arrangement defines open, generous noble spaces and enclosed serving spaces at the interior of the cores. This typology allows for flexibility and adaptability by permitting free spaces to merge and accommodate a function. The resulting spaces are always pulsating allowing for spaces of different scales, height, deepness and different light qualities.
The Atelier Médicis project is organized following the same type and principles but with a very different result in terms

of the atmosphere of the space produced. At the interior of the building four areas are distinguishable (figure 2). The building has free spaces around the inner facades and two large cores which accommodate circulation and services. Between those cores there is another free space, the main stage. By arranging the building in such a manner, the stage can expand using all the central space or a smaller area. At the same time if program requires so, the structure allows for the middle of the upper and lower enclosed cores to enlarge the middle area. These layouts allow for a *flexible* stage for human events and the shifting urban dynamics which are translated as architectural dynamics using the fixed and free spaces of this typology (Rossi, 1982).

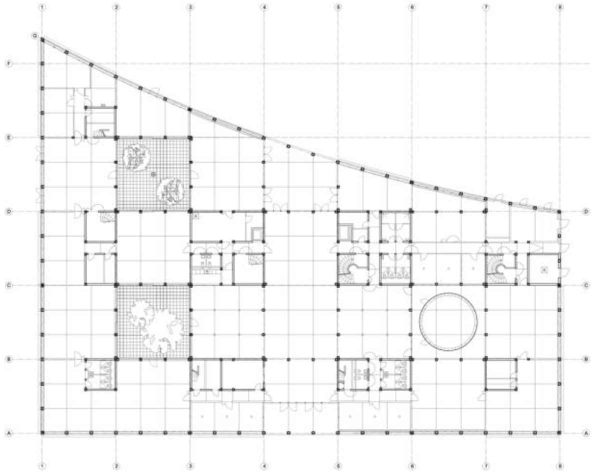

Figure 1: Innovation Hall in Montpellier plan, Studio Muoto

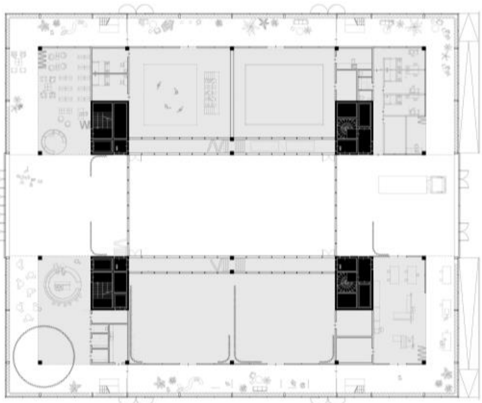

Figure 2: Atelier Médicis plan, Studio Muoto

3. Conclusions

Starting from these two projects and their potential of becoming urban artifacts it can be argued that the principle of producing space having the origin in the space-structure model illustrates a type of construction that allows for a prearranged framework that has unforeseeable spatial qualities enforced by the qualities of the structure (Rossi, 1982). The value of this step forward in developing the space-structure archetype lays in its relationship with history, a dialogue across the centuries within the discipline of architecture.

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Exploring the underground architecture of coal mines

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Summary: *The current subject matter constitutes a fundamental component of an outgoing research thesis focused on comprehending urban evolution influenced by the coal mining sector, assessing the consequences of deindustrialization and ultimately establishing measures for urban regeneration. This paper essentially represents an architectural examination of coal mines from the enterprise of Anina. The following sections present the main vertical and horizontal mining structures, along with their facilities for water management, mineral conveyance as well as the ventilation and lighting systems used underground.*

Keywords: coal mine; shaft, ore; architecture; constructions.

1. Introduction

Exploring the mining area within the city of Anina poses a challenge due to its economic and industrial development. A review of bibliographic sources indicates a lack of detailed information regarding specific mining architecture. However, several books containing relevant insights, such as those written by local author Cristian Liviu Mosoroceanu, are available online. The majority of his writings are a chronological record of significant events in Anina’s history and explain various economic, social and demographic aspects. Another noteworthy author is Rudolf Graf, a museum curator and scientific researcher, who highlights the substantial progress of the industry within the Banat area under StEG’s management since 1855 to 1920. To enhance a deeper comprehension of the built underground, geodesy and construction books accessible in university libraries were also consulted.

2. Analysis of deep coal mines from Steierdorf-Anina

The initial coal mining operations in Steierdorf-Anina were officially documented in 1792 along the areas defined by Porcarului and Ponorului Valleys, managed under private ownership. Following their successful outcomes, additional mining fields began to emerge. Between the years 1815 and 1850, significant efforts were directed towards the construction of the underground levels and particularly focusing on the development of “Breuner”, “Kollowrath”, “Friedrich” and “Kübeck” shafts. Starting from 1851, work commenced on the shafts named “Thinnfeld I”,“Reitz” and “Eugen”. Progress continued in the StEG period, with the excavation of the “Colonie” shaft in Steierdorf, concurrent with the construction of the “Gustav” shaft, also known as “Pit II” in Anina. From 1867 onward, additional shafts such as “Thinnfeld II”,“Uterisch”,“Hildegarde” and “Ponor” were established. Excavation activities at “Pit I” the most renowned in Anina, started in 1874 [1]. Simultaneously, a multitude of underground levels were built. Some of them were expanded and extended to ensure the interconnection between mines.

Based on the information provided above, the mining area of Anina has experienced a substantial underground building process untill the communist period. The entire work of coal extraction was coordinated by a mining enterprise, which comprise several exploitation mines. This involves a series of activities from land excavation, preparation and extraction phases, using strategically positioned shafts adapted to the thickness of the ore layer. The system guarantees ore extraction at the surface, complemented by underground constructions and installations. Upon closer examination, the underground mining constructions can be classified by two primary types: vertical and horizontal.

Vertical constructions encompass the main shafts for transportation while the auxiliary ones are designated for ventilation and water drainage, but also serves as inclines and declines for miners. These shafts typically exhibit a rectangular cross-sectional profile. The downcast shafts have access at the top and, in the lowest point, has a basin for water storage. Meanwhile, the blind shaft serves as a link between the working levels, facilitating the air flow.

Horizontal constructions encompass tunnels, blind galleries, directional or transversal passages, ventilation routes, transport corridor and others. Many of these features have an inclined floor to facilitate the transport of ore to the shaft and the drainage of water into the storage basin. The cross-sectional shape of these spaces is influenced by the load pressure and the locally available materials. Those made of wood have a trapezoidal shape, while the concrete ones exhibit a domed section and the metal structures have an arched shape. Transport tunnels are equipped with rails. The older ones are using wooden rails and the modernized ones are using steel rails. Both types were used for the transportation of ore via wagons. Technical spaces are designed for the engines, including the electrical station and the pumping equipment located next to the shaft. Additionally, in the entrance area near the shaft, its common to find a waiting room for miners and also a medical point.

Horizontal constructions also feature longwall faces with panels that separate the spaces for safety purposes.[2]

The initial natural **ventilation system** of the mines relied on access points at varying elevations. Subsequently, mechanical ventilation, also referred to as artificial air circulation, was implemented with the use of “Focher” fans and

ventilation doors made of wood that required manual operations. Following the year of 1968, ventilation tubes and pneumatically operated doors controlled from distance were introduced. All the equipment was manufactured at the Central Workshop in Anina [3].
One of the priorities in mining operations is underground **water management**. The initial strategy involved guiding water through drainage channels leading to accumulation basins. A substantial enhancement took place when steam engines were introduced to operate pumping systems. The advent of electrical motors enabled the installation of pumps underground, reducing the risk of flooding [4].
Concerning to sources of **illumination**, in the early years of mining operations there were frequent underground explosions and a significant loss of life attributed to the use of open-flame lamps. It wasn’t until the 19th century that safety mining lamps were introduced in Anina. Under the management of StEG, the most commonly used safety lamp in Anina’s mines was the ”Müeseler lamp” [5]. Furthermore, in 1884 was introduced the ”Wolf lamp”, fuelled by gasoline and equipped with a magnetic ignition and shutdown system. In the 20th century, the ”Cereisen” igniter with a flint stone gained popularity. During the UDR management era, ”Concordia safety lamp” with accumulators was also implemented, significantly reducing the risk of underground explosions. Afterwards, during the Ceausescu dictatorship, imports were prohibited and the use of “Elba” electric lamps manufactured in Timișoara, was mandated.

3. Current stage

In the final years of the communist era, the Anina mining enterprise lacked the financial resources needed to invest in the maintenance of its technical infrastructure. Eventually, this fact led to the rise of the deindustrialization phenomenon and the subsequent decay of the mining city.
In 2006, the government suspended the activity of Anina’s last mine due to a fatal underground explosion. The unemployment rate has surged to alarming levels, leading to depopulation. Thereafter, the entire city has experienced major deterioration, including its underground constructions.
Nowadays, the local authorities are exerting substantial efforts to preserve what remains of Anina’s cultural and industrial heritage because these structures and systems provide invaluable insights into the area’s mining history.

4. Conclusions

The coal mining operations in Steierdorf-Anina experienced a significant growth of underground infrastructure over the years, particularly during the periods of StEG and UDR management. This extensive industrial development had a profound impact on the city, leading to its gradual transformation into a bustling urban center. As industries increased, more people were drawn to the city in search of employment opportunities. But unfortunately, in the post-industrial era, almost everything has disappeared.
These findings remain open for further exploration in the outgoing research thesis.

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Buildings of the Future: Challenges or Opportunities?

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Summary: *The buildings of the future accentuate a growing field where both significant challenges and innovative opportunities loom. As society faces climate change, accelerated urbanization and continuing energy requirements, future buildings must adapt to become more sustainable, energy efficient and functional. The buildings of the future have the potential to revolutionize the way we interact with the environment, the economy and the way we live. This paper examines how the buildings of the future can influence these three crucial aspects of our society.*

Keywords: buildings; sustainability; energy efficiency.

1. Introduction

Buildings are an essential part of our daily lives and the environment. In the modern era, we are witnessing a rapid change in technology and our construction priorities. One of the biggest challenges we face today is climate change and environmental degradation. Buildings play a significant role in this problem, as they consume a significant amount of resources and energy.
The buildings of the future have the potential to bring significant benefits to the economy through their energy efficiency, reduction of carbon emissions, stimulation of innovation and technological development, growth of the construction industry, development of the real estate market and reduction of long-term costs. The constructions of the future are likely to bring significant changes in the way we live and the way we interact with the environment. In recent decades, technology development and sustainability concerns have led to innovations in construction, leading to the emergence of breakthrough concepts and technologies.

2. Buildings: challenges or opportunities?

Attitudes towards buildings can vary depending on context and perspective. They can pose both challenges and opportunities, depending on how they are managed and used.
Buildings are the basic pillars of our society, providing spaces for living, working and recreation. But as we face global challenges such as climate change, rapid urbanization, and economic change, buildings must evolve to meet our increasingly complex needs (Bungau C. et al. 2022). Building the future is a solution to these challenges, with the potential to revolutionise the way we interact with the environment, the economy and the way we live.
The buildings of the future must be designed with a major focus on sustainability and energy efficiency (Brezhnrod K.N. et.al. 2017). They require the integration of advanced technologies such as solar panels, energy storage systems and efficient insulation to reduce carbon footprint and energy consumption (Marjaba G E, et al. 2016). Moreover, they carry the concept of 'passive buildings', which are designed to use natural resources, such as sunlight and natural ventilation, to minimise energy consumption.
The buildings of the future equipped with intelligent systems will effectively manage and control all aspects of their use and maintenance (de Wilde P. 2023). Through artificial intelligence (AI), these buildings will be able to adjust temperature, lighting and energy consumption according to users' preferences and needs, thus helping to save energy and resources. AI will also facilitate security in building management, helping to increase comfort and efficiency.
In the context of sustainable development and emerging technologies, these constructions bring with them both significant challenges and opportunities, as presented in Table 1:

Table 1. Challenges and opportunities

Challenges	*Opportunities*
Durability	Long-term cost efficiency
Energy efficiency	More efficient use of space
Emerging technologies	Improved quality of life
Climate change adaptation	Innovation and economic development

The challenges faced in building the buildings of the future are significant, but with the right technology and innovation, they can be overcome. One of the biggest challenges in building them is achieving sustainability (Stanca S. 2023). With climate change and the depletion of natural resources, buildings need to become more energy efficient and environmentally friendly. This involves the use of sustainable materials, the implementation of renewable energy systems and the optimisation of energy efficiency throughout the building.
In a world where energy consumption is a major issue, the buildings of the future must become much more energy

efficient (Amasyali K. et.al. 2016). Smart technologies such as building automation systems and sensors can help monitor and optimize energy consumption in real time (Cao X. et. Al. 2016). Better insulation, energy-efficient windows and more efficient air conditioning systems must also be used to reduce energy consumption.

The life cycle of buildings, from construction to demolition, must also be considered to minimise environmental impact. (Hansen R.N. et. al. 2023). These buildings must be designed to be recycled and reused instead of abandoned or costly demolition.

The buildings of the future represent an unprecedented opportunity to create the built environment of the coming decades. With a focus on energy efficiency, sustainability, advanced technology and flexibility, these buildings will bring significant benefits for both the environment and people. With the support of continuous research and development, the construction of the future that contributes to a better and more sustainable future for all can be achieved.

3. Conclusions

The buildings of the future are oriented towards the good of people and the planet, also considering the concerns for future generations. Therefore, the materials used for construction must be environmentally friendly. The ways of heating and cooling these buildings must also be environmentally friendly. The main purpose of these buildings is to improve people's quality of life, adapt to technological progress and become smart buildings, capable of providing a healthy and comfortable environment for daily activities.

They must meet the performance requirements required for the functions they perform without harming the environment through excessive consumption of resources or emissions of pollutants.

As for humanity's current concerns about the constructions of the present and future, they are closely linked to climate change and the need to adopt a sustainable approach. Regardless of the nature of the construction, both now and in the future, the main priority must be given to sustainability, financial efficiency and minimizing environmental impact.

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Prefabricated construction for sustainability and environmental benefits

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Summary: *The industrialization of construction processes is the answer to the current requirements for the built environment development, whereby a balance is required between reduced execution time, an optimal cost per building and high-quality standards. The use of prefabricated construction can have a number of sustainability benefits: to avoid the use of non-renewable resources of row materials and energy, and to assure an efficient environmental protection.*

Keywords: industrialization; prefabricated; sustainability; environmental.

1. Introduction

The construction industry contributes to more than 10% of the world economy, and, at the same time, this industry is the largest consumer of material resources (40-60% of the total extraction of raw materials), water, and energy (around 40% of energy consumption). It also accounts for up to 39% of total CO_2 emissions in the environment and approximately 35% of the total waste stream. Thus, building development should be accompanied by careful considerations to reduce all negative effects on the environment and society (Forbes.com, 2018; Uai-initiatives.eu).

In the construction industry, it is necessary to reach a balance between the reduced lifting time of the building, decreasing its total cost, and ensuring the quality of the construction on its life cycle. These requirements can be fulfilled through the industrialization of the construction process, which involves standardization and modular prefabrication, with numerous benefits in the context of the implementation of the principles of sustainability and the protection of nature.

Modular constructions, also called prefabricated constructions, are executed with most of the building members made in factories and transported to the construction site to be installed. Through this method, the construction is characterized by a shorter site schedule, better quality control, and a reduced impact on the environment.

2. Methods

The use of prefabricated elements is one of the most important achievements in the industrialization of construction. The concept of prefabricated constructions is not new, being used in many countries, including Romania, and there are also, in some EU countries, government strategies that impose a minimum percentage limit for the share of constructions made in the prefabricated system out of the total constructions made. The basic principles of prefabricated buildings are based on a high degree of repetition in construction works and lead to a series of advantages, which are: the fast speed of construction works, reduced cost of building, high quality of construction, consumption efficiency of raw materials and the reduction of their costs, implemented energy efficiency targets by using renewable energy resources, increases in productivity and safety labour due to the mechanization of the technological process, eliminating the influence of climatic conditions to on-site construction activities, and eliminating waste and the possibility of using recyclable waste in a controlled context.

The total building cost is the sum of the direct cost of setting up the building and the costs related to its maintenance and decommissioning. The main components that influence the total cost are represented by the materials and execution technologies used; therefore, they are the key to reduction. In the construction materials industry, the solutions are numerous and varied - from the gradual innovation of traditional materials for obtaining superior performances, to the generation of new combinations of materials with additional multifunctional characteristics, up to modern innovative materials with completely new performances (European Commission, 2015). Also, a wide variety of new tools and equipment is promoted on the market, with the digital space and robotics playing a central role in the construction industry. These current trends, met in any industry, open up new possibilities, and the prefabricated constructions is the result of all innovation processes, being the driver to meet the requirements of sustainability, the environmental protection, and the communities' health. Thereby, efficiency in the use of materials is reached, and, on average, a reduction of up to 90% of the waste resulting from the construction process is estimated. Due to the industrialization in the manufacturing process of modular elements, the construction execution time is reduced by approximately 50% and the cost of a prefabricated construction is reduced by up to 20% in comparison to an in-situ executed building (Europa.EU). The graph from Figure 1 shows the increase in construction speed, such that the building duration in the case of the prefabricated method is almost 50% less than the duration of traditional method works schedule.

Major cost components are determined during the design phase, and, at this stage, it is still relatively easy to make changes without additional costs, as shown in Figure 2. The prefabricated method ensures the achievement of all its advantages if it is established in the conception stage.

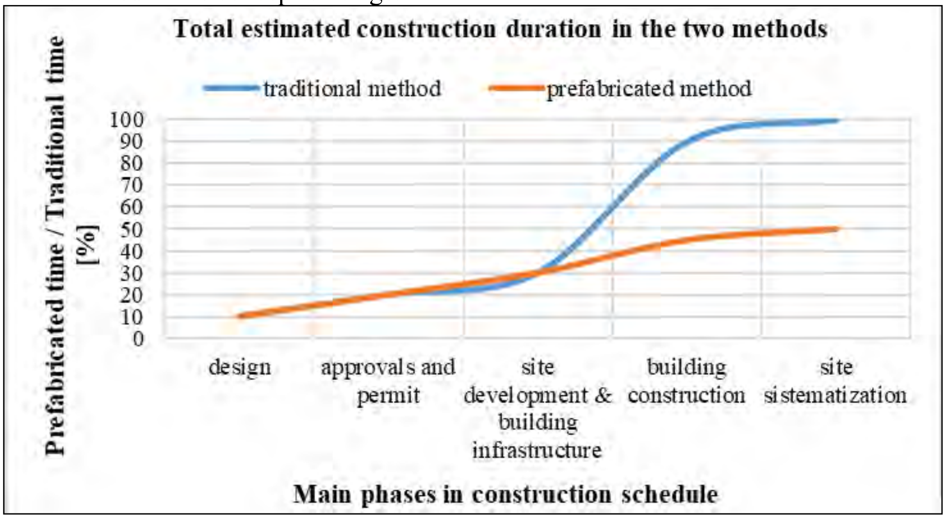

Figure 1: The chart highlighting the high speed of construction

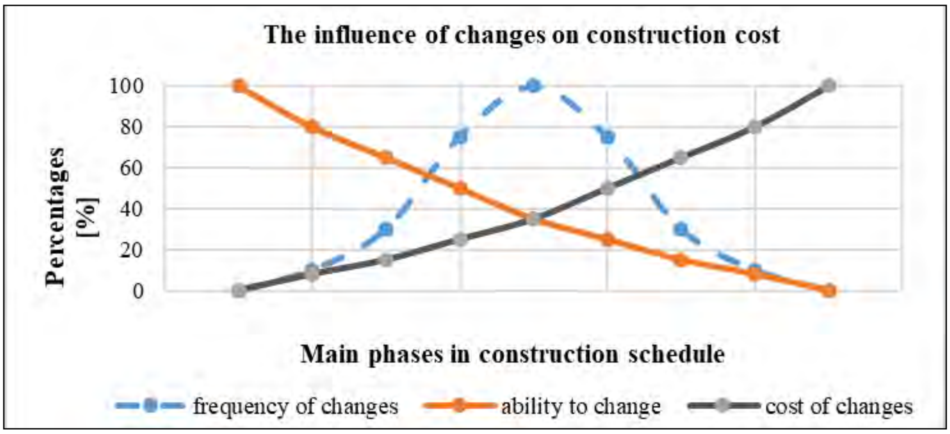

Figure 2: The influence of changes on construction cost

3. Results and Discussion

To make major improvements, the construction industry must embrace the prefabricated method more broadly. In the presented context, prefabricated/modular buildings represent the next generation of housing, single-story or multi-story, in which new sustainable materials have become a reliable alternative to traditional materials. Prefabricated construction can provide the solution to increase the construction speed and/or to reduce the cost during setting up the building, and can also offer viable solutions to the requirements of sustainability and environmental protection if all parties, along the value chain, from design to execution, will take measures to forward the execution technology and transfer, as many activities as possible, from the building site to the factory.

4. Conclusions

Modular construction will bring great benefits: for the wider society, by reducing construction costs and adverse social effects; for the environment, by improving the efficient use of materials or by reducing the unfavourable environmental impact of buildings over time.

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Case study on the thermal performance analysis of well insulated buildings

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Summary: *This work presents the thermal performance study of three buildings designed and executed in the last 12 years. All three buildings are characterized by a high degree of thermal insulation, higher than the minimum requirements in force at the time of design. The main objective of the work is to evaluate the heating demands of the buildings and the degree of fulfilment of the current energy performance requirements related to the mandatory nearly zero-energy building standard.*

Keywords: heating demand; energy efficiency; thermal performance.

1. Introduction

Thermal performance of buildings is essential for ensuring occupant comfort and energy efficiency, the latter being a crucial aspect in mitigating climate change. The EU is committed to improving the energy efficiency of buildings, aiming for a "climate-neutral" building stock by 2050. The Energy Performance of Building Directive (Directive 2010/31/EU) outlines key strategies for this goal. This paper elaborates on the thermal performance analysis of three case study buildings, with focus on assessing the thermal transfer characteristics of the envelope elements as well as the heating demand.

2. Methods

The research in this paper is based on the study of three buildings (see Figure 1) located in west side of Romania, Timisoara. All three buildings are very well insulated, above the minimum requirements in Romania at the moment of the design. Building A and Building B have 300 mm, while building C has 250 mm of expanded polystyrene thermal insulation on the facades. The insulation thickness of the slab on grade and roof has similar values for all three buildings, meaning 400 mm of thermal insulation. Although all three buildings are very well insulated, there is a major difference between them when it comes to compactness. While Building A and Building B have relatively favourable ratio between envelope area and building interior volume (A/V), a much higher value can be observed for Building C.

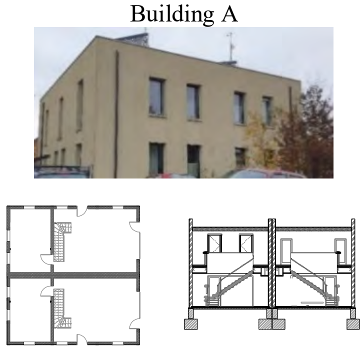
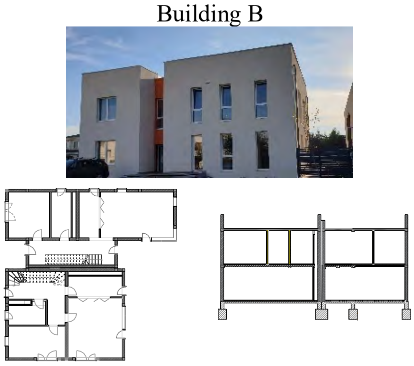
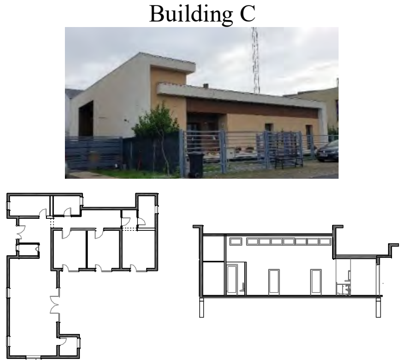
Building A	Building B	Building C
		
Exterior walls 215,40 m^2 Windows 88,46 m^2 Roof 162,98 m^2 Slab on grade 150,46 m^2 Cantilevered floor 15,65 m^2 Total interior volume 948,61m^3 A/V 0,67 m^2/m^3	Exterior walls 325,66 m^2 Windows 92,36 m^2 Roof 170,00 m^2 Slab on grade 170,00 m^2 Total interior volume 1013,4 m^3 A/V 0,72 m^2/m^3	Exterior walls 220,84 m^2 Windows 41,81 m^2 Roof 154,35 m^2 Slab on grade 154,35 m^2 Total interior volume 545,85 m^3 A/V 1,05 m^2/m^3

Figure 1: Architecture and geometry of the case study buildings

The calculation of the unidirectional thermal transfer resistances R of the construction elements were conducted following the calculation procedure in the Romanian norm C107/3-2005. Further, the corrected thermal transfer resistances R’ were calculated, considering the negative effect of thermal bridges by using the correction coefficient r. The thermal bridges were assessed following the guidelines set out in EN ISO 10211, using thermal bridges simulation models. The heating demand assessment was performed using Passive House Planning Package 10.

3. Results and Discussion

Table 1 presents the thermal transfer characteristics of the three case study buildings. It can be noticed that while R for opaque components have similar values for all three buildings, the differences between R' are higher. Furthermore, when analysing the graph presented in Figure 2, it is noticeable that in case of Building C, thermal bridges have a greater share of the total specific heat transfer coefficient. When analysing the annual heating demand presented in Figure 3, it can be observed that for building A we have the lowest value, followed by building B. The highest value, more than double, is obtained for building C.

Table 1. Envelope elements characteristics of the case study buildings

	Envelope element	Thermal transfer resistance **R** [m^2K/W/]	Thermal bridges correction coefficient **r** [-]	Corrected thermal transfer resistance **R'** [m^2K/W/]	Target corrected thermal transfer resistance $\mathbf{R'_{min}}$ (Mc001/2022) [m^2K/W/]
Building A (residential)	Exterior walls	7,41	*0,831*	6,16	4,00
	Windows	-	-	1,39	0,90
	Roof	10,00	0,840	8,40	6,67
	Slab on grade	10,40	0,750	7,80	5,00
	Cantilevered floor	13,10	0,870	11,40	6,67
Building B (non-residential)	Exterior walls	7,89	*0,827*	6,53	3,00
	Windows	-	-	1,39	0,83
	Roof	8,89	0,789	7,01	6,00
	Slab on grade	9,57	0,750	7,18	5,00
Building C (residential)	Exterior walls	7,08	*0,708*	5,01	4,00
	Windows	-	-	1,25	0,90
	Roof	9,94	0,630	6,26	6,67
	Slab on grade	10,19	0,750	7,64	5,00

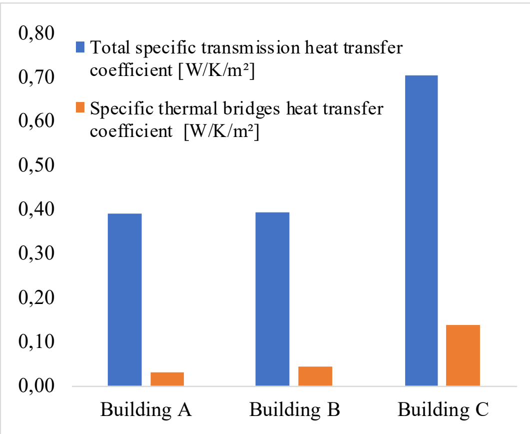


Figure 2: Specific heat transfer coefficients

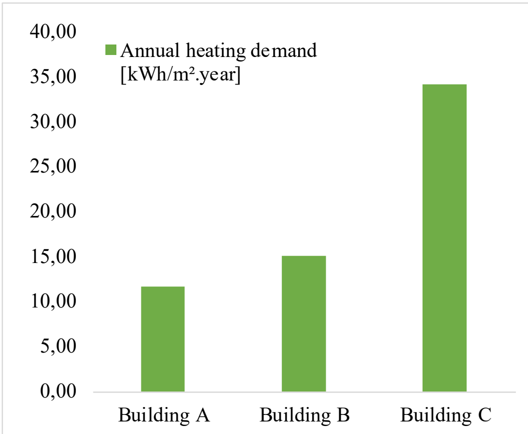


Figure 3: Annual heating demand

4. Conclusions

The study's findings confirm that a building's energy performance is significantly influenced by its compactness, regardless of the degree of thermal insulation. Energy efficient design techniques should place a high priority on the A/V ratio, besides other passive house design strategies, as this is a cost-free measure.

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C107/3-2005. *Normativ privind calculul performanţelor termoenergetice ale elementelor de construcţie ale clădirilor*

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Acknowledgment

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An alternative approach to assessing the thermal performance of windows

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Summary: *Buildings significantly contribute to carbon dioxide emissions, and adopting energy-saving measures in this sector represents an important strategy for emission reduction. Glazing surfaces are essential in meeting the energy efficiency benchmarks set by design standards. Through precise evaluation of windows' thermal transmittance and the incorporation of energy-efficient strategies, there's potential for a marked reduction in both energy consumption and carbon emissions of buildings. However, during the progression of the THERMOG project, challenges surfaced concerning the precise evaluation of glazing surfaces' thermal performance. Consequently, this paper presents a comprehensive overview of the alternative methodology for calculating such surfaces' thermal performance.*

Keywords: thermal performance; thermal transmittance; windows, calculation method.

1. Introduction

The accurate assessment of the thermal transmittance of a window, also known as the U-value, is crucial for several reasons, such as energy efficiency, comfort, condensation, cost savings, and climate change mitigation. The U-value of a window determines how much heat is transferred through it. A lower U-value indicates better insulation and less heat loss or gain, improving building energy efficiency. Accurate assessment of the U-value helps select windows that meet energy efficiency standards and reduce energy consumption for heating and cooling (Bae et al, 2020). Windows with poor thermal performance can lead to condensation on the interior surface, which can cause damage to the window frame, walls, and furnishings. Therefore, an accurate assessment of the U-value helps in selecting windows that provide better thermal comfort by reducing heat transfer, maintaining stable indoor temperatures, and saving money on heating and cooling costs over the long term.

2. Methods

The ISO 10077-1 and 10077-2 (ISO, 2017) outline a methodology for determining the U-value of windows and doors. This standard is bifurcated: the initial segment covers the comprehensive product computation, while the subsequent part details the calculation of thermal transmittance for frame profiles intended for utilization in the initial segment. The provided formula integrates the center of glass's U-value (Ug), the frame's U-value (Uf), and the linear thermal transmittance from the collective effects of the glazing, spacer, and frame (Ψg, i.e., the edge of glazing impacts). The thermal transmittance for these components cites various standards: glazing aligns with EN 673, opaque panels with ISO 10211, and frame and edge components correlate with ISO 10077-2.

Adhering to ISO 10077-2 (Part 2), the frame section's thermal transmittance is deduced using a bi-dimensional numerical method, simulating the glazing substituted by an insulating panel with thermal conductivity of 0.035 W/(m·K) and a thickness equivalent to the insulated glazing unit that it replaces. The linear thermal transmittance from the frame and glazing interaction is determined both with the glazing intact and when an insulating panel replaces it. The standard also states surface resistances and the conditions for computations, setting the internal temperature at 20°C and the external at 0°C.

The calculation methodology proposed by the authors simplifies the calculation method by employing just one step, compared to the two defined by the ISO standard (ISO, 2017). The one-step approach leads to similar results as the standard approach. The simplified method involves modelling and numerical simulation on the window panel described by the frame and the glass package with the actual thermal characteristics. The results obtained include the thermal transmittance value of the frame, as well as the linear heat transfer coefficient related to the glass package. Thus, the value of the glass package used in the modelling is adjusted (Ugc from Figure 1) by affecting it with the resulting coefficient's value. In the end, the overall Uw value is calculated using a simplified version of the formula, which considers only the sum of the product between parts' corresponding area (i.e, the glass unit and separately the frame) multiplied by the transmittance of that part, relative to the total area of the window.

For demonstration, the considered window dimensions were the standard, respectively 1.23 m wide and 1.48 m high. The standard's wood frame, defined by Figure I.4, is used in calculations, with a varying thermal conductivity from 0.12 to 0.23 W/(m·K). For the glazing unit, the package thickness varied from 14 to 30 cm, while for one case dimension scenario, Ug varies from 1.2 to 2.7 W/(m^2·K). The modelling and simulation was performed with the help of the 2D PSIPLAN modelling and simulation software and the WINDOW module (Moga, 2023).

3. Results and Discussion

Figure 1 displays the results only for a specific studied case, notably the wooden frame with a 12 W/(m.K) thermal conductivity and a package thickness of 14 cm. The derived values of Uf=1.355 W/(m^2·K) and Ψg=0.08 W/(m·K) match those specified in Annex I for software validation concerning a wooden frame scenario. For analysis, results rounded to one decimal place are considered. Consequently, the approach we propose yields results consistent with the standard methodology.

Entry Data		Two steps approach										One step approach					
Gr	Ug	Uf	PsiIs	Uw-ISO 10077/1			Psi	Uw				Ufc	Psig	Ugc	Uw		
14	1.20	1.355	0.080	1.466	1.47	1.5	0.078	1.460	1.46	1.5		1.397	0.044	1.372	1.380	1.38	1.4
14	1.30	1.355	0.080	1.536	1.54	1.5	0.075	1.523	1.52	1.5		1.399	0.041	1.462	1.443	1.44	1.4
14	1.40	1.355	0.080	1.605	1.61	1.6	0.073	1.586	1.59	1.6		1.401	0.039	1.551	1.506	1.51	1.5
14	1.50	1.355	0.080	1.675	1.68	1.7	0.070	1.649	1.65	1.6		1.403	0.036	1.641	1.569	1.57	1.6
14	1.60	1.355	0.080	1.745	1.75	1.7	0.068	1.712	1.71	1.7		1.405	0.033	1.731	1.633	1.63	1.6
14	1.70	1.355	0.080	1.815	1.82	1.8	0.066	1.776	1.78	1.8		1.407	0.031	1.820	1.696	1.70	1.7
14	1.80	1.355	0.080	1.885	1.89	1.9	0.063	1.839	1.84	1.8		1.409	0.028	1.910	1.759	1.76	1.8
14	1.90	1.355	0.080	1.955	1.95	2.0	0.061	1.903	1.90	1.9		1.411	0.026	2.000	1.823	1.82	1.8
14	2.00	1.355	0.080	2.025	2.02	2.0	0.059	1.966	1.97	2.0		1.413	0.023	2.090	1.886	1.89	1.9
14	2.10	1.355	0.080	2.095	2.09	2.1	0.056	2.030	2.03	2.0		1.415	0.021	2.181	1.950	1.95	2.0
14	2.20	1.355	0.080	2.165	2.16	2.2	0.054	2.094	2.09	2.1		1.417	0.018	2.271	2.014	2.01	2.0
14	2.30	1.355	0.080	2.235	2.23	2.2	0.052	2.157	2.16	2.2		1.419	0.016	2.361	2.077	2.08	2.1
14	2.40	1.355	0.080	2.305	2.30	2.3	0.050	2.221	2.22	2.2		1.421	0.013	2.451	2.141	2.14	2.1
14	2.50	1.355	0.080	2.374	2.37	2.4	0.047	2.285	2.29	2.3		1.423	0.011	2.542	2.205	2.21	2.2
14	2.60	1.355	0.080	2.444	2.44	2.4	0.045	2.349	2.35	2.3		1.425	0.008	2.633	2.269	2.27	2.3
14	2.70	1.355	0.080	2.514	2.51	2.5	0.043	2.413	2.41	2.4		1.427	0.006	2.723	2.333	2.33	2.3

Figure 1: Results for the proposed approach – wood frame case scenario

4. Conclusions

The pressing need to reduce carbon dioxide emissions from buildings underscores the significance of accurately evaluating the thermal transmittance of windows. This paper presented an alternative, simplified method for calculating the U-value of windows, highlighting its consistency with established ISO standards. The study demonstrated the potential for streamlining assessments without compromising accuracy by utilizing a one-step approach. The results, particularly from the wooden frame case study, reaffirmed the proposed methodology's validity against standard benchmarks. As energy efficiency remains paramount in building design and construction, tools and methods that offer accuracy and efficiency, like the one proposed, will be invaluable for architects, engineers, and policymakers. Simultaneously, it will assist in evaluating the thermal performance of the glazing surface thermographed during the research campaign conducted for the THERMOG project.

5. Acknowledgments

This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CCCDI - UEFISCDI, project number PN-III-P2-2.1-PED-2021-4137, within PNCDI III - CT 714PED / 2022.

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Project THERMOG 714PED / 2022: https://www.thermogproject.com/

Non-Destructive Assessment of Building Thermal Performance: The THERMOG Project

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Summary: *The THERMOG project addresses the complexities in evaluating the thermal performance of building envelope elements during energy audits. With numerous variables influencing thermal performance, existing software often overlooks specific real-world scenarios and linear thermal bridges. THERMOG introduces a novel methodology and software, harnessing aerial and terrestrial thermography to provide accurate assessments based on actual building conditions and material properties, bypassing normative or manufacturer-declared values. This approach streamlines the audit process, ensuring more authentic results.*

Keywords: thermal performance; thermography; UAV-based imaging; methodology; software.

1. Introduction

Non-destructive assessment of building thermal performance using thermography is a reliable and efficient method for evaluating the thermal behaviour of buildings. This technique uses infrared thermography (IRT) to capture thermal images (thermograms) of surface temperatures, providing immediate spatial information about heat losses due to compromised or poorly installed insulation, moisture accumulation, thermal bridging, and sources of air leakage.

One of the key applications of thermography in building assessment is the detection and quantification of thermal bridges. These are areas or elements in the building envelope that have higher thermal conductance compared to the rest of the envelope, leading to significant thermal losses and affecting the overall thermal performance of the building (Bianchi et al, 2014). In addition to thermal bridges, thermography is also used to detect air leakage through the building envelope. A blower door test is typically used with thermography to measure air leakage in the building, helping to identify and prioritize areas of air leakage for sealing purposes (Mahmoodzadeh et al, 2020).

Infrared thermography can be applied at multiple scales, including the mesoscale or city scale, local-scale or neighbourhood scale, and microscale or, as mentioned, building scale. At these scales, it can be used to observe the urban heat island (UHI) effect, analyse urban heat fluxes, detect defects in buildings, evaluate their thermal performance, and study urban descriptors (Martin et al, 2022).

Thus, the thermography approach can identify and quantify all the anomalies mentioned above, prioritizing areas for improvement and ultimately enhancing the energy efficiency and comfort of buildings. However, further research and development are needed to fully exploit the potential of this technique, particularly in terms of integrating it with other data sources and advanced data processing techniques and applying it at different scales and contexts.

2. Methods

In light of this, a research project titled THERMOG (THERMOG, 2022) is underway, delving into the utilization of aerial and terrestrial infrared thermography (IRT) for evaluating building envelopes' thermal performance. The study seeks to juxtapose the outcomes from both techniques, appraise the precision and trustworthiness of the gathered thermal data, and discern the strengths and drawbacks inherent to each method. Through fulfilling these goals, THERMOG aspires to shed light on the promise held by aerial and terrestrial thermography in building envelope thermal evaluation and to guide the formulation of guidelines for their application in this domain.

Several distinct research objectives are defined for the development of the project, which include:

- Drawing parallels by identifying the disparities and similarities in aerial and terrestrial thermography outcomes when assessing building envelope thermal performance;
- Examining the precision and dependability of aerial and terrestrial thermography methods in measuring building envelopes' thermal properties while recognizing elements that might influence the data's integrity;
- Highlighting potential obstacles and constraints associated with these methodologies;
- Offering insights, grounded in research outcomes, on the optimal utilization of aerial and terrestrial thermography for building envelope thermal evaluations.
- Streamlining the timeframe for building examinations and yielding results that represent the building's thermal behaviour.

The THERMOG approach and its associated software are crafted for user-friendliness and to accurately represent building efficacy. THERMOG is evolving as a tool employing IRT to assess the thermal attributes of building envelopes in real-world scenarios (i.e., in-situ performance). The software is engineered for ease of use, aiming to mirror the actual behaviour of the building. The methodology and software encompass two primary segments: data gathering and evaluation. The data-gathering component collects thermal imagery, environmental conditions, and specifics about the examined building. Conversely, the data evaluation component engages in preliminary and advanced processing of the collected data to derive the intended results.

3. Results and Discussion

Currently, researchers from several Romanian universities, including Universitatea Tehnică din Cluj-Napoca, Universitatea Tehnică "Gh. Asachi" Iași, Universitatea Tehnică de Construcții din București, and Universitatea Politehnică din Timișoara, are actively participating in the extensive project. This initiative covers zones with varied characteristics and encompasses 26 buildings with distinct functions. These include low to medium-rise housing, student dormitories, commercial and office spaces, industrial facilities, educational structures such as university spaces, and a kindergarten. Twenty of these buildings have undergone detailed thermographic and photogrammetric evaluations. The gathered data from these assessments is under rigorous pre and post-processing within the project's framework, ensuring a thorough analysis of each building's thermal performance and structural nuances.

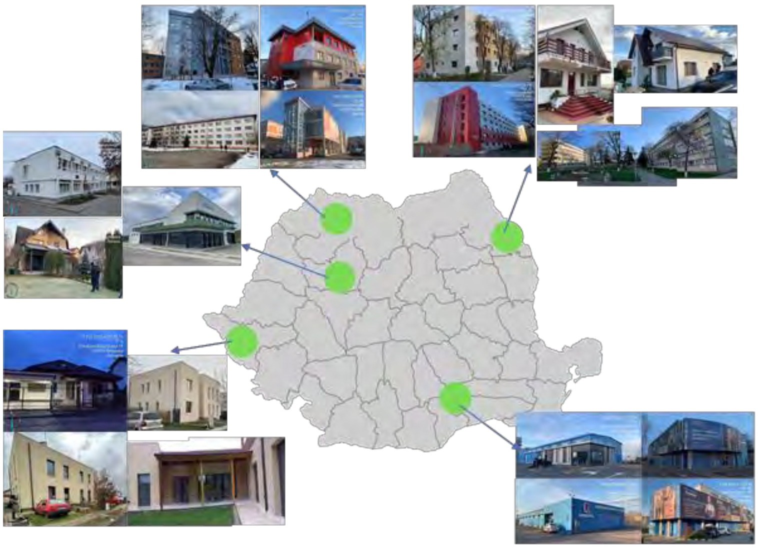

Figure 1: Overview of the investigated buildings

4. Conclusions

Recently, there's been a growing demand for effective methods to measure the genuine thermal performance of building envelope components. A discrepancy termed the "performance gap", is observed in contemporary practices between a building's actual energy performance and its intended design performance. Presently, researchers are emphasizing the use of IRT, drawn to its non-intrusive attributes that precisely assess the thermal efficiency of building envelope parts. As the THERMOG project unfolds, the approach will delve deeper into various thermal irregularities and evaluate heat distribution within building elements. Given the methodology's nascent phase, the proposed approach will undergo tests across diverse buildings, varying in height and situated in different climatic zones, aiming to minimize potential field measurement inaccuracies. Adjustments will be made to the methodology to address any challenges or limitations of aerial thermography use.

5. Acknowledgments

This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CCCDI - UEFISCDI, project number PN-III-P2-2.1-PED-2021-4137, within PNCDI III - CT 714PED / 2022.

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Project THERMOG 714PED / 2022: https://www.thermogproject.com/

Thermo-energy performance of industrial buildings

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Summary: *The PhD research delves deep into global energy consumption and CO_2 emissions, focusing on the industrial buildings construction sector. It highlights international regulations, emphasizing the need for eco-conscious construction practices and explores industrial hall types, structural solutions, and worldwide trends. Diverse case studies are presented, followed by thermo-energy analyses and assessment of environmental impacts, particularly carbon emissions, through life cycle analysis. The findings are verified through experimental thermography. The synthesis in the final chapter guides future sustainable construction practices, emphasizing eco-friendly design and regulatory compliance, making a substantial contribution to scientific knowledge in the construction sector.*

Keywords: industrial buildings design; energy efficiency; environmental impact; CO_2 emissions; sustainable construction.

1. Introduction

The research investigates the thermo-energy efficiency of industrial buildings, emphasizing energy-efficient design in terms of building envelope thermal performance and environmental impact. It addresses the pressing need to reduce buildings' environmental impact by focusing on sustainable materials and optimal thermotechnic design (Hensen J., Lamberts R., 2011). The study also analyses the building envelope's crucial role as a barrier between indoor and outdoor environments (Vijayan D.S., Sivasuriyan A. et al., 2022). Key factors influencing energy efficiency are identified, exploring various building envelope designs and materials under diverse conditions using modelling and simulation programs. Additionally, it evaluates materials' embodied energy, carbon footprint, sustainability, and recyclability. Ultimately, the research aims to provide practical recommendations, encompassing specific design features, materials use, and construction techniques to enhance energy efficiency, reduce environmental impact, and ensure long-term sustainability in industrial constructions.

2. Methods

The first study analyses five industrial hall-type buildings, determining parameters like thermal resistance and energy requirements. It evaluates envelope options and materials impact by identifying optimal solutions in terms of thermal performance, adhering to standards and employing THERM 7.8 software (Finlayson E., Mitchell R. et al., 1998). The second study conducts a Life Cycle Analysis (LCA) on diverse hall types, assessing embodied emissions, energy, and sustainability (Rodrigues V. et al., 2018). Using Athena Impact Estimator software, it considers the entire construction lifecycle, providing insights for eco-friendly industrial buildings. The third analysis implies using infrared thermography to establish the actual thermal performance of the building envelope. This method implies the use of terrestrial and aerial thermography for establishing thermal performance of the assessed surface, and at the same time detecting surface temperature variations that can indicate thermal and/or structural anomalies.

3. Results and Discussion

The case studies analysed are as follows: hall-type 1 features a metal structure with a building envelope made of PIR (polyisocyanurate) sandwich panels; hall-type 2 is designed using metal columns and glulam beams and incorporates wood sandwich panels for walls and PIR sandwich panels for the roof; hall-type 3 constructed with a prefabricated concrete structure, employs PIR sandwich panels for its envelope; hall-type 4 featuring a prefabricated concrete structure, employs concrete sandwich panels for walls and insulated metal sheets for roof; hall type 5 with a metal framework and a building envelope made of PIR sandwich panels. Comparatively, the average thermal resistances of the entire building envelope R'_{med}, the global thermal insulation coefficient denoted by G_1 along with the ratio between its value and the reference value denoted by G_{1ref}, the heating demand and LCA analysis results for the studied hall-type buildings are presented in figures 1-6.

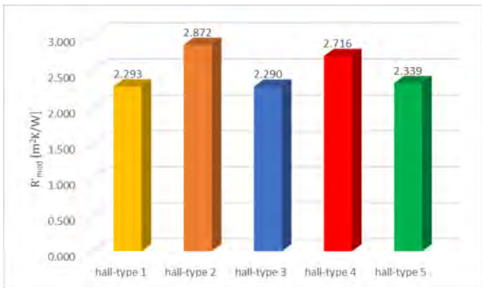

Figure 1: Average building envelope thermal resistance

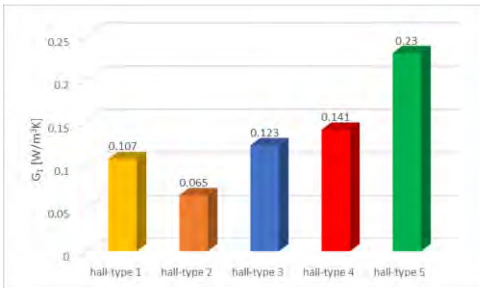

Figure 2: Global thermal insulation coefficient

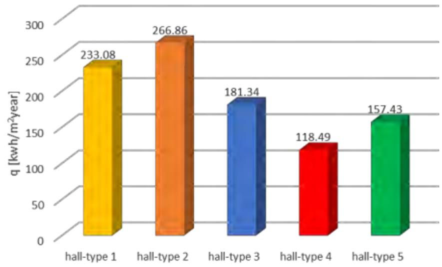

Figure 3: Heating demand

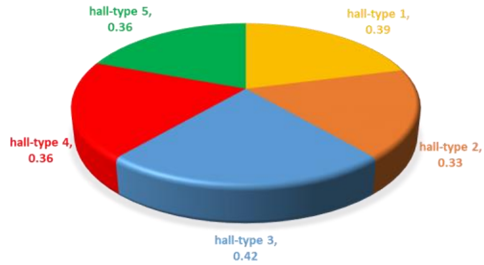

Figure 4: G_1/G_{1ref} ratio [W/m^{3}K]

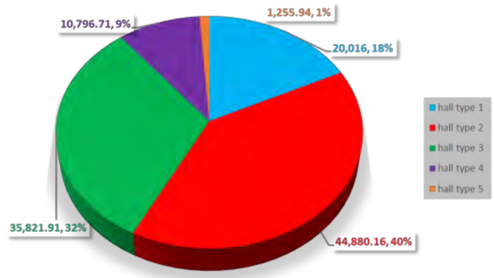

Figure 5: Embodied CO_2 [tonsCO_2eq]

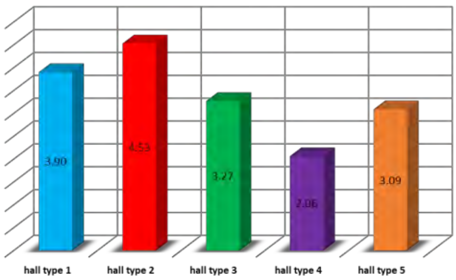

Figure 6: Embodied CO_2/surface [tonsCO_2eq/m^2]

4. Conclusions

This research has conducted a detailed exploration of sustainable design, construction, and operation of industrial hall-type buildings. The study critically examines various studies, offering vital insights into energy efficiency, material usage, and operational performance in modern industrial constructions. By synthesizing these perspectives, the research aims to provide a holistic understanding of the complex relationship between theoretical design ideals and real-world outcomes. The focus is improving energy efficiency, reducing carbon emissions, and bridging the gap between design intentions and operational realities. Through theoretical knowledge and empirical investigations, the study advocates for durable and sustainable practices, promoting energy efficiency and minimizing environmental impact in the built sector.

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ACKNOWLEDGMENT: This paper was financially supported by the Project "Network of excellence in applied research and innovation for doctoral and postdoctoral programs / InoHubDoc", project co-funded by the European Social Fund financing agreement no. POCU/993/6/13/153437

C70 International Conference
”Tradition and Innovation - 70 Years of Constructions in Transilvania”

The acoustic comfort in rooms intended for educational purposes

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Summary: *This paper develops a study based on ensuring the acoustic comfort in rooms intended for educational purposes. The importance of the reverberation time determination was highlighted. Reverberation time is considered an important criterion in assessing the acoustic quality in enclosed spaces. The obtained values were corrected according to STAS 9783/0-84 and Normative C125-2013. Three solutions were proposed to improve the acoustic comfort of the studied room and the optimal solution was chosen.*

Keywords: acoustic comfort; reverberation time; educational room; acoustic measurement; acoustic optimization.

1. Introduction

In classrooms, participants can concentrate better if negative acoustic phenomena, that can distract their activities from the educational process, are eliminated. Thus, their performance in the educational process will be improved.
Following the determination of the reverberation time, through acoustic measurements and theoretical studies, it has been found that the admissible limits imposed by the regulations in force were not respected.
After the theoretical implementation of the proposed solutions, the values of the reverberation time fell within the admissible limits and thus the necessary acoustic comfort for a good performance of didactic activities was achieved.

2. Case study

The studied classroom is intended for lectures, scientific conferences and other events, having a capacity of 187 seats. The perimeter surfaces encountered in the studied room are plaster, wood, parquet, HPL plywood. Moreover, the classroom is equipped with educational furniture, TV, video projector, speakers, blackboard.
The plan dimensions are: 15x9 m. The level height is variable being approximately 3.30 m. The volume of the studied room, based on the established dimensions, is 458.5 m^3 (Figure 1).
The equipment used for the measurements is Bruel&Kjaer type and it includes the following elements: sound level meter, power amplifier 'Audio Power Amplifier 100 W Stereo Type 2716-C', omnidirectional sound source 'OmniPower Sound Source Type 4292-L', tripod for the sound level meter and for the sound source and cables, used for interconnecting the measuring equipment. For this determination 18 microphones positions and 1 source position were considered.

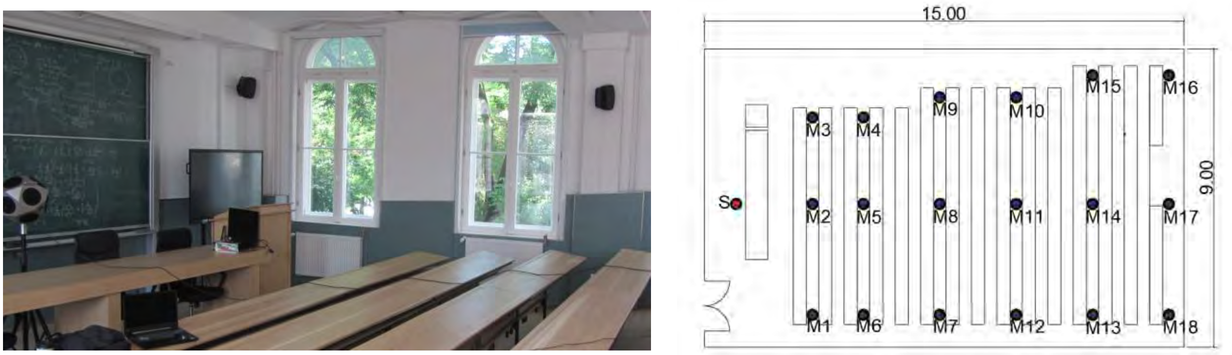

Figure 1: The studied room: 18 microphones positions and 1 source position

3. Results and Discussion

A comparative study was carried out between the methodology addressed by STAS 9783/0-84 and Normative C125-2013 (Figure 2).

Following the measurements, the reverberation time values were obtained for the 6 standardized frequencies. The recorded values do not respect the limits imposed by STAS 9783/0-84 and Normative C125-2013. Thus, 3 acoustic rehabilitation solutions, disposed on the back wall of the room, were studied (Figure 3) in order to achieve the necessary acoustic comfort. It was decided also to upholster all the seats in all the proposed solutions.
Following the calculations, the solutions are: (S1) 11 panels, Mega Acoustic FiberPro 120 Binary Bean Natura type, (S2) 11 panels, The Razor 25mm Acoustic Panel type, (S3) 31 panels, KusWave 3D Polyester fiber acoustic panel type.
All the studied solutions offer the necessary acoustic comfort in accordance with STAS 9783/0-84 and Normative C125-2013.
Based on the result it can be concluded that if the chairs in the studied room are upholstered, the conditions imposed by the two technical regulations are respected.

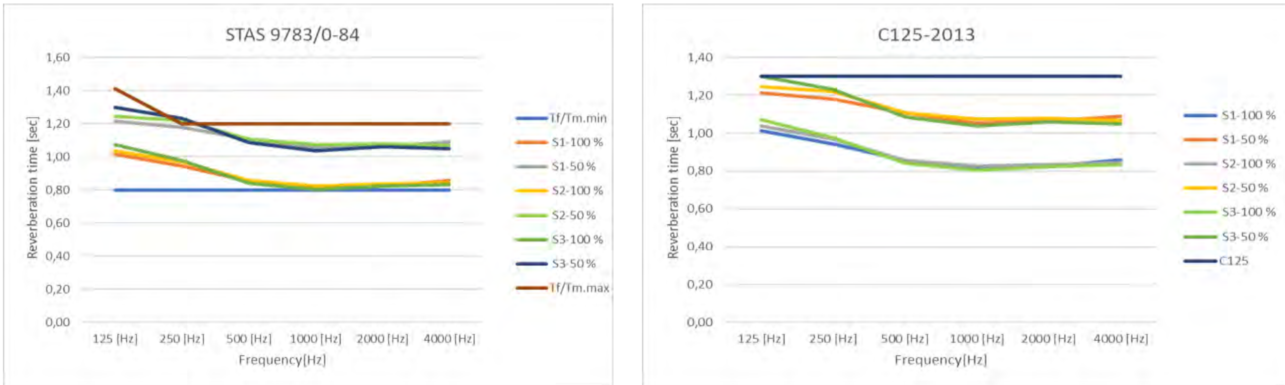

Figure 2: The comparative study between STAS 9783/0-84 and Normative C125-2013

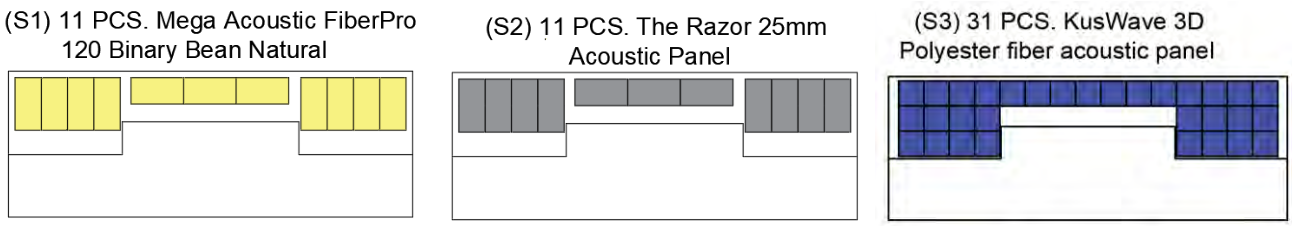

Figure 3: Distribution of acoustic panels S1, S2 and S3

4. Conclusions

The purpose of the presented study was to ensure the acoustic comfort for an educational room.
Based on the reverberation time (theoretical and practical determinations) three solutions were proposed to meet the conditions imposed by STAS 9783/0-84 and Normative C 125-2013. From the technical, economic, and aesthetic conditions, the optimum solution was also chosen, namely solution 2, which involves upholstering all the seats and installing 11 The Razor 25mm Acoustic Panel sound-absorbing panels.
It was concluded that extremely similar results were obtained, either by calculations made according to STAS 9783/0-84, or by Normative C 125-2013. According to STAS 9783/0-84, the acoustic comfort is achieved by providing simultaneously the needed reverberation time values imposed both for 50% and 100% occupancy state. According to Normative C 125-2013, the acoustic comfort is achieved if the reverberation time values does not exceed the maximum limits. The solution including the upholstery of all the seats corresponds to both STAS 9783/0-84 and Normative C 125-2013.

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Consideration about electrical energy supply of a tiny house

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Summary: *Prefabricated, modular constructions are a suitable solution for holiday homes, especially if the beneficiaries have a busy life and do not have time to manage a construction site far from their residence. For situations where there is no access to the grid, solar panels are an alternative, especially since they can be integrated into the house roof structure, but to be energy independent, it needs an energy storage system and a back-up generator.*

Keywords: solar energy; prefabricated house; PV panels; stand-alone system; hybrid system.

1. Introduction

A house concept that has developed in the recent years is represented by the so-called "tiny house", which, in general, are small prefabricated, modular houses. In general, by composing several modules, it is possible to obtain houses with small or medium living areas, which satisfy the needs of an important sector of the population and are generally intended as holiday homes, social homes or simply places of refuge from urban agglomerations. After the pandemic period, there were extremely many requests in this regard.
These houses have several advantages, among which we mention (Marza et al. 2019, Corsiuc and Marza 2023):
- construction in specialized factories, under the supervision of specialists;
- easy transport by road and, if necessary, by rail or ship;
- optimized production costs;
- low maintenance costs, having low energy consumption due to the small volumes of air that need to be heated/cooled.

These houses can be located in areas where there is the possibility of connecting to the electrical networks, but there are situations in which, either technically this possibility does not exist, or the clients want energy autonomy.

2. Materials and Methods

In this paper the authors are presenting the results of the research regarding the design and dimensioning of a solar PV energy system, that supplies a tiny house in the countryside mostly used on weekends, throughout the year – Fig.1. Since the surface of the roof is reduced, only six PV panels can be mounted on it. That's why, in order to ensure the electricity demand during a whole day and for the whole year, an energy storage system and a back-up generator are needed. To determine the configuration of the system, simulations were made using iHoga software, developed by Dufo-López, which is used for the simulation and optimization of stand-alone and grid-connected hybrid renewable systems using genetic algorithms.

a. b. c.

Figure 1: a. Front photo of the house; b. Floor plan; c. PV panels on the roof.

The electrical energy requirement includes ensuring artificial lighting, preparation of domestic hot water (electric boiler) and other domestic consumers of strict utility (refrigerator, induction stove, TV, appliances for occasional use). The heating of the house is provided by a 5kW fireplace and in the bathroom, there is a 350W electric heated towel rail radiator.
To carry out the simulations, the orientation of the tiny house (South, Azimuth angle = 0^o) and the slope of the roof (10^o) were considered. For this location, using the PVGIS program, the information about the monthly values of solar radiation were used.

Performing the simulation, to ensure the energy demand of the house, the following configuration resulted:

- 6 PV panels of 550 Wp each, with a total power of 3.3 kWp ;
- 24 Batteries having a capacity of 390Ah each, E_{total}= 18.72 kWh;
- Inverter, 1600W;
- PV Battery charge controller of 55 A;
- Battery charger;
- AC Diesel Generator 1.9kVA.

Table 1 presents the energy balance of the system for one year and in Figure 3 the results are presented as a graph.

Table 1. Energy balance during one year.

Energy	Value
Overall Load Energy	1148.5 kWh/yr
Energy delivered by PV	2300.9 kWh/yr
Export energy	1038.1 kWh/yr
Energy charged by Batteries	706.7 kWh/yr
Energy discharged by Batteries	612.9 kWh/yr
Energy delivered by AC Generator	261.1 kWh/yr

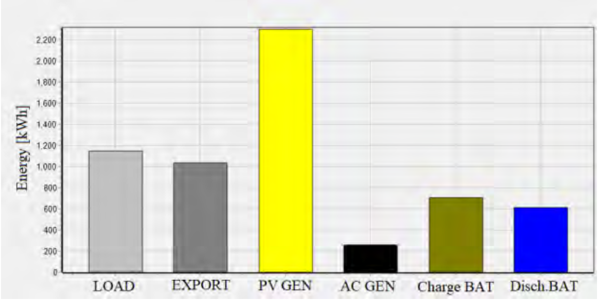

Figure 3: Total annual energy of the system

3. Results and Discussion

Analyzing the results obtained from the simulations, it can be observed that the energy requirement is covered by the production of PV panels in a proportion of 77.26% and the difference is ensured by the electric generator. From the chart from Figure 4, it can be seen that the generator is used only in the cold season, when the energy requirement is higher due to the use of the electric radiator.

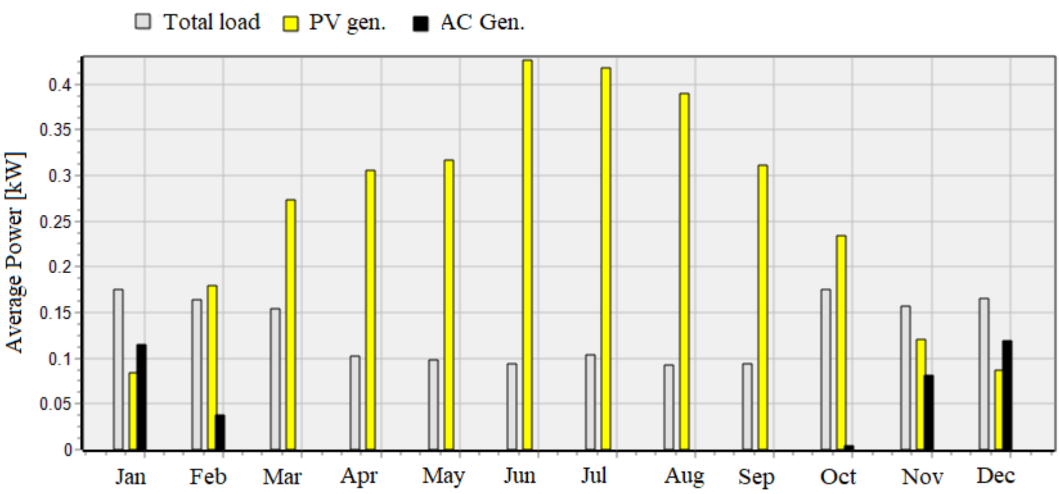

Figure 4: Monthly average power

4. Conclusions

Solar energy is a solution for remote houses, but in this case, due to the limited surface of the roof, there is limited number of solar panels that can be installed. To ensure a continuous supply of energy during the day, a storage system is required. Also, to cover the electricity demand during the cold season, when the solar energy is insufficient, a hybrid system is required, namely a diesel generator was proposed.

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Sustainability and the Built Environment: A Survey of Public Awareness and Interest in Green Building Practices

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Summary: *The study aims to explore the public's awareness of sustainability in construction. A questionnaire was distributed to 470 participants to obtain an all-encompassing view of perception regarding the advantages of green buildings, for the environment and people. The survey results indicate that individuals over the age of 30 with higher education are most aware of the concept of sustainability, i.e. green buildings.*

Keywords: green buildings; sustainability; real estate developers; government policies.

1. Introduction

Among the major global concerns are climate change, polarity, urbanisation and population growth. The building construction industry is recognised as one of the largest consumers of primary energy and natural resources, and a sector that produces 30% of global greenhouse gas emissions and 40%-50% of environmental pollution. To address these issues, green building construction focuses on improving energy efficiency and reducing the negative impact of buildings on the environment. (Zhang Y et al., 2019)
Most homeowners or prospective homeowners tend to invest less in the design and construction of their homes by choosing ones with low cost per square meter, but which are more expensive to heat and cool, require intensive maintenance, and frequent renovations, leading to a much lower long-term value than sustainable homes.
Green buildings are a type of sustainable housing that are designed and constructed to have minimal impact on the environment, based on four essential principles: efficiency, utility, durability, and comfort. Designing and constructing sustainable buildings, or transforming existing buildings into sustainable ones, brings benefits to both the environment and their owners. Among these benefits, we highlight reduced maintenance costs, a healthy living environment, and an increase in the building's value. (Beardsley, 2021)

2. Method

This research is based on a survey conducted on 470 individuals, which is structured into four important sections. The first section of the survey captures general information about the respondents, such as their age, gender, and background. In the second part, we aimed to investigate the current state of knowledge regarding the concept of sustainability/green buildings. In this section, the degree of knowledge (to what extent) among individuals regarding the benefits and economic aspects obtained from owning a sustainable/green building has been examined.
The final section focused on the extent to which people are aware of the economic benefits and aspects gained from owning a sustainable or green building.

3. Results and Discussion

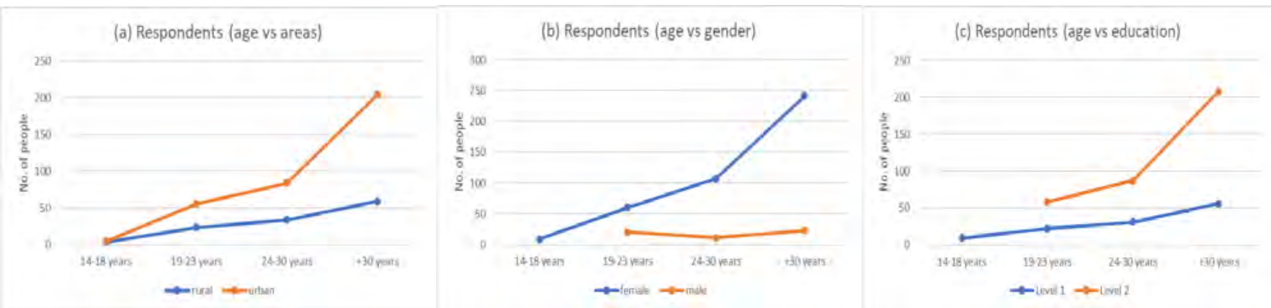

Figure 1: General data about the respondents

The survey results indicate that among the total respondents, 89% were female and 11% were male. Further analysis by age group revealed that 25% were between the ages of 24 and 30, while 56% were over 30 years old. The study focused primarily on individuals with higher education, as this group had access to a wider range of information. Among the respondents aged 24-30, 23% were from rural areas, while the majority (77%) were from urban areas. The percentages are comparable among individuals aged 30 and above, with 20% residing in rural locations and 80% in urban areas. The general information of the respondents is presented in Figure 1.

Figure 2: Concept of sustainability/ green buildings

Figure 2 presents information on sustainability concepts and green buildings. Subfigure (a) addresses three main questions: the respondents' familiarity with sustainability concepts, their understanding of green buildings, and whether they consider sustainability advantages when purchasing a space. Subfigure (b) requests respondents to offer their opinion on the prioritization of green buildings by real estate developers, whether green buildings improve the quality of life, and whether the government should be more involved in green building policies.

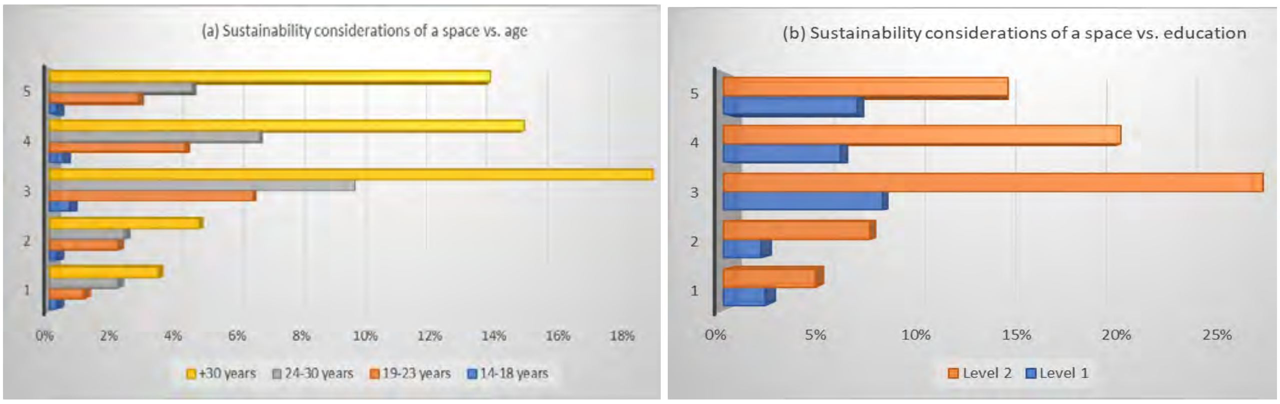

Figure 3: Sustainably considerations of a space

Figure 3 examines how often people consider sustainability and energy efficiency when buying or renting property or office space, rated on a 1 to 5 scale where 1 means "not at all" and 5 means "extremely important." The analysis is compared between different age groups (subfigure (a)) and education levels (subfigure (b)).

4. Conclusions

The survey shows that the idea of sustainability is known among respondents, especially in urban areas. However, additional information about the benefits of purchasing such a property is still not widely known. The survey opens up possibilities for future analysis of government policies regarding sustainable buildings in Romania. It considers whether developers are following the requirements imposed by official acts, and also raises awareness among the population of the benefits of such investment opportunities.

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Exploring Circular Economy Approaches for Managing Aging Building Stock in Rural Romania: A Research Framework for Sustainable Development

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Summary: *In the context of demographic changes characterised by population decline and urban migration, the rural regions of Romania are confronted with an increasingly complex challenge of effectively managing their ageing and underutilised building inventory. This paper presents a research paradigm that seeks to pioneer circular economy solutions to tackle the declining condition of rural building stock, with the goal of promoting sustainable rural regeneration. The narrative emphasises the importance of adopting an interdisciplinary strategy that incorporates spatial analysis, community participation, technological innovation, and policy advocacy.*

Keywords: Rural Revitalization; Circular Economy; Aging Building Stock; Interdisciplinary Research; Romania.

1. Introduction

Rural areas in Romania are currently undergoing demographic transitions that are characterised by the decline and ageing of their populations. These changes can be attributed to both outmigration and low birth rates (Muntele et al., 2021). The consequence of this phenomenon is the gradual decline and poor exploitation of rural building assets, including residential, agricultural, commercial, and public structures (Prăvălie et al., 2021). The sustained disregard for rural infrastructure can initiate a self-perpetuating cycle of decline, resulting in a further reduction of the sustainability and attractiveness of rural communities. To achieve sustainable rural revitalization, it is imperative to employ innovative solutions that effectively repurpose and enhance the value of ageing structures.
Through strategies like reuse, rehabilitation, and repurposing, the circular economy concepts offer an achievable framework that emphasises the preservation of current building materials (Pomponi & Moncaster, 2017). However, a thorough study of aspects including the quantity, composition, location, and condition of the existing building stock is necessary to fully understand the potential of rural structures as valuable resources (Nägeli et al., 2022). A thorough assessment of rural building stocks can indicate the possibilities for material recovery as well as the constraints and opportunities for adaptation.

2. Methods

This research examines the issue of ageing rural building stock through an array of investigative and practical activities (Figure 1). The first element of this research is geographical analysis to measure and map the ageing rural building stock (Momirović et al, 2019). This spatial study examines rural building typologies, conditions, and stocks, revealing their size, distribution, and material composition.

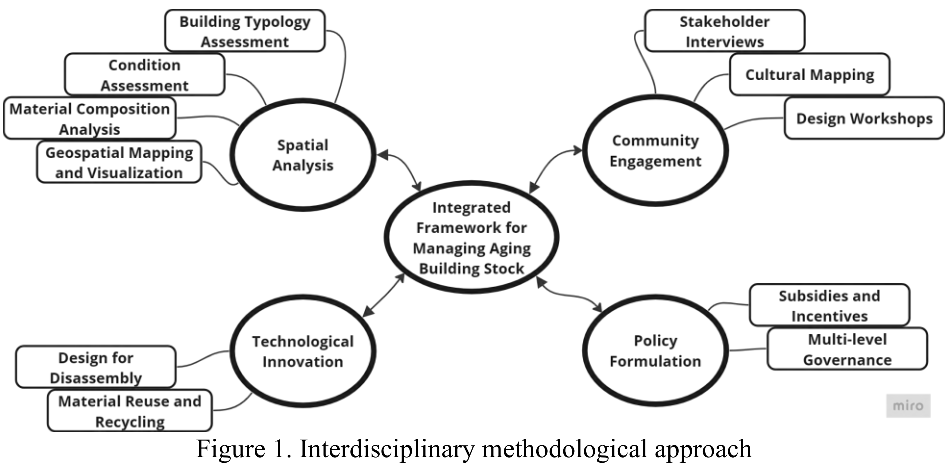

Figure 1. Interdisciplinary methodological approach

In addition to spatial analysis, the study process involves community engagement to imagine structural adaptability.

Effective community engagement through participatory methods is crucial for circular economy success (CitizenLab, 2022). Planning exercises, design workshops, and cultural mapping are used to identify structural adaptation options that meet community needs and values, assuring a bottom-up approach to adaptable measures.
Technology for material reuse is developed and shown in the research. The technological research explores modular design, modular construction, and material reuse to enhance cost-effective adaptation (Rahla et al., 2021). Pilot demonstrations may test and enhance these advances while growing local capacities, ensuring technical advancements are practical, effective, and matched with local requirements.
Another important part of the process is policy design to promote circular rural development. Researchers may explore policies like differentiated laws, subsidies, and public procurement rules that promote circular economy principles (EEA, 2022). The goal is to create a rural circular economy policy framework to encourage sustainable management of ageing building stock.

3. Results and Discussion

The suggested research integrates spatial analysis, community participation, technical innovation, and policy advocacy iteratively. This multidisciplinary approach addresses the challenges and opportunities of managing ageing rural building stock holistically. The proposed methodology has the potential to have greater impacts that go beyond the context of rural Romania. It can offer useful insights and a model that can be replicated for the sustainable management of ageing building stock in other rural areas facing similar demographic and infrastructure issues.

4. Conclusions

The regeneration of rural areas in Romania requires a fundamental change in the way the current built environment is perceived and exploited. Circular economy ideas provide a viable framework for prolonging the lifespan of buildings and simultaneously revitalising rural communities. This study presents an interdisciplinary framework that aims to illustrate the potential of ageing structures to function as valuable assets for the promotion of sustainable development. The groundbreaking advancements in the rural villages of Romania have the potential to serve as a paradigm that may be widely implemented, thereby motivating the development of analogous endeavours in other places confronted with similar challenges.

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Considerations on rainwater management, an essential component for sustainable urban water management

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Summary: *Globally, climate change and rapid population growth together with inadequate management of water resources are leading to increased water scarcity and water resource pollution. The paper provides an analysis of the effects of unsustainable stormwater management and a presentation of sustainable stormwater management methods and techniques in urban areas. The legislative framework and new trends in European legislation on urban water management are also presented.*

Keywords: rainwater; stormwater management; pollution; climate change; water demand.

1. Introduction

Water is an essential natural resource for the world's population in continuous and rapid growth (Bahri, 2012). Users within localities (domestic, public, economic), industrial and agricultural sectors simultaneously put considerable pressure on water resources. In addition, they are often located at a great distance from the serviced areas or require a high level of treatment to meet quality requirements. The increase in water demand is influenced by population growth, economic development and changing consumption patterns (The United Nations World Water Development Report, 2018). Thus, the global water requirement has increased in the last 100 years by 600%, with an annual growth rate of approximately 1.8%. It is estimated that, in the next two decades, the global water requirement will increase significantly in all three areas (localities, industry and agriculture), by approximately 20%-30%, reaching a level of 5500-6000 km^3 per year (Boretti and Rosa, 2019).

2. Stormwater management

The main objectives of a sustainable, integrated management of urban water resources are: ensuring access to water and sanitation infrastructure and services, managing stormwater, wastewater, stormwater runoff and runoff pollution, controlling diseases and epidemics transmitted by water and reducing the risk related to the negative effects of water such as floods, droughts and landslides (Bahri, 2012). Within such integrated urban water management, stormwater management is an essential component from several points of view. Sustainable stormwater management can mitigate flooding from heavy rainfall and enhance local water supplies. In many situations, during periods of heavy rainfall, public, unitary or separate sewer systems cannot discharge all the runoff in a short period of time, so the intake capacity is exceeded, resulting in leaks and potential flooding. Localities in this situation, however, have several options for urban rainwater management, such as the use of rainwater collection systems or retention-infiltration systems, permeable surfaces, infiltration ditches and other natural systems with the aim of slowing down the overflow of waters.

3. Legislative framework and new trends in European legislation on urban water management

The main European directives relevant to the management of urban rainwater are: Directive 2000/60/EC establishes the framework of Community water policy, Directive 91/271/EEC on the treatment of urban waste water, Directive 2007/60/EC on the assessment and management flood risks and the European standard 16941-1:2018 on systems for the use of rainwater. This European Standard sets out requirements and provides recommendations for the design, execution, commissioning and maintenance of rainwater collection systems for use at the point of fall as non-potable water. EU Directive 91/271/EEC on the treatment of urban wastewater, currently in force, is more than 30 years old. Since its adoption in 1991, the quality of Europe's rivers, lakes and seas has improved considerably. However, there are still pollution issues that need to be addressed and are not covered by the current rules. To solve this problem, the Commission proposed an update of the directive (European Commission, Environment, Urban wastewater, 2022). This proposal (Proposal for a directive of the European Parliament and of the Council concerning urban wastewater treatment, 2022) emphasizes that better quantitative and qualitative water management in urban areas will contribute to climate change adaptation. As the rainfall regime has changed, in addition to the risk of flooding, the risk of pollution from untreated stormwater runoff from stormwater discharges and urban runoff is also increasing. Contaminants of emerging interest, such as micropollutants or microplastics, are also present in all Member States. Thus, in order to reduce pollution due to rainwater, member states will be obliged to establish and implement integrated water management plans, at local level, in all large agglomerations and in those with more than 10,000 equivalent inhabitants, where there is a risk for the environment. Priority will be given to preventive measures, including green infrastructures and optimization of existing stormwater management systems (Proposal for a directive of the European Parliament and of the Council concerning urban wastewater treatment, 2022).

4. Sustainable rainwater management techniques

Table 1 presents the most used techniques at the current level. For this purpose, they can be classified into above-ground, ground-level or underground techniques (Qin, 2020).

Table 1. Classification of sustainable techniques of meteoric water management

Name of technique/ item	Location in relation to ground level
Green roof, non-vegetal roof	Above ground
Permeable pavements, pavements that retain water, infiltration trenches, rainwater collection tanks, soil bio-retention systems	On the ground
Water infiltration/retention systems Underground collection tanks	Under the ground

The presented techniques for managing the rainwater represent sustainable, immediate solutions that can be easily and efficiently implemented in terms of costs and which can accompany the long -term improvement methods of the water supply and sewerage infrastructure. These techniques include green roofs, permeable paving surfaces or that retain water, infiltration, basins and tanks for rainwater collection or retention and infiltration systems. Among these techniques (see Figure 1), the retention-infiltration systems presented are currently noted as a sustainable solution, which contributes to the attenuation of the peak flows of the rainwater by extending their discharge time.

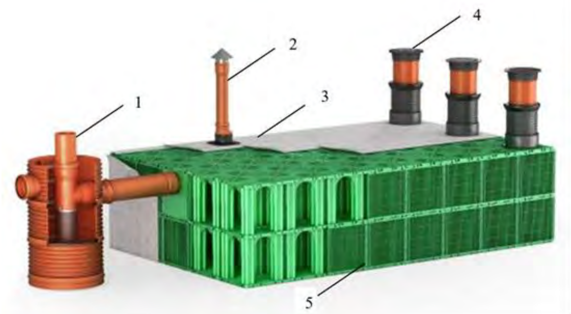

Figure 1: Under the ground water retention system.
1 – Sand separator; 2 – vent, 3 – geotextile membrane, 4 – manhole, 5 – honeycomb style tank.

5. Conclusions

Sustainable management of meteoric water in urban areas can reduce problems related to pollution associated with untreated rainwater. The collection of meteoric water at the place of fall offers a direct water source to solve the problem of water deficit at the household level and can recharge the groundwater, while reducing the risk of floods. Another aspect to underline, in relation to urban rainwater management systems, would be the need for complete documentation. This shall include prescriptions and recommendations regarding the design, execution and maintenance criteria, an analysis of costs and benefits, the impact on the environment and the implications of large -scale adoption.

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SECTION IV

STRUCTURAL MECHANICS

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Closed-form solution for simply supported composite beams with partial interaction

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Summary: *The paper presents an exact analytical method for the elastic analysis of steel-concrete composite beams with partial interaction subjected to concentrated mid-span loading. The solution is expressed in terms of axial force in the concrete slab and is derived by solving the second order differential equation that governs the behaviour of composite beams. A numerical example is provided to demonstrate the accuracy of the proposed method.*

Keywords: steel-concrete composite beams; partial interaction; exact solution.

1. Introduction

A common type of composite beams is represented by a concrete slab supported by a cold formed steel profile interconnected with ductile stud shear connectors that allow relative longitudinal slippage between the connected components. Therefore at cross sectional level, a discontinuity occurs in the strain distribution diagram at the steel-concrete interface, as shown in Figure 1. The evaluation of slip effects on both strength and stiffness properties is of current concern, although significant research has been reported in the past (Queiroz et al. 2007; Chiorean and Buru, 2017). In this paper, the second order differential equation of the steel-concrete element is derived adopting the basic hypothesis of Newmark’s model (1951). The equation is formulated in terms of axial force in the concrete slab under partial interaction and the closed-form solution is derived for a loading scenario. The elastic analysis of steel-concrete composite beams with interlayer slip is highly significant because it can be used to validate the code provisions related to deflection estimation and, moreover it provides specific information for more complex inelastic analysis.

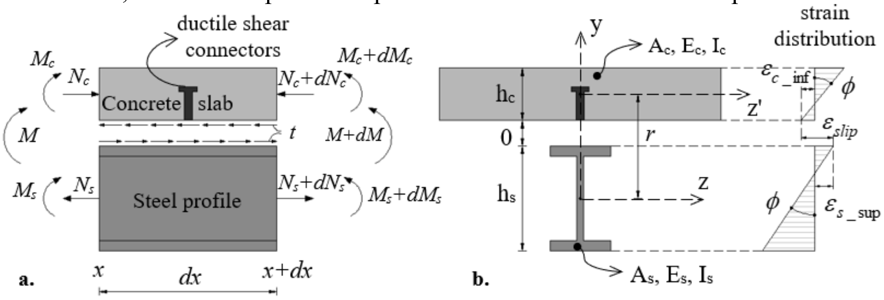

Figure 1 a. Infinitesimal steel-concrete composite element; b. Strain distribution.

2. Differential equation of steel-concrete composite beams with partial interaction

Consider the force distribution within the differential element shown in Figure 1a. Expressing the basic equilibrium of the infinitesimal beam element and using the compatibility relations, the following second order differential equation is obtained, where the general unknown is Nc, i.e. the axial force in the concrete slab in partial interaction conditions:

$$\frac{d^2N_c(x)}{dx^2} - \alpha^2 N_c(x) = -\alpha^2 \frac{r \cdot \left(\overline{EA}\right)}{(EI)^\infty} M(x) \qquad \alpha^2 = k\frac{(EI)^\infty}{\overline{EA}(EI)^0} \tag{1}$$

where, α is a parameter that considers the shear connection stiffness k, the flexural stiffness of the cross section under full and no interaction, $(EI)^\infty$ and $(EI)^0$. Once the solution of the differential equation is determined, it may be used to evaluate the longitudinal slip and the transverse displacement by double integration of Equation (2):

$$\frac{d^2w}{dx^2} = -\frac{M}{(EI)^\infty} + \frac{r}{k}\frac{\overline{EA}}{(EI)^\infty}\frac{d^2N_c}{dx^2} \tag{2}$$

By observing that the first term of the sum in Equation (2) represents the transverse displacement of the steel-concrete beam with full interaction, w_{fi}, the solution of the previous differential equation may be written in the following form:

$$w_{pi} = w_{fi} + \frac{r}{k}\frac{\overline{EA}}{(EI)^\infty}N_c \tag{3}$$

where w_{pi} is the elastic transverse displacement of the steel-concrete element under partial interaction, including in this way rigorously the partial interaction effects on the transverse displacement of the element.

3. Closed-form solution of the differential equation.

The general solution, in terms of axial force in the concrete slab, for a simply supported composite beam under mid-span concentrated loading can be written as shown in Equation (4) and it contains the solution of the homogeneous equation and also the particular solution which is in accordance with the bending moment expression:

$$N_c'(x) = N_{cf}'(x)\left[1 - \frac{P}{\alpha \cdot M(x)}\frac{sh(\alpha x)}{sh(\alpha L)}sh\left(\frac{\alpha L}{2}\right)\right], \quad x \leq \frac{L}{2};$$
$$N_c''(x) = N_{cf}''(x)\left[1 - \frac{P}{\alpha \cdot M(x)}\frac{sh(\alpha L - \alpha x)}{sh(\alpha L)}sh\left(\alpha\frac{L}{2}\right)\right], \quad x \geq \frac{L}{2}; \tag{4}$$

The integration constants were determined by knowing that the axial force is zero at the beam ends and by considering compatibility conditions at midspan.

4. Numerical example

The beam E1 experimentally tested by Chapman & Balakrishan (1964) is considered to validate the analytical procedure described above. The geometric configuration of the beam, the main material and shear connection properties can be found in Chiorean and Buru (2017). In Figure 2a comparative load mid-span deflection curves are shown. The elastic behaviour of the composite beam predicted with the proposed analytical model is in very close agreement with that reported by Queiroz et al. (2007) in which the behaviour is explicitly modelled by using advanced 3D finite element software. Compared to the experimental results, both numerical (Queiroz et al. 2007) and analytical procedures slightly underestimate the initial stiffness of the composite element.

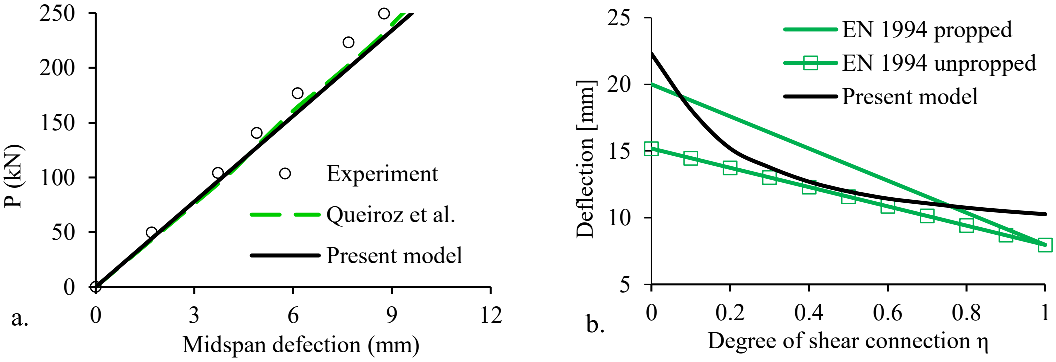

Figure 2a. Load-deflection curves; b. Deflection-shear connection degree curves.

Figure 2b depicts the mid-span deflections evaluated using Equation (3) for shear connection levels ranging from 0 (no interaction) to 1 (full shear connections) and those calculated according to EN 1994-1-1: Eurocode 4 (2006) provisions. The load level was set to 250 kN to assure the elastic behaviour of the beam. It can be noted that the Eurocode 4 provisions asses in an approximate manner the deflections of composite beams with partial shear connection. In this study, the deviations between the exact and code-based deflections are ranging from 3.5% to 22.4% and from 3.2% to 31.9% for propped and unpropped construction, respectively.

5. Conclusions

This paper presented an exact analytical method for the elastic analysis of steel-concrete composite beams under partial interaction conditions. A numerical model was given to demonstrate the accuracy and performance of the model. Furthermore, the solution may be used to derive the force-displacement relations of a 2-noded beam-column element with 6 degrees of freedom under partial interaction in a flexibility-based approach. Moreover, the analytical model can be modified to consider non-uniform shear connector distribution by simply dividing the beam according with variable spacing and treating each segment as beams with uniform distribution.

6. Acknowledgment

The research presented in this paper is part of a more comprehensive research focused on the advanced modelling and analysis of composite steel-concrete elements and frames led by prof. Cosmin G. Chiorean.

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Modelling Methods of Infill Walls in Progressive Collapse Analysis of RC Framed Structures

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Summary: *Modelling of the masonry infill walls in RC framed buildings represent a complex problem. There are two different modelling techniques: micro-modelling and macro-modelling. In this paper the advantages and disadvantages of each technique are pointed out. Micro-modelling is more accurate, but it requires greater computational costs and is time-consuming. Macro-modelling is a more simplified method that can easily be used in engineering structural design.*

Keywords: infill walls; macro-modelling; micro-modelling; progressive collapse; RC structures.

1. Introduction

In the reinforced concrete (RC) framed buildings, the masonry infill walls can have a significant impact on the strength, stiffness, and ductility of the entire structure, and it is important to consider their contribution to the building behaviour. In the current design codes, infill walls are often categorized as non-structural elements, and in the structural analysis models they are considered only as uniform distributed vertical loads on the beams.
There are many studies that have shown the beneficial effect of the infill walls on the seismic and progressive collapse behaviour of the buildings. Li et al. 2016, Shan et al. 2016 have tested more RC frames (with and without infill walls) to evaluate the influence of the infill walls on the progressive collapse performance of these. Experimental results have shown that the infill walls can significantly improve the resistance force and initial stiffness of the frames.
Using Finite Element Method (FEM), Li et al. 2019, Yu et al. 2019 have numerically validated the experimental tests performed by Li et al. 2016, Shan et al. 2016. Also, parametric studies and load transfer mechanisms under a middle column removal scenario have been investigated. In ELS computer software, which is based on Applied Element Method (AEM), Besoiu and Popa, 2017 have found that the infill walls have a valuable contribution in mitigating the progressive collapse risk of a multistorey RC framed building subjected to the loss of a column.
An accurate modelling of the infill walls involves knowing the mechanical properties of masonry, many interacting parameters, and the contact conditions along the interface surface between infill walls and surrounding frame. In this study, the modelling techniques of infill walls in RC framed structures are detailed, highlighting the advantages and disadvantages of each of them.

2. Modelling Methods

Micro-modelling and macro-modelling are two different methods used in the analysis of infilled frame structures. Both methods consider the nonlinear behaviour of materials and the geometrical nonlinearity.
Micro-modelling is a detailed technique that involves using a FEM computer software (ABAQUS, LS-DYNA). In this case the structure is consists by numerous elements to consider the local effect in detail. The masonry panel can be modelled in two different ways: as homogenous material (no distinction between the masonry block and mortar joints) and as two-phase material (masonry block and mortar joints are modelled separately with continuum elements). The boundary conditions at the interface surface between the infill panel and the surrounding frame can be modelled with springs or interface elements.
Macro-modelling is a simplified technique that considers as few elements as possible to represent the masonry panel, which is equivalent to one or more compressive diagonal struts. In this case it is very important to define the geometrical (dimensions, inclination, exact position) and mechanical (constitutive models of materials) properties of the equivalent struts. In the seismic analysis (lateral load) of infilled frame structures, Crisafulli, 1997, Chrysostomou, 1991, El-Dakhakhni, 2003 proposed different macro-models (presented in Figure 1), which can be adopted also in the progressive collapse analysis (vertical load) of buildings.

3. Results and Discussion

In previous research (Besoiu and Popa, 2017), the influence of the infill walls on the progressive collapse resistance of a 13-storey RC framed building subjected to the removal of a first-story corner column was assessed. For this purpose, two numerical model were analysed: a model without infill walls (frame model) and a model with infill walls (micro-model, in which the masonry panel was considered as homogenous material). Nonlinear dynamic analysis results have shown that the infill walls can reduce the maximum vertical displacement of the node above the removed column by about 48%.

High-fidelity micro-modelling is a complex procedure and involves great computational effort and long time for analysis. To reduce these shortcomings, a macro-model similar with those used for seismic analysis (presented in Figure 1) must be developed also for progressive collapse analysis of structures. The advantages and disadvantages of the infill walls modelling methods are shown in Table 1.

Table 1. Advantages and disadvantages of infill walls modelling methods

Modelling Methods	Advantages	Disadvantages
Micro-modelling (detailed method)	• high accuracy • all failure modes are considered • useful in research activity	• time consuming • high computational costs • strong knowledge of a FEM/AEM computer software
Macro-modelling (simplified method)	• computational simplicity • low computational time and costs • useful in practical design activity	• low accuracy • local failure modes are not considered • failure mechanism of the infill-frame interaction are not included

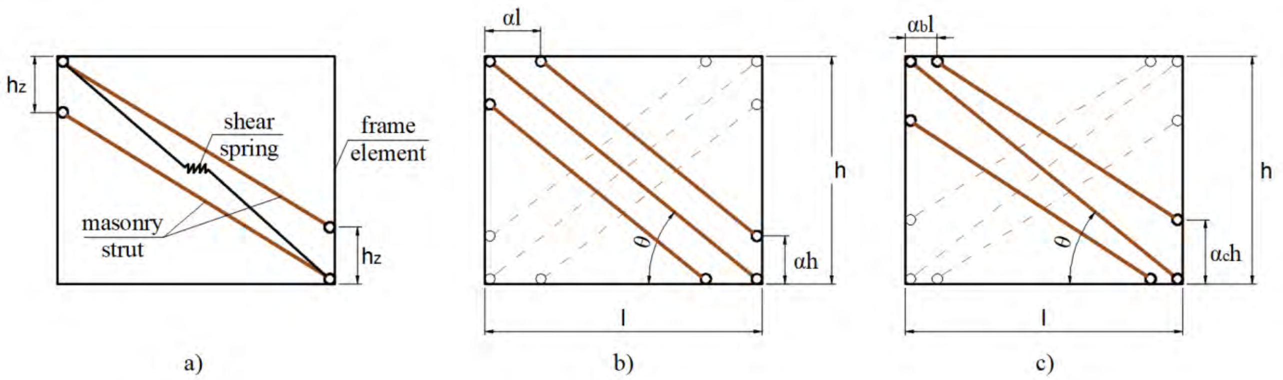

Figure 1: Multiple struts macro-models: a) Crisafulli (1997); b) Chrysostomou (1991); c) El-Dakhakhni (2003)

4. Conclusions

In this study, an overview of the modelling methods of infill walls in framed structures was presented. To evaluate the seismic or progressive collapse response of infilled frame buildings, in the literature different numerical and analytical models are proposed. Micro-modelling is based on Finite Element Method or Applied Element Method, while macro-modelling is based on equivalent compressive strut method. The main objective of the research in progress is to develop a multiple struts macro-model that can be successfully used in the progressive collapse analysis of infilled RC frame structures.

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Variation theorems in energy approach of seismically acted multi-storey structures

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Summary: *Energy balance equation of seismically acted upon multi-storey structures is mathematically processed and adequately interpreted in terms of energy variation theorems. The total energy state is defined in elementary and finite forms. Theorems of variation of energy state are inferred and graphically proved form the numerical results carried out on several steel multi-storey structures.*

Keywords: energy balance equation; energy state variation.

1. Introduction

Seismic action upon structures yields energy and induce it into the structures. Induced energy E_i is split into two main energy groups and, subsequently, follows two directions of development: a group that generates vibratory motion of associated masses and deformations of the structure and a 2nd component that is dissipated via inherent and added damping of the structure (Uang and Bertero, 1990). It may be stated that the 1st group (including kinetic energy E_k and potential energy E_s) *remains* in the structure during motion and became zero at the end of the seismic action, while the 2nd group (including E_{id} - dissipated energy via inherent damping and E_{ad} - dissipated energy via added damping) *leaves* the structure reaches its maximum at the same final instant. The energy components are arranged into defined total energy state and variation theorems are inferred from elementary and finite forms.

2. Analytical approach

The statics and kinematics of a single degree of freedom (SDOF) and of a multi degree of freedom system (MDOF) dynamic system are presented in Fig. 1 and Fig. 2, respectively (Chopra 1995).

a) SDOF system b) MDOF system

Figure 1: Seismically induced static and kinematic structural states

The traditional mathematics of a seismically induced vibratory state of a MDOF consists in the matriceal differential equation of dynamic equilibrium (1) or of the energy balance equilibrium equation (2):

$$\mathbf{M}\cdot\ddot{\mathbf{u}}(t) + \mathbf{C}\cdot\dot{\mathbf{u}}(t) + \mathbf{K}\cdot\mathbf{u}(t) = -\mathbf{M}\cdot\mathbf{r}\cdot\ddot{u}_g(t) \quad (1)$$

$$E_k + E_s + E_d = E_i \quad (2)$$

Here, $\mathbf{u}(t)$ is the story lateral elastic displacements vector while $\ddot{u}_g(t)$ is the recorded ground acceleration.

Let, $E_d = E_{id} + E_{ad}$ be the total dissipated energy. Total lateral story induced displacement $\mathbf{u}_t(t)$ includes base displacement vector $\mathbf{1}\cdot\ddot{u}_g(t)$ and elastic displacement vector $\mathbf{u}(t)$ via:

$$\mathbf{u}_t(t) = \mathbf{u}(t) + \mathbf{1}\cdot\ddot{u}_g(t) \quad (3)$$

Generated energy in seismic event is - from a mathematical point of view - a scalar parameter while, from a phenomenological point of view it is a cumulative amount. Latter aspect is emphasize by the integrating analytical procedures in computation energy. Generic expression of energy $E = \int_0 f(t)\cdot dt$ that leads to the value of energy generated from initial instant zero to the instant t highlight the fundamental difference between the equation of dynamic equilibrium (1) and the equation of energy balance (2) of a structure seismically acted upon.

Indeed, equation (1) of dynamic equilibrium expresses the mechanic state (both, static - equilibrium and kinematic - compatibility) of the structure exclusively at instant t - i.e., instantaneous structural response while, energy balance equation (2) asserts the influence of the past on the structural state at instant t.

3. Energy variation theorems

By simple calculus operations on (2) one successively obtains (Ladar, 2013):

$$dE_k + dE_s + dE_d = dE_i \qquad (4a)$$

$$d(E_k + E_s + E_d) = dE_i \qquad (4b)$$

One may note that the left hand side of (4b) is the variation of energy totally developed at the super-structural levels (i. e. $E_k + E_s + E_d = E_{sup}$), while the right side of (4b) is the variation of seismically induced energy to the infrastructure level (input energy E_i). Further, equation (4b) yields successively into its elementary form (5):

$$dE_{sup} = dE_i \qquad (5)$$

By introducing the concept of total energy state E of the structure at any instant t of the seismic action, one gets:

$$E = E_i - E_{sup} \qquad (6)$$

and (5) may successively reads:

$$dE = 0 \qquad (7)$$

$$E = \text{const.} \qquad (8)$$

The finite form (8) may take a variation form: *The total energy state of a seismically acted upon structure is constant at any instant of seismic action.*

4. Numerical results

Several numerical seismic analyses have been carried out aiming at proving the theoretical results. The numerical results obtained for a five levels (Fig.2) steel structure acted upon by seismic actions Vrancea 1977 and Focsani 1986, respectively are presented in Fig. 3 and Fig. 4. It may easily by proved the constancy of energy state expressed by $E = E_i - E_{sup} = \text{const.}$

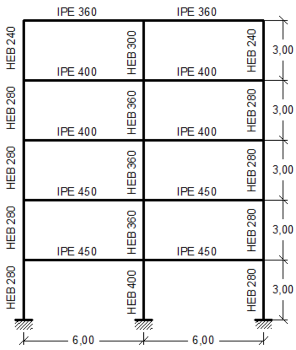

Figure 2: Five storey structure

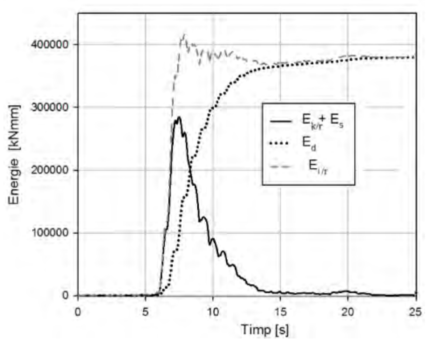

Figure 3: Energy balance - Focsani

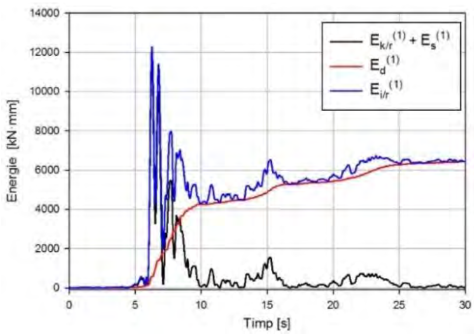

Figure 4: Energy balance – Vrancea

5. Conclusions

Variational interpretation of energy sate in seismically acted upon structures have been inferred from energy balance equation and energy interpretation of equation of dynamic equilibrium. By involving statically equivalent forces and shear base type forces, the work performed by these forces may be included and a new set of theorems are obtained (Lădar, 2013). The theorems and their interpretation prove to be specific cases of general conservation energy theorems. In the field of structural engineering, the mitigation of seismic energy became of general concentration, while it is focusing on the equipment and techniques. Present contribution tries to add a rather theoretical aspect in the matter.

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Lateral Loads Influence on the Progressive Collapse Risk of Flat Slab Structures

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Summary: *The objective of the current research is to numerically investigate the impact of lateral loads on the progressive collapse risk potential of a seismically designed flat slab structure. In the first phase, a quasi-static analysis is performed by subjecting the structure to a sequence of cyclic lateral loads. Following this, the second phase replicates the sudden removal of a ground floor column. The obtained results are assessed by comparison with the progressive collapse failure criterion, provided by the main design guidelines.*

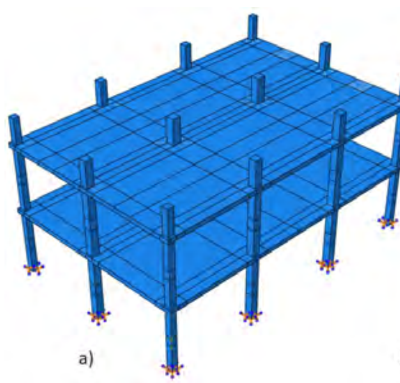
Keywords: progressive collapse; flat slab; RC structures; column failure; cyclic loads.

1. Introduction

The resilience of flat slab structures when exposed to various load scenarios, including gravity loads, lateral forces, and abnormal loads, has become a highly significant subject in technical literature. This topic has garnered considerable attention from researchers such as Qian and Li (2013), Xue et al. (2018) and Mahrous et al. (2020). To the best of the author' knowledge, there has been insufficient investigation into the potential collapse of flat slab structures under the combined influence of gravity and cyclic lateral loads, especially when these loads approach the lateral displacement limit defined by the code. This deficiency extends to scenarios where one or multiple vertical members are abruptly removed. Thus, in this study, the influence of lateral loads on the progressive collapse risk potential of a reinforced concrete flat slab structure, designed in accordance with the Eurocode 8 (2004) regulations, is numerically investigated.

2. Numerical model and analysis methods

A three-dimensional numerical model was developed based on the specimen that underwent experimental testing at the ELSA Laboratory of the EC-JRC Ispra (SlabStress (2019)), based on FEM approach in Abaqus (2013) software. The flat slab structure's layout includes two spans (4.5m), three bays (4.5 and 5m) and two floors (3.2m). Figure 1 illustrates the geometric configuration of the structure, the dimensions of the structural elements and the reinforcement details.



b)

Structural element	Dimensions [cm]	Reinforcement Detailing		
		Longitudinal direction	Transverse direction	Section
Corner column	30 x 30 x 760	12 ϕ14	ϕ10/5	1st column section (0-40cm)
Interior column	40 x 40 x 760	12 ϕ16	ϕ8/10	2nd column section (40-130cm)
External column	35 x 35 x 760	12 ϕ20	ϕ8/10	3rd column section (170-760cm)
Flat slab	20 x 950 x1450	ϕ12	ϕ12	Bottom reinforcement
		ϕ8, ϕ12, ϕ14	ϕ8, ϕ12, ϕ14	Top reinforcement
		Shear reinforcement (headed studs) only on the top floor slab		

Figure 1: a) 3D numerical model; b) Dimensions and reinforcement details of structural elements

The nonlinear concrete behavior is simulated using the "Concrete Damage Plasticity" (CDP) approach, whereas for steel, a combination of the "Plastic" option and the "Ductile Damage" option is employed. This combination allows for the consideration of reinforcement fracture. The finite elements used for concrete are C3D20R solid elements while for the steel reinforcement, B31 linear finite elements are considered.

In accordance with the design guidelines of GSA (2016) and DoD (2016), the assessment of progressive collapse potential can be conducted by employing the "missing column scenarios" technique. The applied loading scheme can be grouped into two distinct phases. In the first phase, two steps are considered. During the first step, vertical loads are applied downward to the structure, and in the second step, a series of cyclic lateral loads are considered. Three cycles are executed for each lateral drift level (0.25%, 0.5%, 1%, etc.) until a maximum drift of 1.5% is attained. This value aligns with the ULS acceptance limit stipulated by the seismic code (Eurocode 8 (2004)). The second phase involves simulating the instant removal of the exterior ground floor column situated on the shorter side of the structure. To capture the dynamic effects of this event, a removal time interval of 0.005 seconds is considered. The nonlinear dynamic procedure, applied in the second phase, has a total duration of 3 seconds.

3. Results and Discussion

The main objective of the current study is to emphasize the influence of the cyclic lateral loads on the progressive collapse risk of a flat slab structure designed to withstand seismic forces, previously exposed to gravitational forces. This influence, indicated in terms of maximum vertical displacement measured above the removed element, is illustrated in Figure 2. If we focus exclusively on the gravity load combination before the instant removal of the vertical support, the maximum displacement registers at 17.81mm. This measurement, corresponding to a total rotation of 0.004 radians, emphasizes the structure's ability to withstand progressive collapse. In contrast, when cyclic lateral loads are applied alongside the gravitational forces, the removal of the exterior column results in a peak downward displacement of 39.96 mm. This represents a 2.24 times increase compared to the previous displacement. This value corresponds to a total rotation of 0.0089 radians, indicating that the structure still maintains a low risk of progressive collapse, in accordance with guidelines from GSA (2016) and DoD (2016).

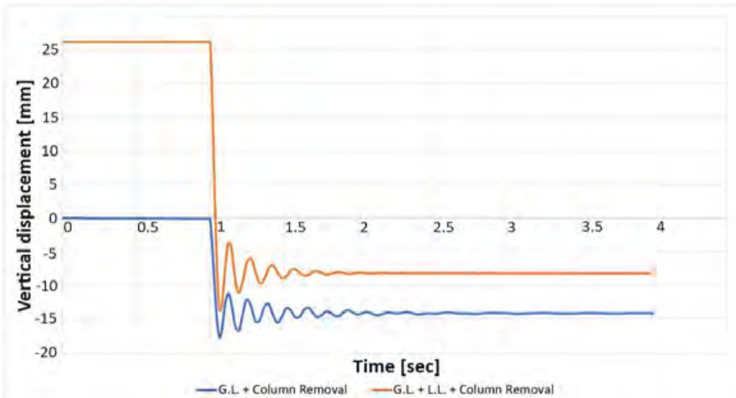


Figure 2: Time-displacement curves: Gravity Load (GL)+Column Removal, Gravity Load (GL)+ Lateral Load (LL)+Column Removal.

It's noteworthy that the maximum vertical displacement commences from distinct initial conditions when compared with the displacement observed in the original loading case. The starting point for the downward movement is situated 26.24mm above the initial position of the slab-column connection, as shown in Figure 2. This phenomenon can be attributed to punching shear failure manifesting in particular connections during the application of cyclic lateral loads.

4. Conclusions

The present investigation reveals that when employing the methodologies outlined in international guidelines for assessing the progressive collapse risk, the analyzed seismically design flat slab structure has a low-risk potential. The maximum plastic rotation angle is significantly lower, specifically one-twelfth of the accepted criterion of 0.05 radians. If the structure experiences a cyclic lateral load of 1.5% inter-story drift ratio prior to the sudden column removal, the observed degradation pattern in the slabs indicates notable punching shear failures in the connections lacking shear reinforcement. Consequently, the vertical displacement increases by a factor of 2.24. This value remains below the guidelines accepted criterion, demonstrating that the structure complies with the progressive collapse requirements.

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Progressive collapse resisting mechanisms of high rise RC frames subjected to column failure

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Summary: *In this paper the progressive collapse response of a ten-story reinforced concrete planar frames is investigated. The numerical model developed in MIDAS FEA software package is calibrated by the experimental test performed by Yi for a three-story RC frame. A nonlinear static "push-down" analysis is conducted for both the calibrated model and the investigated ten-story model. These results indicate the activation of supplementary resisting mechanisms of the planar frame when subjected to column failure.*

Keywords: progressive collapse; column failure; RC frames; nonlinear analysis.

1. Introduction

The progressive collapse is described as a situation where a local failure of a structural element causes the collapse of the adjoining members, which leads to the collapse of the entire building, total damage being disproportionate with the original cause (e.g. explosions, bombs, impact by vehicles).
However, since these accidental loads are extremely rare events that can occur during the lifetime of a structure, it is more appropriate, from an economical point of view, to mitigate the risk for progressive collapse than to specially design them to resist all these threats.
Recent numerical studies have shown the ability to better resist progressive collapse of RC framed structure when subjected to column removal (Tsai and Lin, 2008), results that were validated by the experimental tests (Choi and Kim., 2011), (Yi et al., 2008).
This study investigates the progressive collapse response of a ten-story reinforced planar frames subjected to column failure. The numerical model is calibrated first based on the experimental results provided by Yi et al. (2008). A nonlinear push-down analysis is conducted to simulate the failure of the first-story column. The supplementary resisting mechanisms to better resist progressive collapse for seismically designed RC frames, are highlighted.

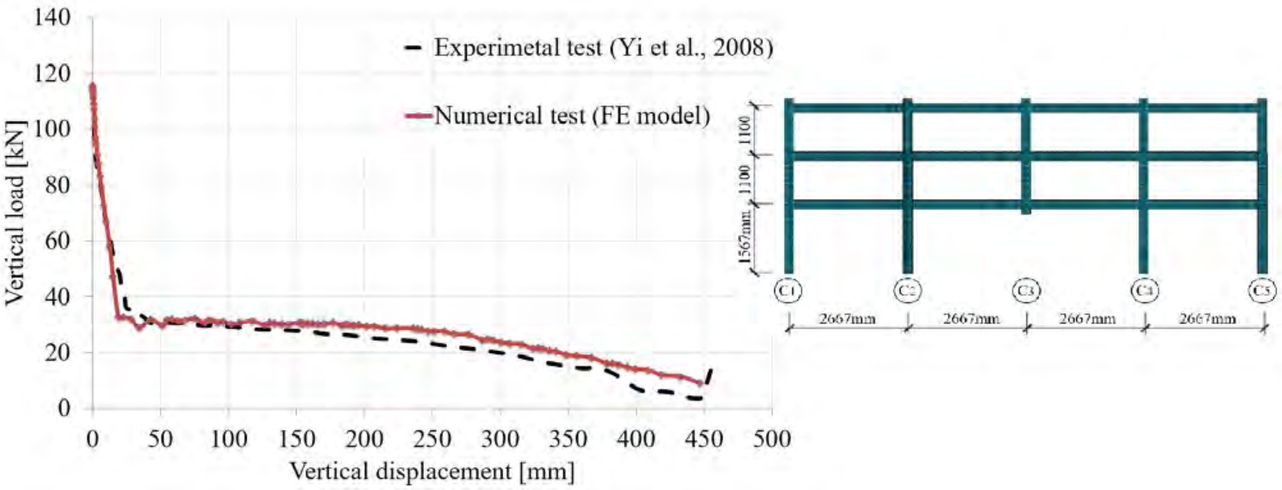

Figure 1. Vertical load - vertical displacement curve: experimental test (Yi et al. 2008) vs. numerical results (Marchis and Ioani, 2016).

2. Numerical model

To estimate the progressive collapse potential, the Alternative Path Method has been selected as the basic approach. According to this method, structures should be capable of developing alternative load paths over the removed column as the result of accidental loads. This method does not require characterization of the threat causing the loss of the column as a result of accidental loads.
In this paper, using the nonlinear "push-down" analysis procedure, the first story middle column (C_3) is considered as failed. The gradual failure in the static procedure is characterized by applying a vertical target displacement (Δ=50cm) at the column removed point; the column is already removed in the initial phase, before runs the analysis.
The numerical model, developed in Midas FEA software package in previous paper (Marchis and Ioani, 2016) and validated by the experimental results obtained by Yi et al. (2008) are illustrated in Figure 1.

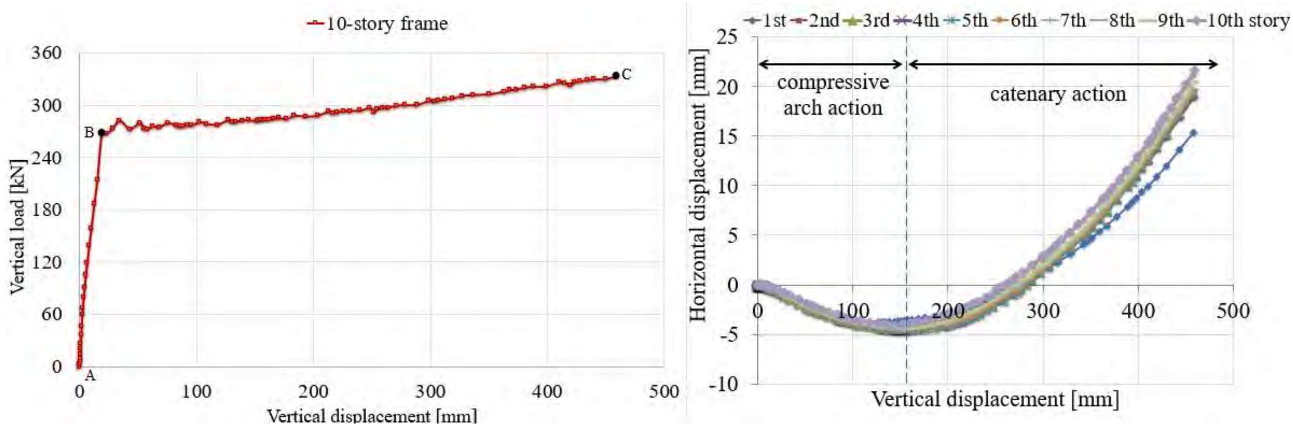

Figure 2. Progressive collapse behavior of the 10-story frame model: (a)Vertical load vs. vertical displacement of the column removed point; (b) Compressive arch action and Catenary action state.

The validated numerical model consists of four 2.667m bays and three stories with a height of 1.567m for the ground level, respectively of 1.10m for the second and third floor (Figure 1). The material characteristics for both concrete and steel are similar with the ones specified in the experimental test (Yi et al. 2008). For concrete, a Thorenfeldt constitutive model is adopted for concrete in compression and a Hordijk model is assumed for concrete in tension; a Von Mises model is considered for the behavior of the reinforcement steel. The concrete elements and the steel reinforcement bars are modelled in MIDAS FEA software using solid 3D finite elements, respectively beam finite elements both with a mesh size of 25mm.

3. Results and Discussion

The load carrying capacity of the 10-story finite element model is illustrated in Figure 2(a). The elastic-plastic state is between point A and B characterized by concrete cracks in tension in the beams adjacent to the removed column C_3. Point B on the curve (Figure 2(a)) is associated with the yield load (F_y=267.27kN) which indicates the activation of the three hinged failure mechanism. The B-C section is characterized by large deformations of the beam elements with small increasing of the load values. Point C on the curve is associated with the peak load (F_u=333.87kN), after that the collapse will take place.

When the yield load F_y is attained, the three hinged failure mechanism is activated. However, the frame still resists to collapse initiation due to the supplementary activated mechanisms. First, the compressive arch action is activated as illustrated in Figure 2(b) until a 150mm for the vertical displacement of the column removed point is attained. At this step, the horizontal displacement of the beams adjacent to the removed column changes from compression to tension; this indicates that the loads associated to the removed column are transmitted by the adjacent beams to the undamaged columns only by tension behaviour. Thus, the catenary action state occurs.

4. Conclusions

This paper investigates the progressive collapse response of a 10-story reinforced concrete frame subjected to column failure as a result of accidental loading. The numerical model developed in MIDAS FEA software was validated by the experimental test (Yi et al. 2008). As expected, when the yield load (F_y=267.27kN) is attained, the three hinged failure mechanism occurs. However, the frame is not considered as failed, yet. Two supplementary resisting mechanisms (the catenary action and the compressive arch action) are activated. The peak load (P_u) attained before the collapse initiation is with 35% higher than the yield load (F_y).

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Advancements in Base Seismic Isolation Systems: A Comprehensive Review

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Summary: *The paper assesses the latest developments in base seismic isolation technology. It scrutinizes various advancements in design, materials, and methodologies employed in passive seismic isolation systems Following the analysis of recent research and case studies, this paper offers an insight into improving structural resilience and minimizing damage caused by seismic events. The comprehensive review underscores the significance of passive seismic isolation as an evolving and effective strategy in enhancing structural safety and stability in seismic regions.*

Keywords: seismic isolation, earthquake engineering, base isolation, structural safety

1. Introduction

A seismic base isolation system is employed to mitigate the impact of ground shaking during earthquakes on structures and their components, safeguarding them from potential damage. This system effectively severs the structural connection between the building or structure and the horizontal ground motion by introducing structural components with minimal horizontal stiffness between the structure and its foundation. As a result, the structure acquires a fundamental frequency significantly lower than both its fixed-base frequency and the prevailing frequencies of the ground motion, enhancing its seismic resilience.
Due to the increasing demand for earthquake-resistant building designs in countries with earthquake-prone zones, the market for base isolators is experiencing significant growth. The global seismic base isolation system market size is estimated to be worth US$ 405.1 million in 2022 and is forecast to a readjusted size of US$ 515.5 million by 2028 with a CAGR of 4.1% during the review period according to a study published by Precision Reports (Precision Reports, 2022). This is just one of the reasons that led research related to base isolation devices to focus on two important directions: optimizing already established isolators and developing new isolation systems, with sustainable materials and technology.

2. Widely employed passive seismic devices

Seismic isolators find widespread application in commercial and residential buildings, while their use in state-owned structures, industrial facilities, and other contexts is less common. The market for seismic isolators can be categorized based on the type of isolators used for structural decoupling. These categories include Low-Damping Rubber Bearings (LDRB), with Natural Rubber Bearings (NRB) being the prevalent choice, High-Damping Rubber Bearings (HDRB), Lead Rubber Bearings (LRB), and Friction Pendulum Bearings (FP).
NRBs are one of the earliest forms of seismic base isolators and are still widely used today. They consist of alternating layers of steel shims and natural rubber pads. NRBs are renowned for their simplicity, cost-effectiveness, and robust performance under seismic loads. Pros include being cost-effective and readily accessible, demonstrating proven reliability in numerous seismic events, requiring minimal maintenance, and being applicable to a wide range of uses. However, there are issues about limited energy dissipation capacity, decreased damping during cyclic loading, and susceptibility to environmental factors like temperature and humidity.
HDRBs, as the name suggests, enhance the damping capacity of rubber bearings by incorporating a higher damping ratio. This is achieved by using special rubber compounds and, in some cases, additional energy dissipating mechanisms. Advantages include increased energy dissipation, which mitigates structural movement during seismic events, heightened resistance to powerful ground motions, adaptability for retrofitting existing buildings, and decreased demands on structures in terms of displacement and acceleration. However, drawbacks consist of a higher initial expense relative to NRBs, a potential for heightened maintenance needs, and a restricted supply of specialized materials and components.
LRBs combine rubber bearings with a central lead core. This design provides both flexibility and energy dissipation, making LRBs a popular choice in seismic isolation. Advantages encompass outstanding energy dissipation and damping capabilities, effectiveness in minimizing building drift and acceleration, a demonstrated track record in withstanding moderate to severe earthquakes, and a longer operational lifespan compared to certain alternatives. However, disadvantages consist of a relatively elevated initial expense, susceptibility to lead core corrosion in specific

environments, and the need for meticulous design and installation to guarantee optimal performance.

FP systems use sliding bearings and pendulum-like mechanisms to dissipate energy during an earthquake. These devices offer a unique approach to base isolation. The advantages include exceptional proficiency in energy dissipation, minimal maintenance prerequisites, suitability for both new construction and retrofitting endeavours, and adaptability across diverse building typologies. On the contrary, limitations involve intricate design and installation processes, necessitating precise calibration, alongside an increased initial cost due to the utilization of specialized components.

Each of the above-mentioned devices offers unique advantages in terms of energy dissipation, stability, ease of implementation, and adjustable characteristics, making them essential components in enhancing structural safety and resilience in earthquake-prone regions. Engineers carefully select and design these devices based on the specific requirements and characteristics of the structure and the surrounding seismic environment.

3. Recent advancements and future direction of research in seismic isolation

Over the years, there have been significant advancements in base seismic isolation devices, driven by research and technological innovation. These developments have not only improved the safety and resilience of structures but have also opened new possibilities for future research directions. The transition from one generation of base isolation system design to the next is characterized by significant seismic events, often revealing increasingly larger spectral values (measured in terms of acceleration, velocity, and displacement) that had not been anticipated in building codes or within the scientific community at that time. The subsequent heightened awareness of these substantial spectral values emphasized the necessity of meeting more rigorous requirements in terms of the design vibration period and design displacements (De Luca, 2019). The main direction of the research is aimed at finding advanced materials, creating new types of isolators, or developing hybrid systems while making the products more sustainable. Hybrid systems are towse that combine two or more isolation devices or elements, such as lead-rubber-bearing with negative stiffness springs (LRB-NS) (Chen et al. 2022), flat-spring friction system (Wei, 2021). One of the most notable advancements in seismic isolation technology is the development of advanced materials. HDRB, laminated elastomeric bearings, and shape memory alloys (SMA) have been extensively researched and incorporated into isolation devices. For many years, the comparatively expensive cost of manufacturing and processing SMAs in buildings was one of the material's limits. The recent progress in the production of affordable shape memory alloys (SMAs), primarily composed of iron (Fe-based SMAs) and copper (Cu-based SMAs), has expanded the potential utilization of SMAs in a broader spectrum of large-scale construction projects. Consequently, the advancement of cost-effective SMAs, particularly those based on iron and copper, represents another significant factor contributing to the increasing adoption of SMA applications in the field of structural engineering and base isolation (Tabrizikahou, 2022). Another direction of research is conducted in elastomeric and sliding isolation systems with adaptive behaviour. Here it is wort mentioning devices like: unbonded fiber-reinforced elastomeric isolator (UFREI), Elastomeric bearing with steel dampers, Rubber isolators with strain-induced crystallization, sliding isolator with variable curvature (SIVC) or friction (SIVF) or isolators involving magnetic fields (Sheikh and Van Engelen, 2022).

4. Conclusions

In conclusion, the evolving landscape of research in passive base seismic isolation is marked by a diverse array of promising directions. From innovative materials and multi-hazard resilience to energy harvesting and adaptive control strategies, these developments hold the potential to revolutionize the field of seismic protection. Moreover, the pursuit of low-cost solutions, sustainability, and rigorous field testing demonstrates a commitment to making these technologies more accessible, environmentally responsible, and empirically validated. Embracing these directions promises not only enhanced structural safety but also a more resilient and sustainable built environment, addressing the pressing challenges posed by seismic hazards.

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CFD simulation of time varying wind pressure on structures

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Summary: *Intended contribution refers to modelling of wind action on multi-storey structures using the Computational Fluid Dynamics approach. The modern CFD technique allows the inclusion of an entire vicinity of structures in dynamic analysis to wind action. The main objective of the contribution is the computation of wind velocity and pressure distributions.*

Keywords: wind; velocity; pressure; CFD.

1. Introduction

Dynamic analysis of structures subjected to wind action is, practically, dominated by quasi-steady approach that, actually substitutes the dynamicity of wind by statically applied forces. Computational Fluid Dynamics (CFD) is a modern approach to wind action allowing for a more realistic model that includes a large distribution of structures inside a bounded layer. The volume such defined including several structures is further modelled via 3D refined finite element technique. The dynamic effect of turbulence generated by built environment is included in computation of velocity and pressure of wind associated to objective structure.

2. Analytical model of natural wind

CFD approach to wind action requires a 3D geometry that includes objective structure and its environment. A wind of a selected velocity is considered acting in the defined boundary layer. Present contribution adopts $k-\omega$ SST turbulence model (Hu et al. 2013; Sun et al. 2009) that is further processed via finite element analysis (Figure 1) leading to wind velocity and pressure distributions (Figure 2) associated to an input wind velocity of 35 m/s (Blaga, 2022).

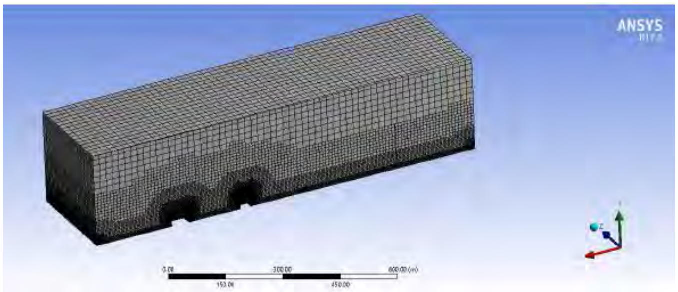

Figure 1: Finite element model of the boundary layer

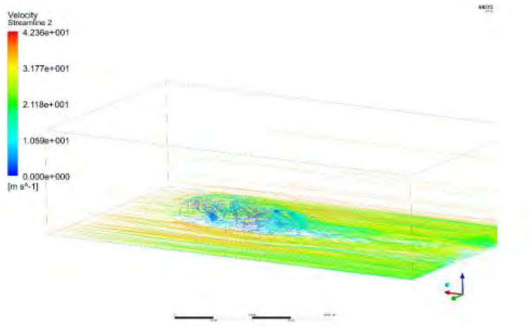

Figure 2: Wind velocity distribution-3D view

3. Numerical results

Carried out study includes several multi-storey structures acted upon by turbulent wind leading to time dependent velocity and pressure on a 12 storeys structure (Figure 3). Referring to the 3D distribution of wind in both, around objective building and a larger surrounding area, an intense concentration of turbulence effect may be concluded (Figure 2).
Among the computed results are the wind velocities (Figure 4, Figure 5) obtained by considering a point at 1.00 m in front of the building. The values of CFD results referring to velocity are only positive since they represent the module of the 3D wind velocity vector. The values vary along the height of the building and - in the same time - emphasize the time variation of velocity, actually the turbulence.
Associated pressure values on inward (Figure 6) and outward façade (Figure 7) respectively express both, wind generated pressure and suction. Suction on inward / exposed façade is the result of wind action on surrounding buildings, while the suction on outward / un-exposed façade is expected.

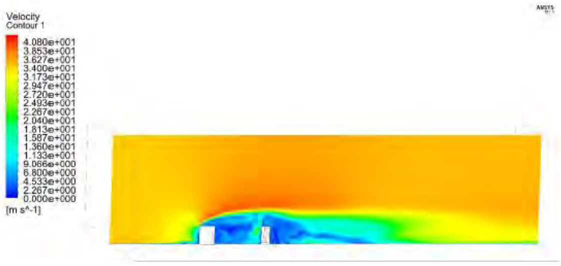

Figure 3: Wind velocity distribution-2D view

Computed results regarding velocities (Figure 4, Figure 5) and pressure / suction (Figure 6, Figure 7) are graphically presented.

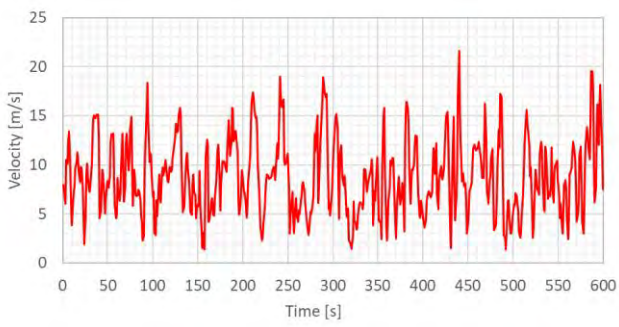

Figure 4: Velocity distribution at z=11.20 m

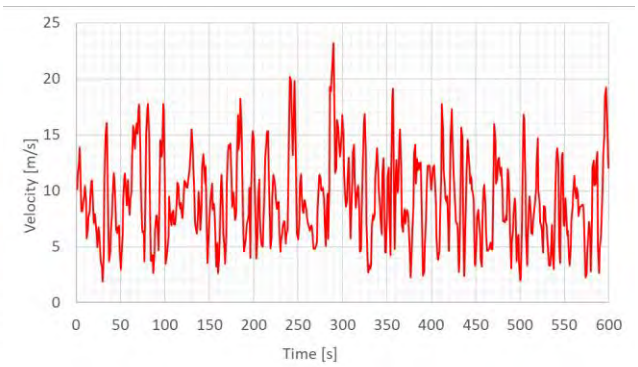

Figure 5: Velocity distribution at z=18.40 m

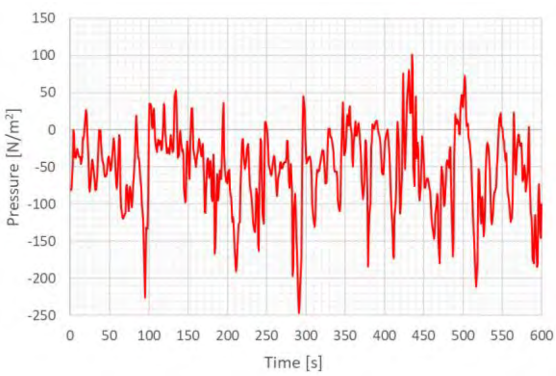

Figure 6: Pressure distribution at z=18.40 m
on inward façade

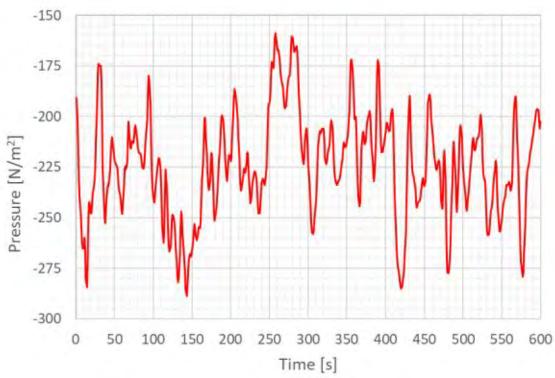

Figure 7: Pressure distribution at z=18.40 m on
on outward façade

4. Conclusions

CFD approach allows for time dependent numerical model - via turbulence - of dynamic wind action. The dynamicity of the action can be concluded from the diagrams of velocity and pressure. A novelty of computed results by CFD approach is the negative pressure on inward façade. The influence of built environment on studied structure is clearly emphasized by pressure distribution on both façades. The turbulence phenomenon is deeply dynamic from both, temporal and spatial point of view leading to the necessity of modelling an entire 3D environment that includes the studied structure.

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A design fire calculation method for enclosure fires

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Summary: *This paper gives a structured method to calculate the design fire curve for an enclosure fire, based on the Eurocode 1991-1-2. For this purpose it has been considered the Room 161 from the Faculty of Construction main building situated at 25 Baritiu Street. A design fire has been determined, based on the actual conditions as the total amount of combustibles within the room, the space geometric layout, the ventilation conditions and the boundary characteristics.*

Keywords: heat release rate; energy released; design fire; fire stages; enclosure.

1. Introduction

The fire action assessment on the buildings it is nowadays acknowledged by most of the design regulations worldwide. There are two basic approaches that can be followed in structural design, namely a prescriptive design, i.e. an implicit form of applying rules and safety measures based on the past experience or a performance based design which requires the application of engineering judgment and knowledge.
Prescriptive based design does not give the possibility to optimise the structures or to reduce the costs, because the impact of different safety measures or the fire behaviour or the structural elements cannot be quantified. In this approach, “one size fits all”, by applying the same rules for all the buildings with the same occupancy type (Franchini, Galosso, & Torero, 2023). The fire is modelled as a fully developed fire by a logarithmic time-temperature curve, referred as the standard fire. All the structural and non-structural elements are required to withstand a certain period of time to the standard fire action keeping their bearing capacity - criterion R, their integrity - criterion E or their insulation - criterion I. The standard fire curve models a fully developed fire, meaning that the initial stages of the fire are disregarded. The logarithm function grows to infinity, so the fire model will increase the temperature continuously to unrealistic values.
Real fires have several stages with different intensities. After the ignition has occurred, the heat starts to build up and there is a growth period which can take several minutes or hours. When the smoke and hot gasses accumulated at the upper part of an enclosure will reach about 500ºC-600ºC, then the flashover may occur, when the fire spreads throughout the entire enclosure. Further, the fire will have a steady burning until 70%-80% of combustibles are consumed, when it will start to decay, decreasing in intensity and eventually it will extinguish. This is the natural fire concept, describing the stages of a real fire within an enclosure, assuming that sufficient oxygen is available and there are no suppression measures (Karlson & Quintiere, 2000).
Prescriptive based design may be adequate for a range of typpical buildings where the past experience did prove compliance, but for unique modern buildings such as airports, mall centres, high rise buildings it is often required another approach based on engineering judment and expertise due to the high complexity of the sistems working all together within the same space. For all the evacuation strategies design, one should model a design fire using the natural fire concept, because the life saving is only possible during the growth period. After the flashover has occurred, the temperatures within the fire enclosure are around 800ºC-1000ºC. The Heating, Ventilation and Air Conditioning (HVAC) systems design is related to the early stages of a fire and it will also require several design fires of different fire scenarios.
The European codes for structural design give a design procedure to model a natural fire inside an enclosure (SR EN 1991-1-2, 2004). The Annex E – normative (SR EN 1991-1-2-2004 National Annex, 2006) - gives several relationships without extensive explanations or suggestive graphs. The subsection E.4, briefly, defines the heat release rate which is the most important parameter in fire dynamics.
This paper is meant to structure the information given in the Annex E and to present the steps to build a design fire curve by a practical example on the Room 161 of the Faculty of Constructions.

2. Eurocode method to construct a design fire

The heat release rate represents the thermal energy released in a fire. It is denoted HRR or Q with a dot above, which means that is a quantity that varies in time. The measuring units, used more often in the calculations are kW (= kJ/s) or MW (=MJ/s). The total amount of energy released is expressed in kJ or MJ and is denoted with a simple letter Q, or with E, to avoid the confusion with the rate of energy released (Karlson & Quintiere, 2000).
While a fire develops within an enclosure, there are two possible burning regimes. The fire can be limited by the lack of sufficient oxygen within and room and through the openings – when is called a ventilation controlled fire, or the fire can be limited by the amount of combustibles – when there is a fuel-controlled fire. In order to construct a fire curve,

showing the heat release rate evolution in time, it is necessary to assess which of the two limiting situation occurs first. The characteristic fire load density is given, in MJ/m^2, in Table E.4, for different occupancy type. For school classrooms, one should take the 80% quartile value for a more conservative approach, if there are no data available for the fuel amount and configuration within that space. This value should be transformed into a design fire load density affecting it with the safety factors given by the formula (E.1). In order to assess the total amount of energy that can be released in the worst case scenario fire, when it occurs a burnout of all combustible materials within that enclosure, the design thermal load density is multiplied with the floor area because it is assumed a fully developed fire stage.
The design fire curve, shown below in Figure 1, has three regions: the growth stage, modelled as a t-squared fire, the steady state fire and the decay period, where the heat released rate has a linear decrease. In the Eurocode it is assumed that the decay phase begins after 70% of the energy has been released, meaning that 30% of the combustibles are left.
Figure 2 represents the layout of the Room 161, giving the configuration of the thermal load, which can be used to assess the characteristic thermal load density, rather than use the prescribed value from table E.4. from Annex E.

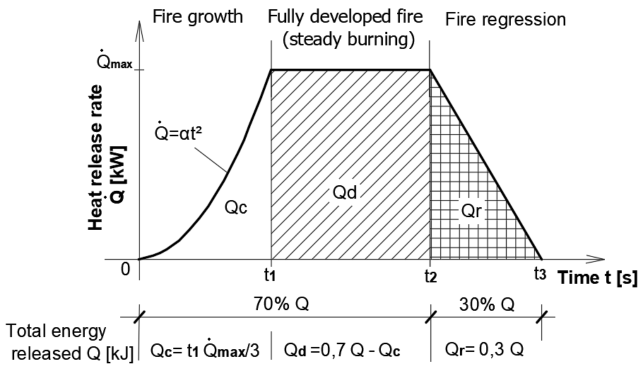

Figure 1: Design fire curve (SR EN 1991-1-2: Annex E)

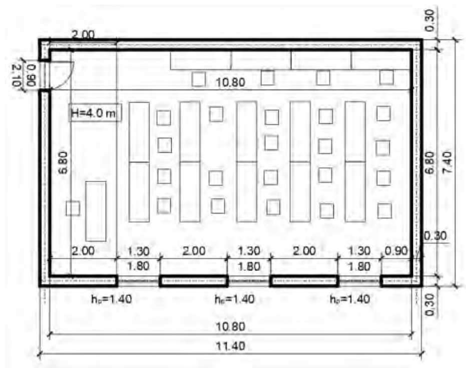

Figure 2: Room 161, 25 Baritiu Street

3. Results and Discussion

The design fire within the Room 161 it is ventilation controlled. The total amount of oxygen available for burning, within the enclosure, without taking into account the openings, would be sufficient to burn approximately 3% of all combustibles. Considering that there is fresh air entering through the openings, the fire will reach the burnout after one hour. The durations for each stage of the design fire are given, below, in Table 1.

Table 1. Summary table with the results for the duration of each design fire stage for the Room 161

Fire stage	Duration [sec]	Duration [minutes]
Growth period	1191	20
Fully developed fire (steady burning)	397	7
Fire decay	2378	40

The design fire curve can further be refined, by taking into account the flashover stage and estimating the energy required to reach this transition to fully developed fire. If the heat released rate for flashover is estimated, within the graph will occur a sudden jump from this calculated value to the maximum. This leads to a shorter growth period.

4. Conclusions

Applying the prescriptive regulations to the complex buildings is a blind design. In some cases, there is a waste of resources and in other cases, the prescriptive solution does not cover the fire hazard, but is impossible to quantify it. The application of the performance based design requires an engineer.

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C70 International Conference
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The Validation of the Natural Characteristics of Vibration of a Shaking Table Tested Model

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Summary: *In this paperwork we present some methods used for the computation of the natural characteristics of vibration for a 3 DDOFs dynamic model. The MAC (Modal Assurance Criterion) was applied for the correlation (i. e. spectral matrix -analytic and test) in the frequency-domain. Also, system identification was performed and corrections were made for the damping.*

Keywords: model validation; seismic tests; steel structure.

1. Introduction

The structural analysis is based both on theoretical and experimental methods. During past decades the scientific tests increased in number and precision and provided strong proof for the analytical algorithms. In this way the design algorithms became more performant.
In this paperwork we present some methods used for the computation of the natural characteristics of vibration for a 3 dynamic degrees of freedom (DDOFs) model. The steel model structure is shown in the photo from Figure No. 1. As easily can be noticed, the real construction is 3D so it has many DDOFs.

Figure 1: The Experimental Model on the Shaking Table

The limited number of transducers and channels of data acquisition leaded to a simplified model (2D). The initial inaccuracies of the analytical model were corrected by the means of system identification techniques in the frequency domain and time domain.
In the end some conclusions are emphasized regarding the system matrices.

2. Methods

In reality the steel model structure was tested for several purposes. Our study is focused on the model verification and validation. The frame has 3 storey and it is fully clamped on the shaking table. The shaking table has 3 degrees of freedom, translational, in the universal Cartesian coordinates system (UCS). The motions were granted along one direction (OX).
The structural model is built in such a way to ensure stiff joints and additional masses are fixed at each horizontal level. These masses contributed to the overall stiffness, acting like rigid plates. Displacement transducers were mounted at each steel storey joint to both columns. The tests demonstrated the same relative displacements for both longitudinal frames.
The experimental map consisted of sine sweeps at several energy levels, as in the Fig. No. 2(a). After that the seismic loads were applied using time-history functions (Vrancea-1986) at increasing intensity. The significant part of this

earthquake ground motion (displacements) is depicted in the Fig. No. 2(b).

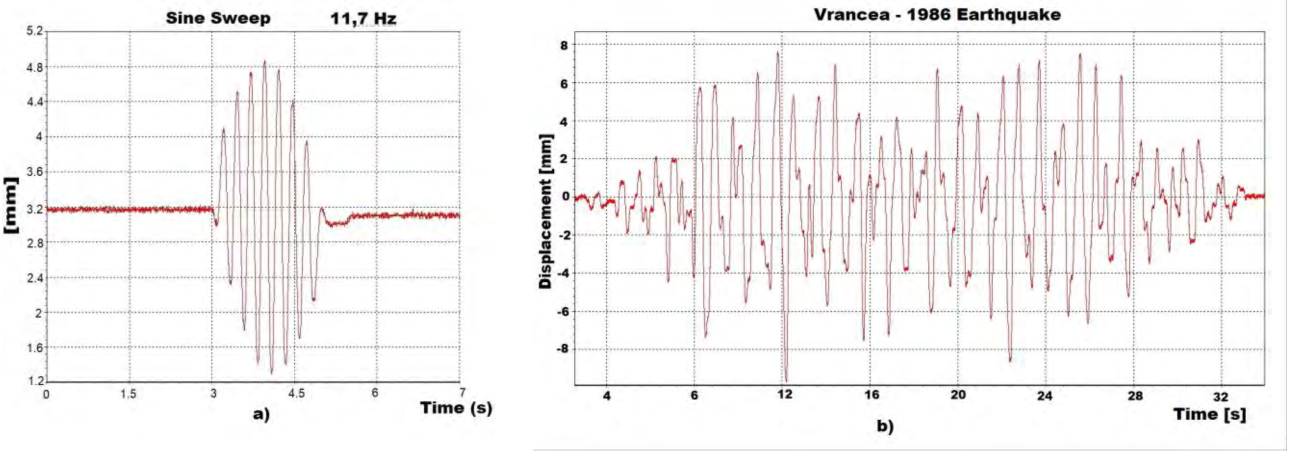

Figure 2(a) The Sweep Sine Input 2(b) The Vrancea-1986 Time History Input (significant window)

The numerical models were carried out by the means of a Finite Element Method (FEM) computer software. The mass matrix is assumed diagonal; the stiffness matrix was computed using the geometric and mechanic properties of the frame members. Because of the stiff plates the model behaved like a shear frame. The sensitive part regarded the damping matrix. By the means of the frequency-domain data the logarithmic decays were evaluated and the damping matrix was assembled.

The FEM tools software was used to validate the system dynamic matrices (with focus on the damping).

Then the same numerical models were compared to the experiment in the time-domain data by the means of some system identification software.

3. Conclusions

The MAC (Modal Assurance Criterion) was applied for the correlation (i. e. spectral matrix -analytic and test) in the frequency-domain. Also, system identification was performed and corrections were made for the damping matrix elements.

The mass matrix is invariant; the stiffness matrix needed some corrections (parametric, regarding the mechanical properties of the flexural elements i.e. columns). In this way the tested natural frequencies fitted with the finite element computer model and the spectral and modal matrices were validated.

The damping was analysed after the comparison in between the time history results (experimental and the computer-based analysis).

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Timber rails: Statistical analysis of reduced-to-scale samples

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Summary: *The aim of the current paper is to present a years-long research program, which focused on investigating the behaviour of timber rails subjected in a 3-point test to failure. The sample population shares the following parameters: no of lamellae, positioning of lamellae, jointing, height and breath of section, timber species, country of origin for the timber used.*

Keywords: timber; rails; lamellae; statistic.

1. Introduction

The investigation programme debuted in 2015 and has managed to collect over a period of 8 years a no of 811 timber rails (D. Moldovan, 2015 to date), fashioned to the specifications required by the Beneficiary and provided by various National, European and Extra-European Contractors. Since the focus of the research was to establish the behaviour of the material rather than that of the element, in combination with the ready-available testing equipment, the rails are reduced-to-scale.
Six variations were assessed during the initial phase, with a duration of about 3 years. Based on the experience gained, the population presented here-in shares the following traits: no of lamellae – 12, positioning of lamellae – vertical, jointing – Laminated Veneer Lumber (LVL), dimensions (length x height x breath) – 2000 x 65 x 36 mm, timber species – poplar, country of origin for the timber used – domestic.

2. Methods

The Beneficiary of the current investigation provided all the rails. Testing was conducted in the Reinforced Concrete Laboratory of the Faculty of Civil Engineering in Cluj-Napoca, in a 3-point setup benchmark. Experimental data was collected by use of a data acquisition unit type Hottinger, Brüel & Kjær (HBK), thorough its dedicated software interface available under the commercial name of CATMAN (https://www.hbm.com/...).
The equipment would control the following terminals:

1) Force transducer: (commercial name) C6A 1MN, with a minimum read of 6 kgf (Sensor T-ID: HBM_C6A_1MN, 200,00 ms (5 Hz), Amplifier type SR 55 Carrier frequency + Counter, Transducer type Full bridge, Measuring range 3 mV/V);
2) Displacement transducer: (commercial name) WA 300mm, sensitivity 4 digits (Sensor T-ID: HBM_WA_300mm, 200,00 ms (5 Hz), Amplifier type SR 55 Carrier frequency + Counter, Transducer type Full bridge, Measuring range 125 mV/V);

The force was increased in steps of (2 N/s) on a loading machine type WPM 262/6-1977 of 3000 [kN] and precision class 1. All the equipment has the corresponding calibration and certification valid.
For audio-video recording a photo camera type FUJIFILM FinePix A900, using an external memory card of 2 GB and powered by 2 batteries type AA, 1,5 V LR6, was used during the initial phase. Later, a NIKON D3300, using an external memory card of 64 GB and powered by a lithium-ion battery pack of 7.2 V 1230 mAh 8.9 Wh, provided the corresponding features.

3. Results and Discussion

In general, due to shipping and handling conditions, the parcels to be evaluated contained ten rails. Assuming a normal distribution of results with the corresponding standard deviation, the following mean characteristic values were established (see Figure 1), for each.
The comparison presented here-in will focus on identifying the answer to the following questions:

1) Is a normal distribution of results consistent with the data collected so far?
2) Is the assumed standard deviation consistent with the same?

Therefore, each data-point is in turn a ”mean” value for the corresponding parcel, as supplied by the Beneficiary. When the ”default” no of samples in each parcel is different from ten, that will be specified for clarity.
The spreading of results, within the same series and among different series as well, may be explained either by the small

distance between the position of one of the longitudinal halving jointing and that of the applied force which caused the localisation of the failure at that spot (the gross sections), or the failure of the longitudinal glued areas in contact (the lamellae sections). Any such behaviour caused the overall results (the ”characteristic” values) to decrease below the threshold more than the trend of the series may have suggested otherwise, i.e., see Figure 1 – sample 810.

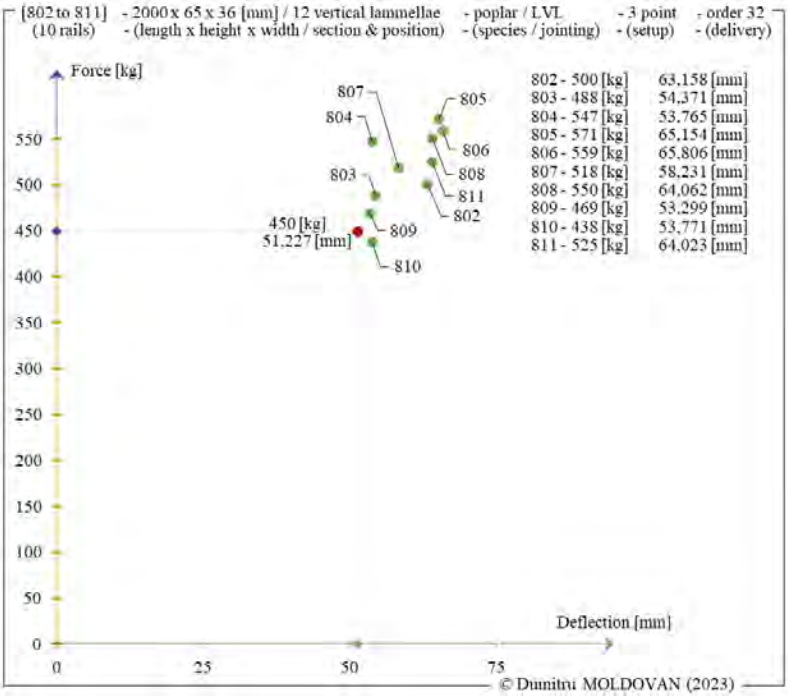

Figure 1: Selected force-displacement diagrams

Out of ten results, seven are equal or higher than 500 kg (”algebraic mean” of 538 kg, rounded down), one is within a deviation of less than 3% to the minimum indicated (2,4%), one is within a deviation of less than 7% to the minimum indicated (6,2%) and the cited sample is the only one to be as low as 13% (12,4%) from the same. Whist the series clearly indicates a tendency to have a higher ultimate load, the ”mean” is of 450 kg, an overall decrease of 10% from said minimum of 500 kg, and of 16% (16,3%) from the ”algebraic mean” of 538 kg.
Similarly, in terms of deflections, five are equal or higher than 63 mm (”algebraic mean” of 64 mm, rounded down), four are clearly grouped around a minimum of 53 mm (”algebraic mean” of 53 mm, rounded down) and one is about equally in-between (see sample 807).

4. Conclusions

It is the authors opinion that the material (samples) tested (see SFIF, 2016) for definitions, additional information, etc.:

1) What may be deemed as ”premature collapse” of individual samples may be attributed to the vertical shear in the case of the gross section, since there seems to be a correlation between the point where the force was applied and the position of a halved jointing or other ”structural defects” of one lamella. Hence, the lack of timber growth defects for each individual lamella in the composite cross section may constitute a major quality factor, as expected;
2) If any of the previous causes did not lead to the premature failure of the sample, there is a clear trend of both the ultimate force and the maximum deflection to have higher values than otherwise considered as ”characteristic” for the standard deviation.

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SECTION V

REINFORCED and STEEL STRUCTURES

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Effect of Nanomaterials on the Structural Behavior of a Reinforced Concrete Building

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Summary: *The paper presents the influence of adding bentonite and titanium dioxide nanoparticles in the concrete mix on the structural behavior of a 5-story reinforced concrete building. The modal and displacement analysis were performed, as well as the evaluation of internal forces. Due to the increase in the modulus of elasticity and the decrease in density of the nanoparticle-modified concrete, a more rigid structure was obtained compared to the reference one.*

Keywords: bentonite; titanium dioxide; concrete structure; structural analysis; displacements.

1. Introduction

Bentonite and titanium dioxide TiO_2 nanoparticles have been researched separately in the civil engineering domain, but studies are still required for them to become fully industrialized. Bentonite nanoparticles proved to have a positive influence on the mechanical strength of cementitious composites (Wang, 2017). TiO_2 has also been proven to have positive effects on the mechanical strength of concrete (Joshaghani, 2018). Research regarding the impact of using combined bentonite and TiO_2 in cementitious composites is scarce, but they confirm the effectiveness of combining them in improving mechanical strength (Selvasofia et al., 2022). Combining a widely available nanomaterial like bentonite with the photocatalytic TiO_2 leads to a more ecological concrete with improved strength and durability.

2. Materials and Structural Model

The structural model has been selected from the Register of Building Models (ICCPDC, 1986). The building was designed as a dual structure, made mainly of reinforced concrete frames, with some additional structural walls in the staircase area. To analyse the structural response to various actions, SAP2000 software was used. Figure 1 presents the transverse section of the building taken from the Register of Building Models, along with the structural model designed in SAP2000.

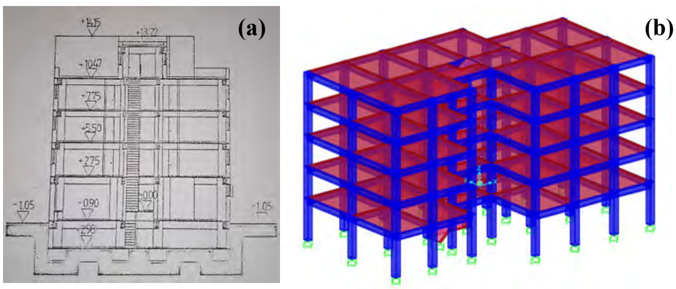

Figure 1. Building C3e1 (a) transverse section; (b) structural model from SAP2000

The beams, columns and structural walls were made of C20/25 concrete, with BST500 reinforcement, while the floor slab is made of C16/20 concrete, with BST500 reinforcement. The element sections were as follows: beams – 50x25 cm, columns – 50x50 cm, structural wall – 20 cm thickness, floor slab – 15 cm. The load combinations considered both the permanent and variable loads, together with the seismic loading, according to SR-EN 1990-2004 (ASRO, 2004) and CR 0-2012 (UTCB, 2012). For analysis and comparative purposes, three mixes were considered, their main properties added to the design being listed in Table 1. The nanomaterial-modified concrete mixes comprised bentonite B and titanium dioxide TiO_2. Only C20/25 concrete was modified with nanomaterials.

Table 1. Mechanical characteristics of concrete mixes

Mix	Nanoparticle mix	Compressive strength at 28 days on cylinders [MPa]	Longitudinal modulus of elasticity [MPa]	Density [g/cm^3]	Unit weight [kN/m^3]
Reference	-	26.96	30312	2.30	22.52
COMB1	1.5% B + 0.5% TiO_2	34.54	31081	2.26	22.18
COMB2	1.5% B + 0.75% TiO_2	38.70	32267	2.25	22.09

3. Results and Discussion

3.1. Structural dynamic parameters

The modal vibration periods corresponding to the structural model were evaluated for all considered mixes. A decrease in the fundamental vibration period was registered for both structures made of nanomaterial-modified reinforced concrete, the results being presented in Table 2. The change in value was computed compared to the reference structure.

Table 2. Modal vibration periods

	Reference	COMB1	COMB2
Mode 1	0.601	0.594	0.5844
Change	-	-1.21%	-2.83%
Mode 2	0.585	0.578	0.568
Change	-	-1.28%	-2.88%
Mode 3	0.401	0.396	0.389
Change	-	-1.32%	-3.00%

3.2. Internal forces

For analyzing the impact of adding nanomaterials to the concrete mix from the structural point of view, a frame located in the longitudinal direction was selected. It was found that adding both bentonite and TiO_2 nanoparticles in the concrete mix had a positive effect on the columns, decreasing the value of axial forces, shear forces and bending moments, for all combinations, including the seismic ones. The result was explained by the reduction in density which mostly affects the columns. The beams, on the other hand, for which the weight had a smaller impact, experience both positive and negative variations compared to the reference structure.

3.3. Displacement analysis

The absolute displacements were computed for one longitudinal and one transverse frame, applying the seismic action in the direction in which the measurement was done. Figure 2 presents the deformed shape of the COMB2-modified reinforced concrete structure acted by seismic action in the X direction. For X direction, the maximum absolute displacement decreased by 2.73% for the structure made of COMB1-modified concrete, and by 6.08% for the structure made of COMB2-modified concrete, compared to the reference structure. For the Y direction, a decrease of 2.73% is obtained for the COMB1-modified concrete structure and by 6.07% - for the COMB2-modified concrete structure.

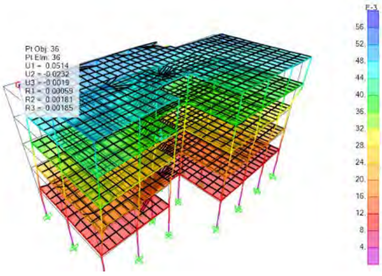

Figure 2. Displacement analysis – Absolute displacement COMB2

4. Conclusions

The paper presents the influence of replacing cement and aggregates with bentonite and TiO_2 nanoparticles on the structural behavior of a 5-story building. Considering the reduction in weight and the increase in modulus of elasticity, the rigidity of the building increases, as the results of the modal and displacement analysis reveal. The decrease of the axial forces in the columns is a direct effect of the reduction in density of the nanoparticle-modified material. Overall, the addition of both bentonite and TiO_2 in the concrete mix has positive effects on the structural response.

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Structural design of keyed surfaces for precast concrete columns embedded in pocket foundations

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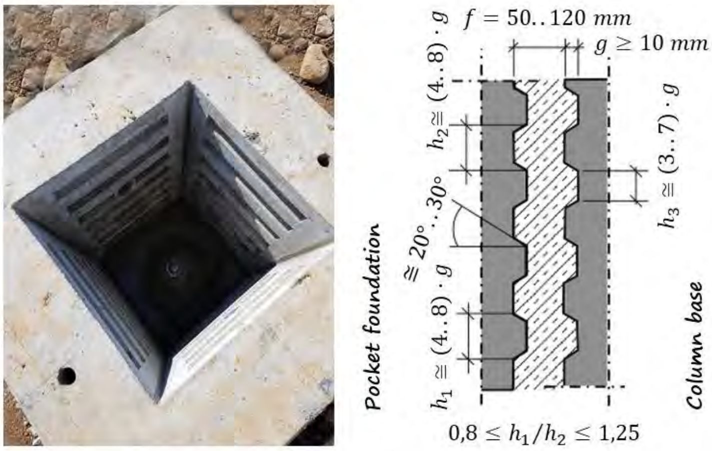
Summary: *The connection between a prefabricated reinforced concrete column and the pocket foundation is a case treated from a general perspective (ASRO, 2004; MDRAP, 2014), and when the structural engineer is faced with the dimensioning or verification of the keyed joint surfaces filled with monolithic concrete, it hits several unknowns. The present work aims to fill in the missing information by presenting a calculation model.*

Keywords: keyed surface; precast concrete column; shear; pocket foundation; structural connection.

1. Introduction

The precast concrete column - pocket foundation keyed connection (Figure 1) can be considered in the design calculations as a monolithic joint between a concrete column and a foundation (ASRO, 2004; MDRAP, 2014). As a condition for the punching shear dimensioning to be carried out in the assumption of a monolithic column-foundation, it is necessary to verify the shear transfer between the column and the footing (ASRO, 2004; MDRAP, 2014).



f (mm)	g (mm)	h_1 (mm)	h_3 (mm)
50	10	50	40
50	10	60	50
70	15	60	45
100	20	100	80
100	25	125	100
120	25	120	90
100	30	150	120
120	30	150	120

Figure 1: Precast pocket foundation by ©SW Umwelttechnik Romania (foto left), key geometry at the interface of precast concrete column and pocket foundation (center) and recommended values for key geometry (table right).

2. Design method

The strut-and-tie modelling (STM) is a simple method based on truss analogy dedicated to the dimensioning of reinforced concrete members. To establish the model, (Bachmann et. al. 2021) consider that the trajectory of inner forces in the cross-section of a column fixed in a pocket foundation with keyed internal walls can be split into struts and ties (Figure 2). In this way, the normal force, the shear force and the bending moment are transformed exclusively into uniaxial tensile (T_i) and compression (C_i) inner forces for the purpose of sizing the pocket foundation (horizontal and vertical reinforcement), as well as the actual joint (the keyed surfaces between the concrete filling). One part of the normal forces is transferred from the column to the foundation through the keyed surfaces, with an angle of the connecting strut (C_1) which crosses the filled in situ concrete of $\theta \cong 45^o...55^o$. The mathematical formulas for the parameters represented in Figure 2 necessary to determine the load-bearing capacity of the keyed joint are given below. The notations used are in accordance with those of SR EN 1992-1-1:2004 and NP 112-2014.

$$\tau_{Rd,i} = c \cdot f_{ctd} + \mu \cdot \sigma_n \leq 0,5 \cdot \upsilon \cdot f_{cd}$$

$$V_{Rd,i} = \tau_{Rd,i} \cdot A_i = \tau_{Rd,i} \cdot (b_s \cdot t)$$

$$\tau_{Rd,i} = 0,5 \cdot \frac{f_{ctk,0,005}}{\gamma_c} + 0,9 \cdot \sigma_n \leq 0,5 \cdot 0,6 \cdot \left(1 - \frac{f_{ck}[MPa]}{250}\right) \cdot \frac{f_{ck}}{\gamma_c}$$

$$\sigma_n = \frac{C_1 \cdot cos\,\theta}{A_i} = \frac{T_2 + T_3}{b_s \cdot t} = \frac{V_{Ed} + (F_s \cdot z)/(s+z)}{b_s \cdot (H_p - f_h)} = \frac{V_{Ed} + (\gamma_{Rd} \cdot A_{sl,1\_lat,ef} \cdot f_{yd} \cdot z)/(s+z)}{b_s \cdot (H_p - f_h)}$$

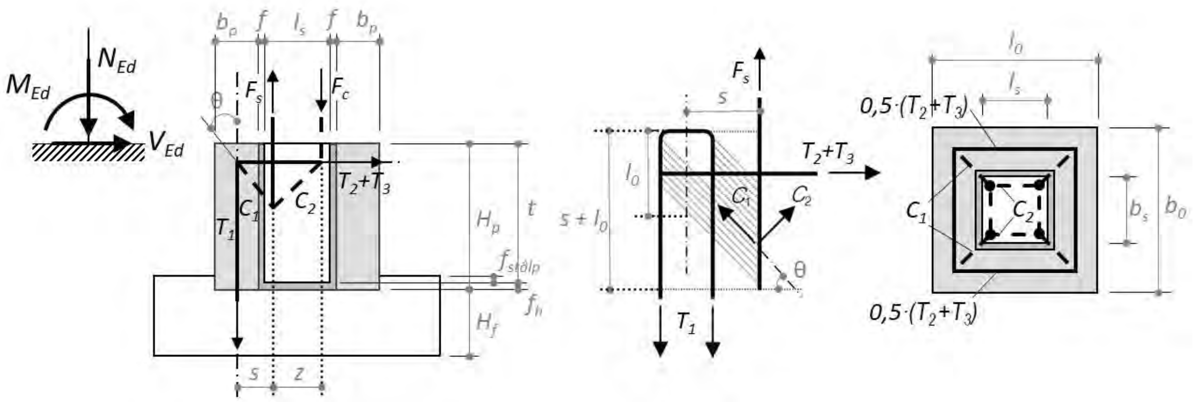


Figure 2: The strut-and-tie model for structural design of pocket foundation with keyed internal walls, based on Deutscher Beton- und Bautechnik-Verein E.V. (2012)

3. Results on a case study

A prefabricated concrete column – pocket foundation with keyed internal walls (Table 1) is considered. Knowing that the indentations comply with the geometry indicated in the technical regulations in force (Figure 1), the shear capacity of the keyed joint is determined.

Table 1. Input values for the case study and results

Parameter	Value	Meaning
		Input
C30/37, C28/35, C25/30		Strength classes for concrete in column, joint and foundation
f	100 mm	Thickness of the in situ concrete filling around the column
f_h	50 mm	Thickness of the in situ concrete filling below the column
f_{stalp}	50 mm	The embedment depth of the column in the pocket
b_p	250 mm	Wall thickness of the pocket foundation
H_p	1100 mm	Total height of the pocket
b_s , l_s	600 mm	Size of the column`s rectangular cross section
$A_{sl,1\_lat,ef}$	1256 mm^2	Total cross section area of the longitudinal rebars on one side of the column (4ϕ20)
B500 C	-	Steel grade and ductility class of the steel used as reinforcement
V_{Ed}	73 kN	Design value of the applied shear force at the column base
DCH	-	Ductility class for the superstructure
γ_{Rd}	1,15	Overstrength factor which considers the overstrength of the superstructure in DCH
θ	45^o	Inclination of the strut crossing the joint
		Results
σ_n	0,82 N/mm^2	Compression stress per unit area caused by the normal force across the joint interface
$\tau_{Rd,i}$	1,37 N/mm^2	Design shear stress resistance at the interface
$V_{Rd,i}$	863 kN	Design value of the shear resistance at the interface
$V_{Ed,i}$	546 kN	Design value of the shear force at the interface, $V_{Ed,i} = F_s$

4. Conclusions

The STM can be used to estimate the load-bearing capacity of a keyed surface for prefabricated concrete column - pocket foundation connection. Analyzing the results of the numerical example, for a concrete column reinforced each side with 4 longitudinal rebars of ϕ20 and embedded in the foundation over a depth of t=1,05 m, it is obtained a shear strength of the indented construction joint 58% higher than necessary.

5. References (only a selection from the list)

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Practical considerations in the assessment of column buckling lengths for multi-storey, integrally prefabricated structures

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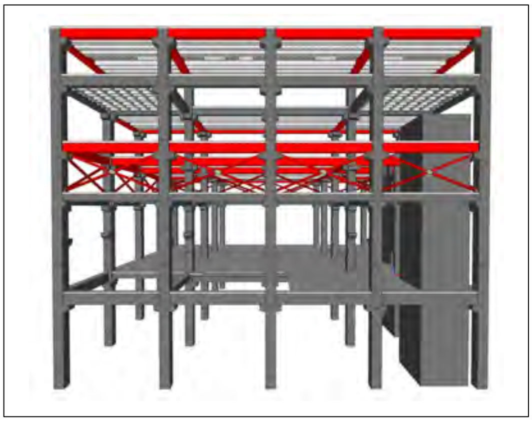
Summary: *Determining the buckling lengths for columns in multi-storey prefabricated structures is an important issue in their correct design. The difficulty in dealing with this issue is the way in which the beam-column node can be achieved, in most cases a rigid connection between them being very difficult to adopt. For this reason, in the case of hinged or semi-rigid nodes, the exact assessment of the buckling lengths for the columns is not always convenient. In the following article, several options are proposed for an industrial structure, entirely prefabricated, with a P+4 height regime, with a maximum column height of 35m.*

Keywords: buckling lengths for prefabricated columns; fully prefabricated multi-storey structures; beam-column connections; framed structure; column continuity joints.

1. Introduction

This article presents a simplified approach to the assessment of the buckling lengths of the columns of prefabricated multi-storey structures, starting from the formulations given by the standards and then customizing the problem so that their determination is as accurate as possible and in accordance with the chosen structural system.
The studied columns are part of an industrial structure, irregular both in plan and vertically. Although the spans are identical in both directions, due to the different level heights, the extension of the floors at different level heights, the eccentric position of the rigid zones formed by the diaphragms of the lift and stairwell, as well as certain setbacks, the analysis and behaviour of the structural model is not common.



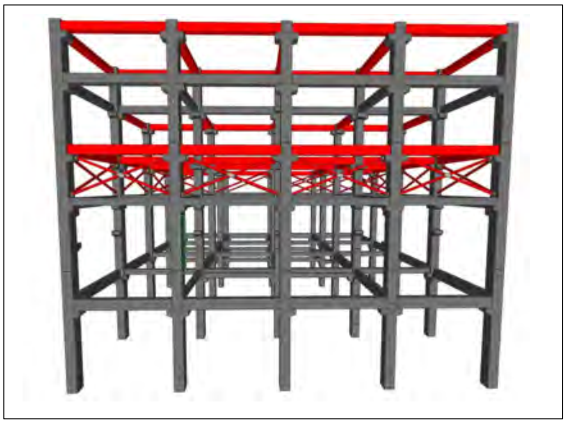


Figure 1: 3D structure views

The structure is designed as a multi-storey, prestressed, prefabricated reinforced concrete frame structure with hinged beam-column joints for most situations. In order to reduce lateral displacements at elevation +23.40m, the beam-column joints elements are considered to be recessed. In the transverse direction, the structure has 4 spans of 10.50m and in the longitudinal direction it has 4 spans of 10.50m. The structure is P+4E in height, with a full floor only at +7.48m, at the other levels the floors will be partially built only on certain areas of the structure.
The location of the structure is in an area with low seismic acceleration, 0.10g, and average wind and snow loads, 0.4 kN/mp and 1.5 kN/mp, respectively, while the values of technological loads are significant, 10-20 kN/mp.

2. Results and Discussion

The analysis of the buckling length on a 35m high pole with the classical method gives a calculation length result of 48.30m so an overall amplification factor of 1.35.
The presence of rigid nodes and, mainly, of the bracing system at elevation 18.30 - 23.90 modifies and may reduce the values of the effective buckling lengths. Thus, a simplified global plan model was designed and then, the columns targeted for analysis were considered in several assumptions depending on the direction of analysis, with and without bracing.

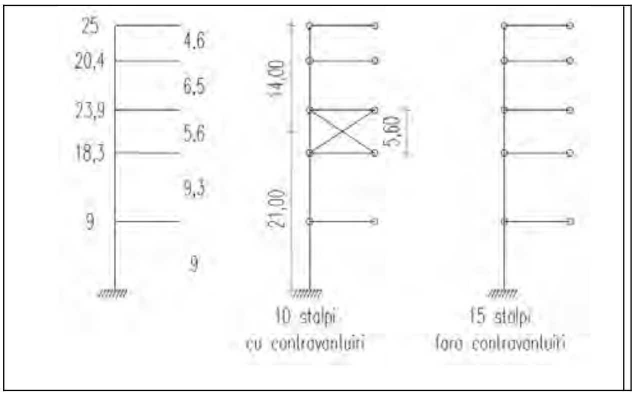


Figure 2: Calculation pattern layout

In the case of the analysis on an isolated column on the bracing level, it was divided into two areas, the lower area of the bracing and the areas above it, resulting in a buckling length for the lower part of 22m, with a buckling coefficient of 1.04, and for the upper part 28 with coefficient 2 or with certain corrections 21m, i.e. with a buckling coefficient of only 1.5.

Two patterns were proposed for the analysis on the unbraced direction: one without considering the tie through washers but with hinged rungs, and a second pattern in which the consideration of tie through washers with hinged rungs was taken into account. The result indicated a buckling length of 25m for the lower area and 28m for the upper area of the columns in this direction.

A differentiation can also be made with regard to their position in the level, the corner columns having at the lower end a direct opposite length of 24m compared to 22m for the straight ones.

So for the calculation a buckling length of 25m can be considered below the level of the bracing system, for a column height of 21m, with a maximum coefficient of 1.20, and for the column over the rigid system, 28m, for a column height of 14m, so coefficient 2.

3. Conclusions

The analysis of the columns of a multi-storey prefabricated structure with both hinged and embedded fixings in their relationship to the beams obviously changes the buckling length considered and hence immediately the section required to be adopted. The introduction at a certain level of rigid nodes, where technologically possible, and the provision of a system of vertical bracing around the perimeter and on the whole level, practically generate a completely different behaviour of deformation of the columns. The resulting maximum buckling length in this case is 28m, which implies the need for a section of only 1.00x 1.00m.

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Testing of precast concrete shear panels

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Summary: *The multi-storey precast structures often use shear walls to sustain the lateral loads, and the connections between panels play a major role in the structural response. This paper presents an experimental campaign of vertical connections between precast reinforced concrete wall panels. Six commonly used connection layouts were tested under pure shear and the detected shear capacities were compared with the design code EN 1992-1-1 predictions.*

Keywords: shear walls; vertical connections; shear capacity; experimental testing.

1. Introduction

This research project started from the need of a better understanding of the connections behaviour in terms of shear stiffness and capacity which have a major influence in the internal forces distribution and global response of the precast concrete walls. This research topic came from the multinational company Consolis which greatly supported the experiments carried out in the TUCN laboratory. The testing and the results interpretation were presented in detail at two fib conferences (Miclausoiu et al. 2022) and one experimental report (Miclausoiu 2023).

2. Methods

Six commonly used connection layouts were tested under pure shear. Figure 1 presents the push-off test setup. For each connection layout, three identical specimens were tested. The structural connection type divides the experimental program into two sections: connections utilizing steel assemblies (SA) and connections with high strength wire-loops (WL). The test specimens consist of two L-shaped wall panels interconnected by specific connection layouts. SA1 and SA2 connections are created using welding, while SA3 connection is achieved through bolting. The wall panels are specially designed to avoid failures other than the shearing of the connection. SA1 and SA2 connection layouts (Figure 2) were inspired by a typical connection detail widely used by Consolis in Sweden. The specimens were designed to be representative for the real construction, SA3 connection layout is a prototype proposed within Consolis' R&D department. Connection details can be seen in Figures 1-3.

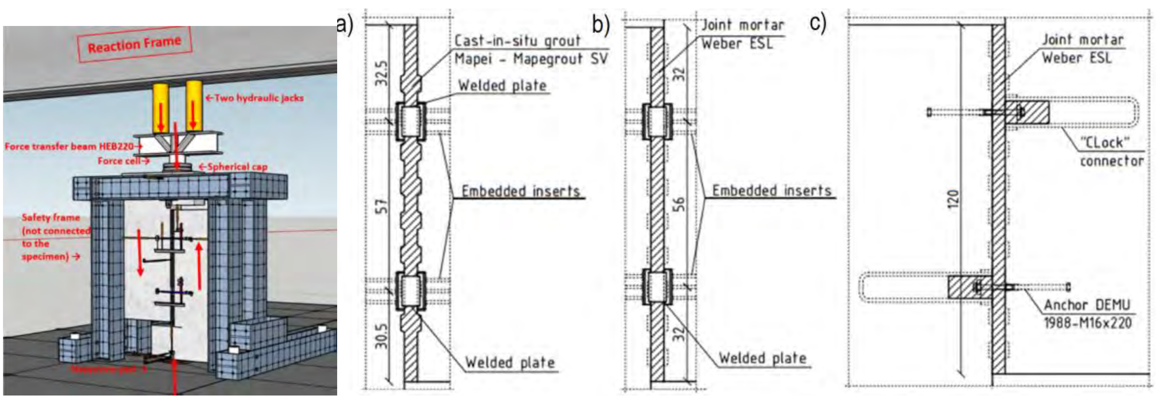

Figure 1 Push-off test setup; Test specimens details [in cm] a) specimens SA1; b) specimens SA2; c) specimens SA3;

Figure 2 Steel assemblies (SA) 3D visualization

3. Results and Discussion

Figure 4 presents the shear force vs. shear displacements for the first two connection types (SA1 and SA2) which presented the best behaviour in terms of consistency and post-cracking strength reserve.

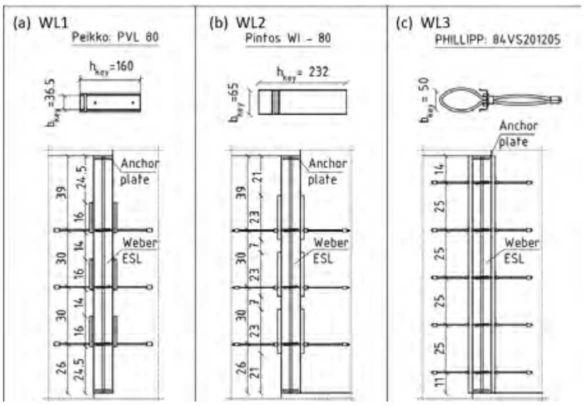

Figure 3 Test specimens' details [in cm]: a) specimens WL1; b) specimens WL2; c) specimens WL3

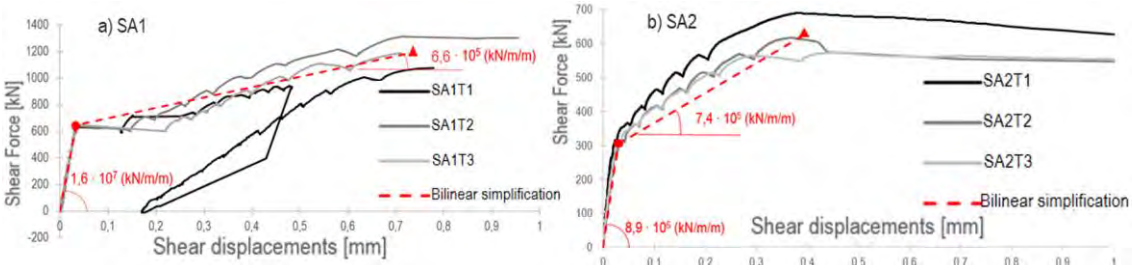

Figure 4 Shear vs average shear-slip for the connections with shear keys and steel assemblies (pre-peak behaviour)

The applicability of equation 6.25 from EN 1992-1-1 for the shear capacity of these connection layouts was verified with the test results.

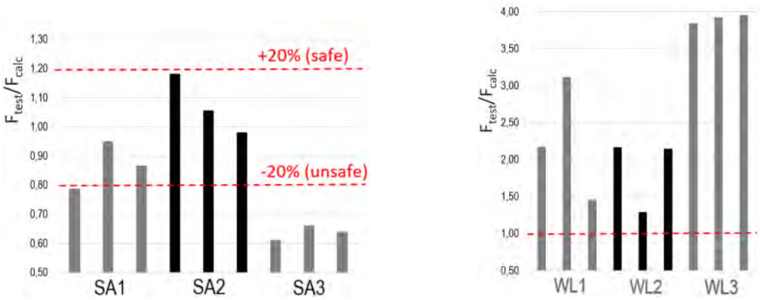

Figure 5 Comparisons of test results with eq. 6.25 from EN1992-1-1

4. Conclusions

The welded plates connections showed consistent results. The bolted connection is a prototype meant to be a more balanced connection layout, having high and reliable shear resistance (comparable to the welded plates and shear keys connections) and in the same time, allowing a practical casting process. Its shear capacity was lower than expected (overestimated by Eurocode 2). Wire loop boxes showed a brittle failure, and their capacity showed a very wide spread of values. This connection type was proven very sensitive to joint grouting, and it seems that is not reliable to be used for complex structural systems.

5. References

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A preliminary approach for determining the shear stiffness of trapezoidal sheet diaphragms, based on experimental load-displacement curves

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Summary: *Experimental investigations were conducted by the authors on isolated diaphragm configurations to evaluate the structure-cladding interaction. The tested specimens were designed as panel assemblies with sheeting spanning perpendicular to the span and connecting to the supporting structure on two sides only. For these types of diaphragms, where the shear connectors to the main structure are neglected, the design method of the actual standard (ECCS, 1995) is not applicable. The purpose of this paper is to present a procedure for determining the shear stiffness of the tested trapezoidal sheet diaphragms, based on the experimental load-displacement curves. The experimental data processing is ongoing, the approach presented in this paper is preliminary.*

Keywords: stressed-skin design; experimental investigations; diaphragm stiffness; trapezoidal sheets; steel structures.

1. Introduction

In order to analyse the structure-cladding interaction, experimental investigations were conducted on different types of diaphragms in the Structures and Materials Research Laboratory of the Technical University of Cluj-Napoca. This experimental program covered a comprehensive study of sandwich panel and trapezoidal sheet diaphragms, but this paper focuses solely on the results of the trapezoidal sheet diaphragm tests. The roof detail selected for the experimental investigations consisted of two bays of 2.5 meters each, with a length of 3 meters. A total of 20 distinct configurations of trapezoidal sheet diaphragm were examined. The „skin" of these configurations was supported by Z150 or Z200 purlins with S350GD+Z steel grade. The sheeting was fixed to the purlins with self-drilling screws EJOT JT2-6-5.5x25-V16. As seam fasteners EJOT JT2-3-4.8x19 V14/2 self-drilling screws were used. The trapezoidal sheets used in the panel assemblies were manufactured by the Joris Ide company with S250GD+ZM steel grade. Test setup and preliminary experimental results were presented in a conference article (Nagy et al., 2023).
The tested configurations can be identified as panel assemblies (diaphragm) with sheeting spanning perpendicular to the span and connecting to the supporting structure on two sides only. This type of diaphragm is not covered in the European Standard (ECCS, 1995) since shear connectors are completely omitted. Thus, the tested configurations can be considered non-standard diaphragms, although they are commonly used in practice, highlighting the need to extend the design method for such configurations and the importance of updating the current design standard accordingly.
Furthermore, there is no specific method for diaphragm stiffness determination, based on experimental load-displacement curves. Davies and Bryan (1982) notes that the flexibility of the diaphragm is defined as the reciprocal of the slope of the linear elastic part of the curve. However, the experimental investigations have revealed that even initial loading stage of the diaphragm exhibit non-linear behavior. Consequently, in this region, several tangent lines can be constructed due to variations in the slope. Assuming for the initial slope an elastic range, tends to overestimate the stiffness of the diaphragms. For this reason, the authors aim is to develop a more accurate methodology to determine the diaphragm stiffness, with the help of experimental load-displacement curves.

2. Developed method and discussion

The developed preliminary computational approach for determining the shear stiffness of the tested diaphragms was inspired by the European Standard (ECCS, 1986), which refers to the testing procedures of structural elements under cyclic loads. This document presents several potential definitions for the elastic range of monotonic tests (first phase) on steel structural elements. The general definition (the yield point is at the intersection of the two specific tangent lines) was chosen and modified as the base of the developed preliminary method. This method extracts the relevant data from the test results, namely the vertical displacements and applied force values (measured at the base of the middle beam – loading point). Subsequently, an initial data filtering step is implemented to eliminate the unloading portion of the curve (Figure 1). This is achieved by identifying and preserving only the ascending segments of the dataset (increasing values registered in displacements). In the following step the computational procedure fits a polynomial curve to the filtered data (Figure 2), typically a high-order polynomial is used for this purpose (in this case, a 17^{th} degree polynomial, chosen empirically). This polynomial curve represents the behaviour of the tested panel assembly. Then the algorithm identifies an auxiliary point on the fitted curve, where the derivative reaches a specific threshold ($1/10^{th}$ of the derivative at $x=0$). This auxiliary point plays a crucial role as a reference point for the subsequent construction of tangent lines.

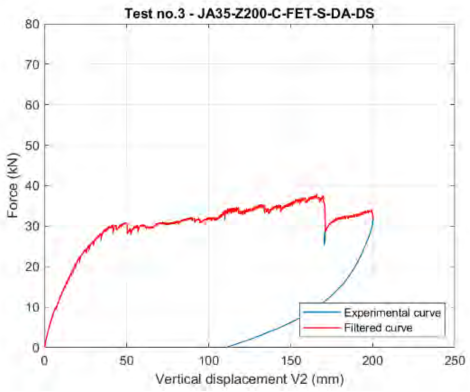

Figure 1: Data Filtering

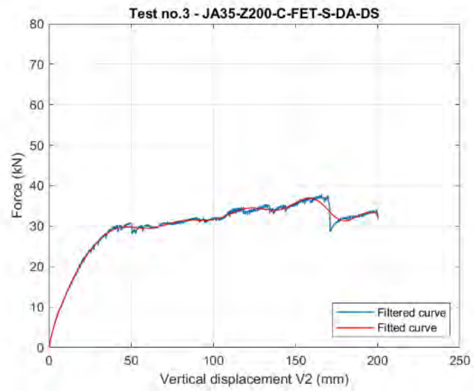

Figure 2: Polynomial curve fitting

Tangent lines are constructed at two key points: the origin of the polynomial load-displacement curve and the identified auxiliary point. The intersection of these tangent lines determines the theoretical yield point of the tested panel assemblies which is projected horizontally on the curve (Figure 3 - true yield point). Lastly, a linear trend line is fitted to the polynomial load-displacement curve between the origin of the curve and the true yield point (Figure 4). This linear trend line provides a simplified representation of the stiffness of the tested diaphragms.

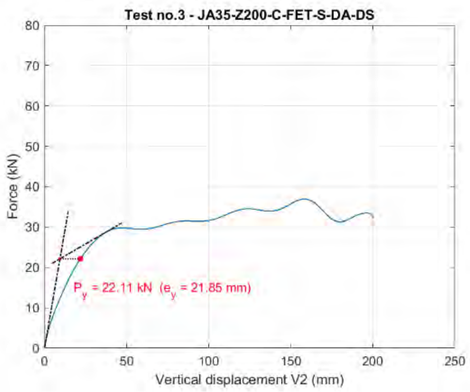

Figure 3: Determining the position of the true yield point

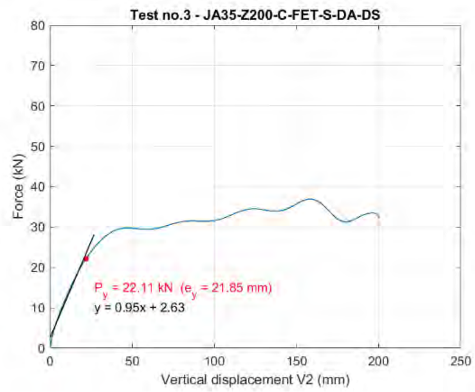

Figure 4: Trendline fitting

3. Preliminary conclusions

The presented preliminary approach offers a promising direction for determining the shear stiffness of trapezoidal sheet diaphragms based on experimental load-deflection curves. However, it's important to note that this approach has limitations, as it was tested solely on the specific diaphragm configurations used in the mentioned experiments and further refinement is possible.

4. Acknowledgements

The authors would like to express their gratitude to the following companies, who financed the experimental works: Chiulan, Terasteel, Mexi Web Project, Joriside, Con-A, Ejot, Hilti. Current research would not be possible without their provided support.
Authors acknowledge the financial support provided by Hungarian Academy of Sciences through *Domus* program and Sapientia Hungariae Foundation through *Collegium Talentum* grant.

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Polyvalent hall in city of Blaj: designing the steel roof structure

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Summary: *The design concept of the roof for the Multipurpose Sports Arena in Blaj includes two longitudinal spatial truss girders with a span of 53.80 m which are supporting transversal girders 29m span over the playing field, and 11m over the seats area. The two main beams are resting on four concrete towers, with a cross section of 3.75 m x 3.75 m (hollow core). In order to obtain an improved performance in seismic load cases, four hydraulic dampers are introduced between the steel roof and the concrete superstructure.*

Keywords: design steel roof; seismic dampers.

1. Introduction

The new Multipurpose Sports Arena in Blaj city can accommodate 2,000 indoor seats that can be extended up to 3500, and it was designed for sports competitions, namely volleyball, basketball, handball, boxing, but also concerts, shows, fairs or exhibitions. The flat size of the construction is 57.80 m x 83.0 m, with a height elevation at the ridge of +13.35m (STRUKTOPLAN, 2020).

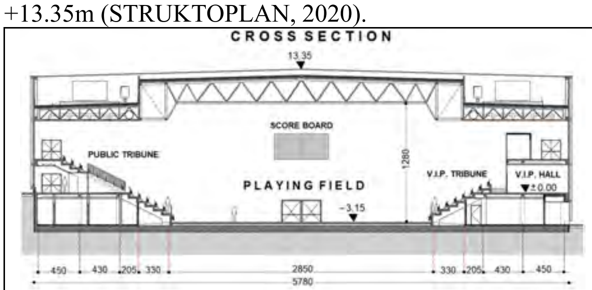

Figure 1. Building’s section through central area of the gym

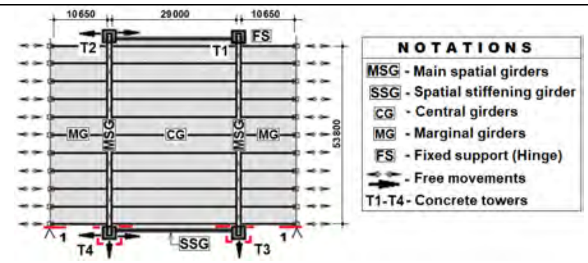

Figure 2. Arrangement of the support bearings (Central zone)

2. Structure of the steel roof

In order to take over the reactions of the two longitudinal main spatial beams -MSG, with a span of 53.80 m, 4 concrete towers – T1…T4, with a plane size of 3.75 m x 3.75 m and a height of 8.0 m were designed in the corners of the playing surface (Moga and Guțiu, 2018; STRUKTOPLAN, 2020).
The main beams are spatial structures, consisting of two lattice beams with a height of 3.80 m located at a distance of 2.80 m interax, braced between the upper and lower chords, and also braced with counterbraces in transverse vertical planes, next to the secondary beams.
In the transverse direction, above the playing surface, secondary lattices beams, named central beams -CB are arranged, with a span of 29.0 m, with bars made of rectangular pipes, Figure 2.
Between the towers, respectively between the ends of the main beams, in transverse direction, were designed spatial stiffening beams - SSG, which ensure the stability of the main beams and the spatial configuration of the roof framing by forming a rigid contour.

3. Seismic protection and roof structure configuration

The seismic protection and the roof structure configuration have been accomplished by three constructive methods, as follows (BS EN 1519, 2018; FREYSSINET, 2016; MAGEBA, 2016, P100-2013, 2013):
A. Use of seismic isolators between the main beams and the concrete towers and by allowing free movements in a predetermined horizonal directions
The main spatial beams are static simply supported on the four concrete towers, each beam has an independent support, being used elastomeric bearings (figure 3).
B. Use of hydraulic dampers for seismic protection
In the case of Dissipation devices, part of the energy generated by an earthquake can be dissipated by dampers to minimize the effects on the structures. Dampers offer only very low resistance to slow movements and are completely effective during quick stresses (earthquakes).

Figure 3. Metal block for displacements blocking (Tower T3): a) Photo image; b) Rendering

Seismic connectors, whose distinguishing feature is that they provide only very low resistance to slow displacements due to temperature variations, shrinkage and creep. They create a robust connection between the superstructure and the supporting structures during quick displacements mainly associated with seismic events.

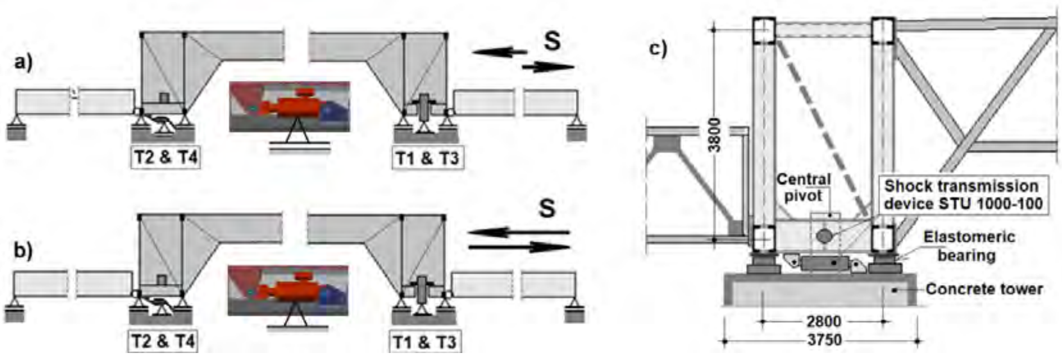

Figure 4. Static transverse schemes of the metal framing structure and detail of support:
a) Usually loading case; b) Major seismic forces c) Hydraulic locking devices for T4 tower

C. Configuration of the wind bracing

In order to achieve lateral stability for the truss girders and to create the diaphragm effect for the entire roof (ASRO. SR-EN 1993-1-1, 2006; ASRO. SR-EN1993-2, 2007; CR-0-2012, 2012; P100-2013, 2013), the structure has been designed with several bracing systems. This ensures the transfer of horizontal forces to the concrete towers with the advantage of increasing the spatial behavior of the building.

4. Conclusions

One of the most complex challenges of the project was the design of the connection between the steel roof and the concrete structure, which requires different capability in accordance to the each load case: allowing horizontal deflection, in case of snow and wind forces and blocking the nodal support, in seismic scenarios. In order to obtain the targeted behavior, hydraulic dampers are introduced and spatial performance of the entire structure it is achieved.

The architectural, technical and functional solutions adopted correspond to the current standards in this field, being the result of appreciable efforts from the involved factors – administration-beneficiary, architects, engineers and specialists in the field of execution of constructions with a high level of technicality and exigency.

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Composite structures carbon footprint in comparison with traditional concrete and steel ones

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Summary: *The paper investigates the performances of composite structures made with fully encased steel-concrete composite columns in seismic zones in comparison with traditional concrete and steel solutions, in order to reduce carbon footprint.*

Keywords: composite frames; fully encased steel-concrete columns; reduced carbon footprint.

1. Introduction

At the base of the present article stood a large research work of both authors (Vermesan (mar. Haupt-Karp) A., 2013; Urian G., 2015). The numerical model was calibrated and validated using experimental tests taken from the international literature. The experimentally tested columns had different types of concrete or steel, different structural steel or reinforcing steel ratios. The columns were subjected (monotonic and cyclic) to constant axial force and lateral forces. The validation of the numerical model was realized by comparison of experimental force-displacement curves with numerical ones

2. Materials and methods

For the proposed case study three similar frame structures were chosen. The structures had six, eight and twelve levels. The floor plan was the same for all structures, with two openings of 7.00 m in transversal direction and five 6.00 m openings in longitudinal direction. The height of each level was considered 3.20 m (see Figure 1). The frames were realised with fully encased steel-concrete composite columns and rigid steel beams.

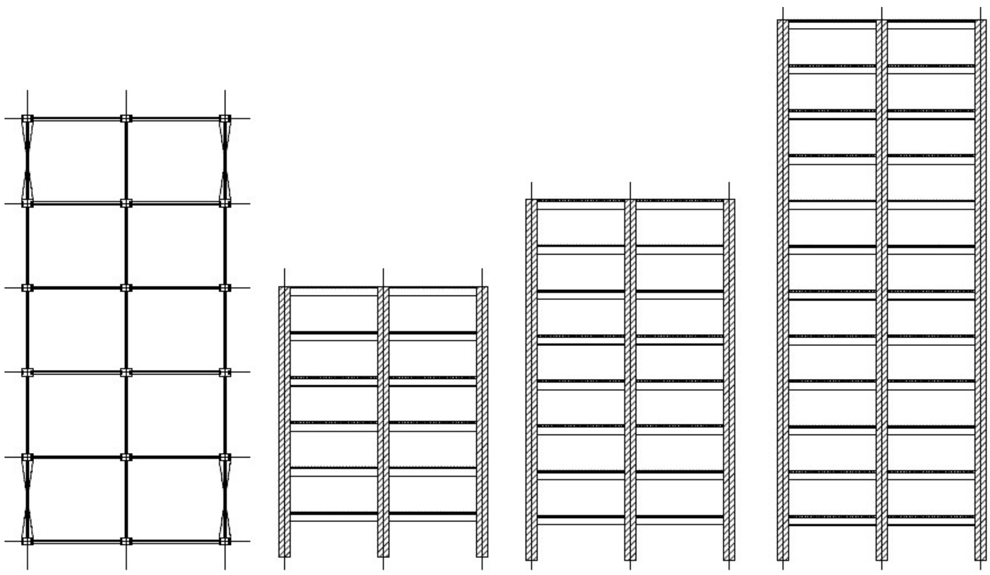

Figure 1: Floor plan and transversal frames

For each type of structure were chosen three types of columns with different structural steel ratio: low, medium and high. The considered loads were the same for all levels. The chosen seismic zone had a peak ground acceleration of 0.32 g and corner period of 1.60 s. The materials chosen in the design of the structures were: C40/50 concrete class, S500 for reinforcing steel and S355 for structural steel. The structures were noted as following: the first number represents the height of the structure, L is from level and the last number represents the structural steel ratio, 1 for low, 2 for medium and 3 for high. So, the structure called 12L2 means: structure with twelve levels and medium structural steel ratio. To investigate the structural performances of the proposed composite structures two seismic analysis were performed: pushover analysis and dynamic time history analysis.
The aim of the paper is the analysis of carbon footprint of composite structures in comparison with traditional ones. The three types of structures, which had six, eight and twelve levels were design in traditional solutions of reinforced

concrete and steel. All design elements were the same: the floor plan, height of structures, loads, seismic zone, etc. The elements that were designed differently were the columns, which were designed in traditional solutions. For all composite structures and also for the reinforced concrete and steel structures the carbon footprint was evaluated by establishing the GWP (global-warming potential) using the commercial software developed by ArcelorMittal, named AMECO V3.02.

3. Results and Discussion

The obtained global-warming potential is presented in Table 1 for all types of composite, reinforced concrete and steel structures. The values are calculated for 1.00 m of column. For better view of the results they were multiplied by 1000. At first are presented the values obtained for the composite structures. The next line presents the best value obtained from the three situations of composite columns. With RC are noted the structures made with reinforced concrete columns and with S the steel ones. The number before RC and S represents the levels number of the structure.
As can be observed in Table 1 the traditional solution with reinforced concrete columns offers the biggest GWP values. In comparison with the composite solution the global-warming potential increases with 24%÷85%. From the composite columns the ones which offer the most efficient value are the one made with low structural steel ratio, between 0.20-0.35. The difference between composite and steel structures is about 0.5%÷18% in favor of steel structures. When comparing those two solutions, excepting the obtained GWP value, the designed engineer must take into account many important problems that affect steel structures in comparison with composite ones: fire and corrosive protection, prevention of element buckling. By embedding the steel profile into a concrete section all these problems with steel structures are resolved.

Table 1. Global-warming potential for all structures

Structure	GWP x 1000 Structural steel	Reinforcement	Concrete	Transport	Total
6L1	182.78	52.25	82.14	7.15	324.32
6L2	251.52	42.30	69.59	7.86	371.27
6L3	281.25	34.83	57.64	7.90	381.62
(6L1 ,6L2, 6L3)					324.32
6RC	0.00	192.82	278.45	12.76	484.03
6S	286.27	0.00	0.00	6.31	292.58
8L1	156.47	95.79	130.32	9.06	391.64
8L2	204.72	74.64	111.49	8.96	399.81
8L3	342.66	39.81	82.96	10.35	475.78
(8L1, 8L2, 8L3)					391.64
8RC	0.00	278.65	400.97	18.39	698.01
8S	311.86	0.00	0.00	6.87	318.73
12L1	263.10	334.14	235.11	20.84	853.19
12L2	559.16	156.74	238.91	19.52	974.33
12L3	681.43	105.74	166.51	20.42	974.10
(12L1, 12L2, 12L3)					853.19
12RC	0.00	639.40	902.19	41.62	1583.21
12S	606.01	0.00	0.00	12.71	618.72

4. Conclusions

As can be observed in Table 1 the traditional solution with reinforced concrete columns offers the larger GWP values and the steel one the lowest. A valid alternative solution from both points of view: sustainability and structural is the composite one. In comparison with reinforced concrete structures the composite one are more efficient from both points of view. In comparison with steel ones the composite solution offers many structural advantages and the difference between the GWP values is not that significant in comparison with the structural ones.

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SECTION VI

SOIL MECHANICS and FOUNDATIONS

C70 International Conference
”Tradition and Innovation - 70 Years of Constructions in Transilvania”

Differences in mechanical response of a cantilever pile wall excavation regarding material nonlinearity of soil constitutive model

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Summary: *Estimation of deep excavation mechanical response represents a challenge in geotechnical engineering, and it is a subject studied intensively to establish the most optimal soil model to be used. Nowadays, the mechanical behavior of soils can be modelled at various degrees of accuracy. Using Mohr-Coulomb model and Hardening Soil model the mechanical response of a deep excavation was analyzed and a comparison between the results obtained from the two models was made.*

Keywords: Mohr-Coulomb model; Hardening Soil model; deep excavation; FEM.

1. Introduction

The first model for soil behavior is considered to be the Mohr-Coulomb model (MC), which is a linear elastic perfectly plastic model, and it is based on the combination of Hooke's law and the Mohr-Coulomb failure criterion. In the second part of the 20^{th} century several non-linear models were formulated, such as hardening plasticity, critical state theory, hypoplasticity etc. Now there are numerous Finite Element Method (FEM) software available, with advanced nonlinear soil constitutive models. One of the most used such type of model is Hardening Soil model adopted for this study. This paper proposes a comparison between the results obtain from Mohr-Coulomb model and Hardening Soil Model (HSM) for a deep exaction. The analysis were performed by FEM plane strain analysis using PLAXIS 2D software.

2. Mohr-Coulomb model and Hardening Soil model

2.1. Mohr-Coulomb model (MC)

The model includes 5 calibration parameters, two elastic parameters from Hooke's law: Poisson's ration, ν, and Young's modulus, E, two parameters from Coulomb's failure criterion: the friction angle, φ and cohesion, c and the dilatancy angle, ψ. According with literature, MC can be used to obtain an estimate value for the deformations, but for more accuracy a non-linear soil model needs to be used.

2.2. Hardening Soil model (HSM)

HSM is a nonlinear mechanical model with two types of hardening, shearing hardening and compression hardening. The model includes 7 calibration parameters, respectively parameters of Coulomb's failure criterion:, φ , c, ψ and stiffness parameters: E_{50}^{ref} (reference secant stiffness modulus), E_{oed}^{ref} (reference oedometer modulus), E_{ur}^{ref} (reference unloading/reloading stiffness modulus) and m (power for stress-level dependency of stiffness). According with literature HSM model is more suitable to predict displacement and failure for excavation applications.

3. Project description and geotechnical conditions

The project site is located in the northern part of Romania. The project involves the construction of a building with a height regime of basement and ground floor

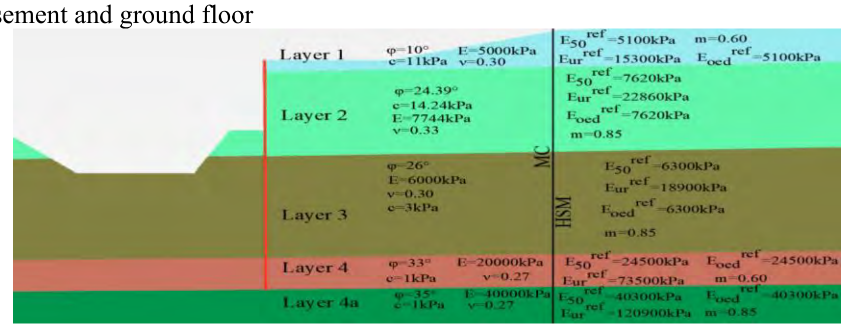

Figure 1: Stratigraphy and geotechnical parameters of the analyzed profile

The excavation level is variable involving a global depth of 3.45 m and locally a 5.45 m dept (Figure 1). The analyzed profile is presented in Figure 1. The stratigraphy consists of 5 soil layers with geotechnical parameters taken into consideration presented in Figure 1, with no ground water level.

4. Results of the comparative study

In order to capture the mechanic response induced by excavation there were performed FEM plane strain analysis. Thereby, the excavation was supported by a cantilever retaining structure composed of a pile row wall. The piles have 80 cm diameter, were placed at 90 cm distance between centers, and had a total depth of 11.00 m. The pile wall was modeled as a plate element with axial stiffens of 1620000 kN/m and a flexural stiffens of 55070 kNm. The excavation was modelled in multiple stages of analysis and the results capture the stage of final excavation configuration. All the analyses are conducted as incremental, interactive analysis, in order to capture the nonlinear (elasto-plastic) behavior of the soil-structure interaction. The results confirm the expectation that the nonlinear behavior of the soil pays a major role regarding the estimation of deep excavations mechanical response in terms of displacements (Figure 2). The exposed result focused of the major interest displacements of the excavation: pile wall displacement profile (horizontal displacement), soil settlement profile (on the upper part of the retaining structure) and Excavation heave profile (heave of the excavation bottom), Figure 2. All displacement profiles were plotted both in MC and HSM cases (Figure 2).

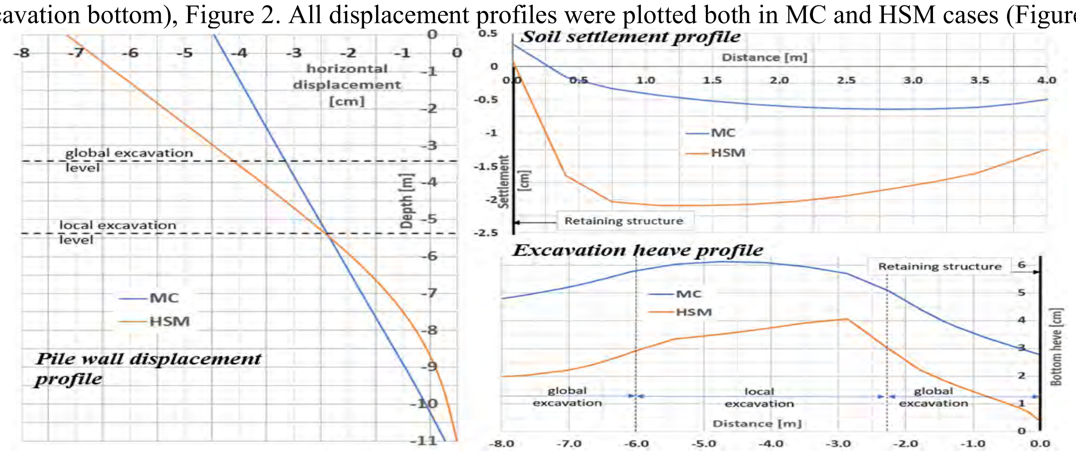

Figure 2: Comparative results in terms of excavation displacements.

5. Discussions and conclusions

Analyzing the results some certain elements had to be pointed. First of all, HSM model denotes a greater pile wall horizontal displacement (7.65 cm) comparing with MC results (4.49 cm), Figure 2. Another interesting aspect is that by HSM, the pile wall describes a flexible behavior (bending deformed shape), while by MC the pile wall describes a rigid body behavior (deformed shaped is composed by translation and rotation displacements), Figure 2. The soil settlement profile is more pregnant by HSM, while MC predicts a lees magnitude settlement profile and much more, in the proximal vicinity of the pile wall, the soil uplifts (Figure 2). This aspect is counter to the commonsense engineering judgement and reality, the practical experience denotes the fact that usually the soil profile will suffer major settlement near the cantilever pile wall in compensation with the top wall horizontal displacement. Regarding heave of the excavation bottom, MC delivers a greater heave profile, while the HSM provides lower heave profile. In this aspect (bottom heave) it is unclear to clearly quantify the exact value of the bottom heave without special monitoring measures (tasometric columns), but the engineering judgement and experience implies that for a 5.45 m excavation a heave of 6.05 cm (MC) is exaggerated. After all the above, it can be concluded that the material nonlinearity is an major aspect that should be carefully taken into account in geotechnical problems that involves a major stress disturbance (excavations). HSM is step forward in order to get closer to reality by FEM numerical analysis, but there is still a path to cover till the scope, and therefore the research process is continuing in order to achieve a clear understanding of the deep soil mechanics.

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Slope stability analisys for deep excavation using soil nailing technique

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Summary: *The execution of new buildings deep excavations requires increased caution in the initial phase. In order to be on the safe side, the stability of the excavation should be ensured. One method of executing such works is open excavations stabilised by soil nailing technique. In the current paper, the application of soil nailing technique is analysed by usual slope stability methods based on limit equilibrium theory. It is shown that the stability of the excavation slopes is greatly influenced by the type of geotechnical characteristic values introduced in the analisys.*

Keywords: soil nailing; deep excavation; slope stability; limit equilibrium.

1. Introduction

The application of the soil nailing technique was studied on a deep sloped excavation which was necessary for the execution of a building. The configuration of the site was modelled through a scaled geotechnical profile (Fig. 1) taking into consideration the topographic conditions and the soil geotechnical characteristics. Based on these inputs, several values of the geotechnical parameters were employed (local, mean, minimum) in limit equilibrium slope stability analyses to evaluate the stability factor, F_s.

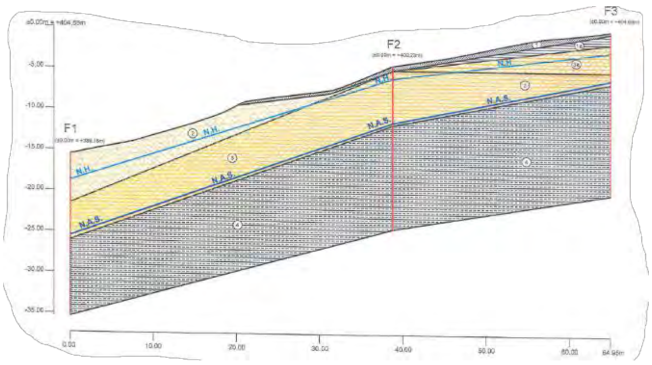

Figure 1: Geotechnical profile of the site

2. Geomorphological and Geotechnical Conditions

The general slope of the site is about 23% in the N-S direction and locally can exceed 45%. The ground investigations consisted in 3 geotechnical boreholes that revealed the following stratigraphy: top soil, (2) blackish silty clay, (3) yellowish-brownish clayey sand, loose with intercalations of small gravel, (3a) yellowish-brownish silty clay, contractile with sand bands, (4.1) silty sandy clay/yellowish-brownish silty clay, contractile with sand bands, (4.2) Grey marl. The underground water level was found out to be laying at depths of -10,00m/-7,00m/-6,00m form the top of boreholes F1/F2/F3. The values of the geotechnical parameters were determined from laboratory tests and statistically processed (NP 122:2010) in order to find the characteristic values to be used in the stability analyses (Table 1):

Table 1 Characteristic values for the geotechnical parameters used in the stability analyses

Layer no.	γ_k (kN/m^3)			φ_k (°)			c_k (kPa)		
	X_k inf	X_k sup	X_k loc	X_k inf	X_k sup	X_k loc	X_k inf	X_k sup	X_k loc
2	18.14	19.14	18.05	24.65	26.34	26.10	3.65	5.34	3.50
3	18.76	19.31	18.17	17.81	19.18	17.35	23.73	27.77	22.33
3a	18.94	19.03	18.94	11.30	14.69	11.12	21.31	24.69	21.00
4.1	19.85	20.16	19.26	15.69	17.63	15.51	52.73	64.60	51.64
4.2	19.85	20.16	19.42	11.63	14.36	10.69	142.13	194.53	121.22

3. Methods of Analysis

In order to analyse the stability of the slopes, Fine Geo 5 software was used together with the Bishop method. The software is based on the limit equilibrium method. The software also allows the introduction of soil nails on the surface of the analysed slope and in this manner, the stability of the slopes consolidated by soil nailing techniques was assessed. The soil nailing technique (Rajhans et al. 2022, Yang et al. 2020) assumes that the reinforced soil slopes are executed in stages from top to bottom as the excavation is carried out. Reinforcement elements (size, inclination, number), the facade element of the slope (the shotcrete), as well as the height of an excavation step usually results from a dimensioning calculation that aims to satisfy all conditions related to the ultimate limit states for geo-engineering structures, also taking into account the sequence of execution phases (Villalobos et al. 2021).

4. Results and Discussion

The slope stability analyses were carried out for multiple phases of execution as follows:

- General stability of initial slope by using mean values of parameters → F_s=1,41 → stable slope
- Local stability using local values for the parameters → F_s=0,81 → unstable slope, (Fig. 2)
- Local stability of sloped excavation consolidated with soil nailing technique using local values for the parameters → F_s=1,29 → stable slope, (Fig. 3)

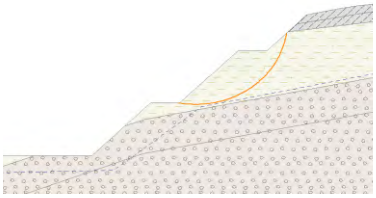

Figure 2: Unreinforced unstable slope

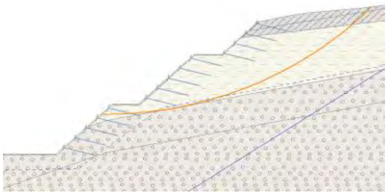

Figure 3: Reinforced stable slope

As it can be seen from Figure 3, the final excavation would not have been possible in the presented configuration without any consolidation measure, local slope failure. Figure 4 shows that the soil nails have a beneficial effect on the stability of the slope, improving the stability up to a value of the safety factor of F_s=1,29, which was considered acceptable for this situation. The solution of soil nailing was adopted as the main consolidation measure of the slopes of excavation, which allowed all the infrastructure works to be executed without any complications in conditions of safety (Fig. 4).

Figure 4: Final excavation unconsolidated and locally failed (left) and consolidated by soil nailing technique (right)

5. Conclusions

On the geotechnical profile, slope stability analyses were ran using Bishop limit equilibrium method, with the assumption of a circular sliding surface, considering different characteristic values for the geotechnical parameters of the ground, determined through statistical methods. The results showed that the general stability should be computed using mean values for the parameters, while the stability of the side slopes is better approximated by using local values. Also, the consolidation method taken into consideration (soil nailing) proved to be efficient from the point of view of stability and also of the water flow through the slope.

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Secant piles pit enclosure with deep soil mixing columns and CFA piles

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Summary: *This article presents an alternative solution for an excavation pit within a residential project in Târgu Mureş. Secant deep soil mixing columns in addition to CFA piles, proves to be a very effective, environmentally friendly (lower carbon footprint), cost and time saving solution, compared to traditional secant piles pit enclosure. Main challenge was to find an effective solution due to traffic, neighbour buildings and site space constraints. Given the non-cohesive soil layer which is 2 meters thick, and due to the presence of ground water within, it was important to seal this layer, to prevent water in-flow.*

Keywords: excavation; pit enclosure; deep soil mixing; sealing.

1. Introduction

The proposed design had to give a technical and economical solution for the support of an excavation for a residential project, “DOX Apartments”, located in Tudor Vladimirescu Street, nr. 43-45, Targu Mures city, Mures County, Romania. Due to the limited space of approximately 780 sqm and the existing neighbouring buildings, the jobsite came with a lot of challenges regarding execution and design (figure 1, left: site layout).
The architectural level (on which relate all the measurements) ±0.00m is +313.68 mASL.

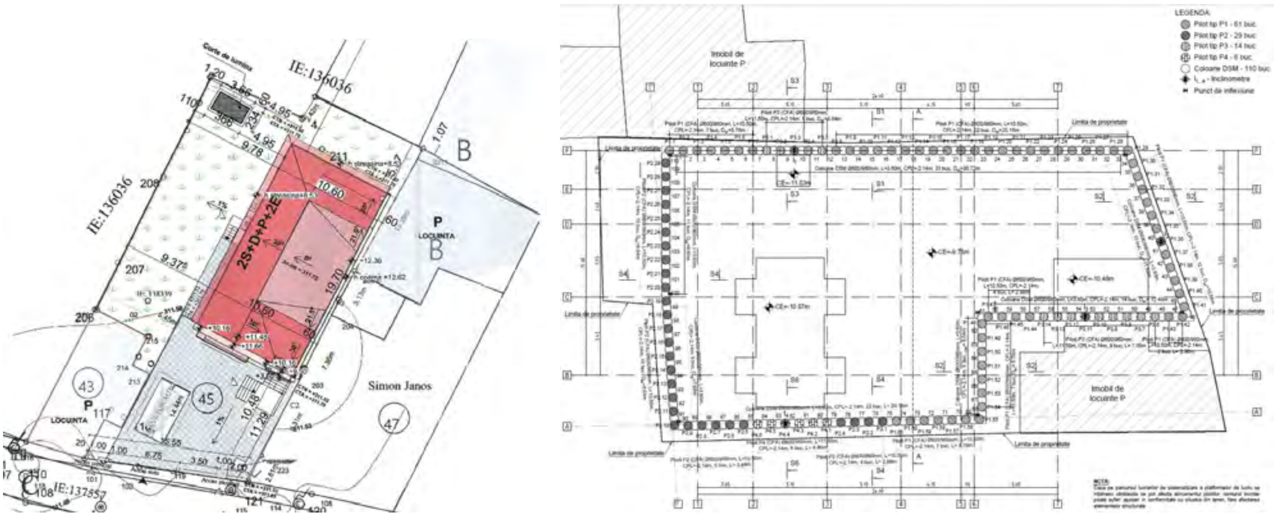

Figure 1: left: Site layout, right: retaining wall layout

2. Solution

The soil stratigraphy encountered based on the geotechnical study was a succession of clayey sandy silt followed by a 2 metres thick non-cohesive layer, in which the water was embedded and finally a stiff marly clay.
The main solutions for properly ensuring the safe excavation until the designed level for the raft foundation consisted of making either a diaphragm wall or secant pile wall enclosure, supported by one strut level.
Due to the limitation of space and neighbouring buildings, the diaphragm wall solution was not feasible in this case, so the secant pile wall solution was further developed (figure 1, right: retaining wall layout). Taking into consideration the soil stratigraphy particularities in Targu Mures area, and the need to properly seal a relatively thin layer of non-cohesive soil of 2 meters, an alternative solution based on Primary Deep Soil Mixing (Colmix®) columns 600 mm and Secondary CFA 600 mm piles was proposed for this project (figure 2, left: characteristic section).
With this solution, not only the execution schedule and the material quantities improved but also the environmental impact was lowered substantially, resulting in a much lower carbon footprint for the overall project.
Taking into account the purpose of the DSM columns, the most important characteristic of the treated soil was established to be the permeability and not the UCS strength, in order to properly seal the enclosure. The final mix was targeted to have low permeability (between 10-8 m/s and 10-9 m/s) and an average UCS of1-2 MPa, in order to easily break through the mixed column with the CFA600 augers (secondary piles).

Figure 2: left: Characteristic section, right: construction site photo

Deep soil mixing columns were designed to be executed from natural ground level (-2.15 m) and embed 50 cm in the marly clay level(-7.75 m). Drilling length per one deep soil mixing column was 5.60 m with a diameter of 600 mm.
The targeted soil mixing index BRN was 360, with a permeability of 10^{-9} m/s (lower if possible) up to 10-8 m/s (maximum accepted in order to proper seal the non-cohesive layer).
Design approach and calculations were performed according to current regulations both Eurocode 7, (ASRO, 2004), corresponding national annex, ASRO (2007) and Romanian regulations regarding deep soil mixing and bored piles execution, ASRO (2005, 2015).

3. Test results on DSM samples

Treated soil samples were taken from above (spoil resulted when tool was retracted from the ground, when mixing procedure was finished).
Laboratory testing included UCS testing and also permeability in consolidation cells, which were performed externally on three sample series each with three cylinders per each DSM column at 7, 14 and 28 days.
On fresh samples collected on cylinders, permeability showed good values between 10^{-9} and 10^{-8} m/s (between targeted results) and UCS value at 28 days exceeded targeted value (2 MPa).
Although UCS value exceeded the expected, primary DSM columns were easily drilled through by 600 mm CFA augers.
Core samples were also tested from several columns and showed also good UCS values at an average of 1.8 MPa, with permeability values within the expected range (Soletanche Bachy, 2013).

4. Conclusions

The final solution consisting of a combined retaining wall using deep soil mixing technique applied on primary piles and CFA technology for secondary piles (figure 2, right: construction site photo) proved to be the perfect mix between tradition and innovation, resulting in a very successful project with an overall carbon footprint reduction of approximately 40 tons of equivalent CO2.

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Circular diaphragm wall for a deep shaft

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Summary: *This article presents a case study regarding a circular retaining structure constructed in 2023 for a technological shaft within an aluminium processing plant in Medieșu Aurit, Satu Mare County. The project's scope of works was the design and execution of a pit necessary to accommodate a monolithic reinforced concrete structure that will serve the future facility. The adopted solution consisted in a self-supporting circular diaphragm wall, for which soil structure interaction was analysed by means of finite element method.*

Keywords: Shaft; diaphragm wall; uplift; plug.

1. Introduction

The project scope was the design and execution of a deep excavation inside a circular shaft (figure 1, left: technical concept) which will allow the construction of an interior structure, part of the vertical casting machine objective, a technological facility serving the future investment (figure 1, right: photo during circular shaft construction). The project required a deep excavation supporting solution for the construction of the future equipment in the expansion of the Aluminium extruded profiles factory. The site is located in Medieșu Aurit, part of the county of Satu Mare, situated in the north-western region of Romania, close to the Hungarian border.
The aim of the project was obtaining an efficient structural system in terms of execution, by adopting the presented solution and enhancing productivity for carrying out the construction works, optimally adapted to the particularities of the project.
Due to dimensions of the operating equipment designed to the function in the casting shaft, as due to the requirements of the construction of the infrastructure, the excavation was designed with a depth of 11,3 meters with respect to natural ground level (figure 2, right: shaft's characteristic section).

Figure 1: left: technical concept – vertical casting machine (VCM), right: photo during circular shaft construction

2. Circular deep shaft solution

Considering the project's particularities, the adopted solution consists in a circular shaft of 8 meters diameter, constructed as diaphragm wall reinforced concrete panels which will enable construction of the interior vertical casting machine's structure.
The diaphragm wall thickness has been set at 60 cm and was executed in the limits of shaped guiding walls (figure 2, left: circular diaphragm wall shaft geometry).
In the design process, multiple excavation support solutions have been studied (ground anchors, horizontal or inclined struts, top-down excavation method, etc.). Design approach and calculations were performed according to current regulations both Eurocode 7, (ASRO, 2004), corresponding national annex, ASRO (2007) and Romanian regulations, ASRO (2015), NP 120 (2014) and NP 124 (2010).

The technological characteristics of the project and the structural configuration of the newly designed construction imposed the necessity of adopting a retaining system which can provide excavation protection as well as an increased productivity of execution.
Due to the presence of large packs of sand and gravel, embedment in a clay layer has not been possible, thus resulting in the necessity of adopting a soil improvement method solution in the base of the diaphragm wall, below excavation level.
Earth and water pressure loads are transferred as compression by means of arch effect of in the concrete mass, specific to circular structures.

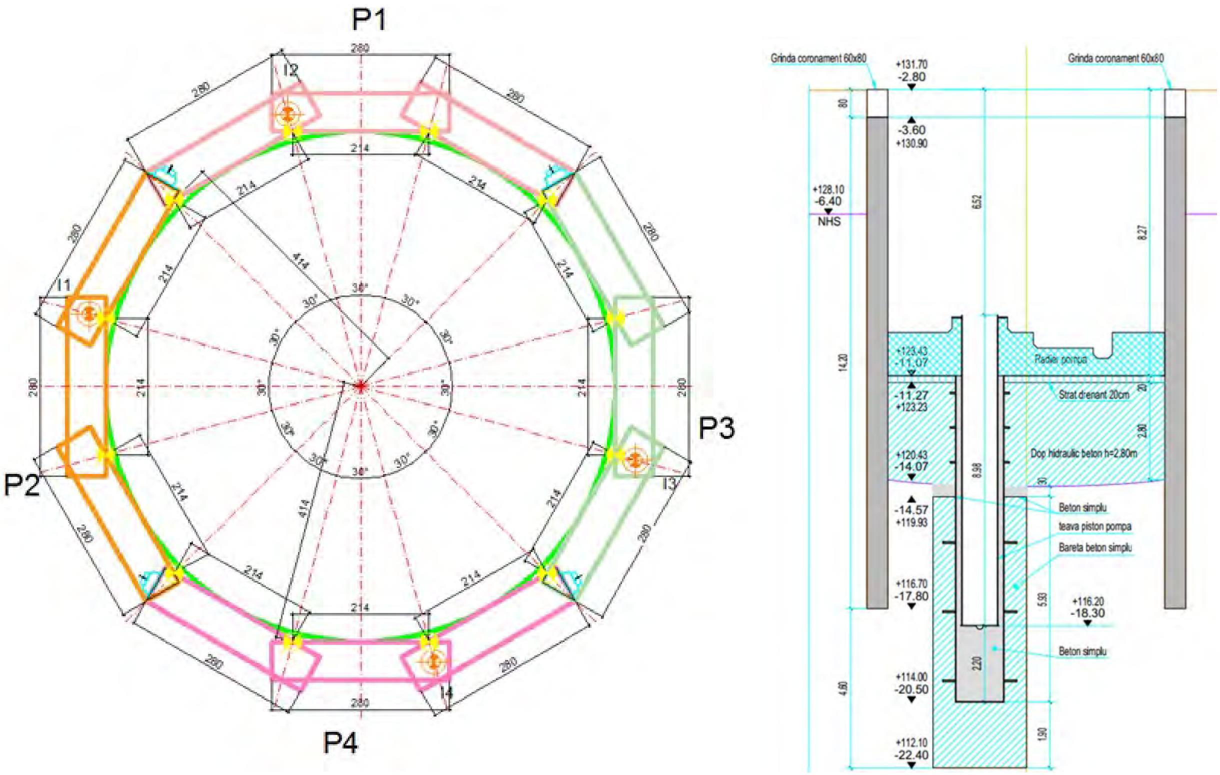

Figure 2: left: Circular diaphragm wall shaft geometry, right: shaft’s characteristic section

Diaphragm wall panels are 15 meters deep, embedded in sand and gravel ground layers.
The soil improvement solution adopted consists in substituting permeable layers of soil with hydraulic concrete on a certain length, which has been done after the inside shaft excavation works performed down to 4 meters above the d-wall base level. The hydraulic concrete plug is almost 3 meters thick, dimensioned for uplift verification, and is considered as foundation level for the structural reinforced concrete raft and the future superstructure. In order to embed a technological steel tube with dimensions of 1400x10 mm, after diaphragm wall execution, a supporting barrette, has been constructed inside the shaft..

3. Conclusions

The adopted solution for the project blends the traditional diaphragm wall technology with innovative calculation and execution methods, resulting in an efficient project, both in regards with the execution schedule and the materials put in place.

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"Tradition and Innovation - 70 Years of Constructions in Transilvania"

Adaptation of pit enclosure for extended excavation

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Summary: *This article presents a case study about supporting an existing diaphragm wall enclosure in Cluj-Napoca, originally designed for an excavation of 15.7 m, which after modifying the design theme must ensure an excavation depth of about. 21 m. Initial design provided a d-wall retaining structure of 60 cm thickness and a depth of 23.75 m. To ensure a deeper excavation than in the initial solution it was foreseen to adapt the temporary support system in order to bear all new efforts. The supporting system was intensively monitored with the help of inclinometers, topographical marks and extensometers mounted on the struts.*

Keywords: excavation; diaphragm wall; monitoring; strutting system; retaining.

1. Introduction

The scope of the project was the adaptation and execution of a support system for a deep excavation in the city of Cluj-Napoca, in north-west Romania, which came with special design and execution challenges, resulting from the requirement to adapt the support system of a diaphragm wall with a thickness of 60 cm, designed for a deep excavation of 15.60 m, being built already, for 5 meters deeper excavation (20.70 m).
The existing project needed a solution for deep excavation supporting system, in order to build a structure having multiple functions – residential as well as commercial.
Supporting system adaptation for deepening initial excavation level with another 5 meters was one of the biggest challenges of geotechnical engineering (figure 1, right: construction site photo).

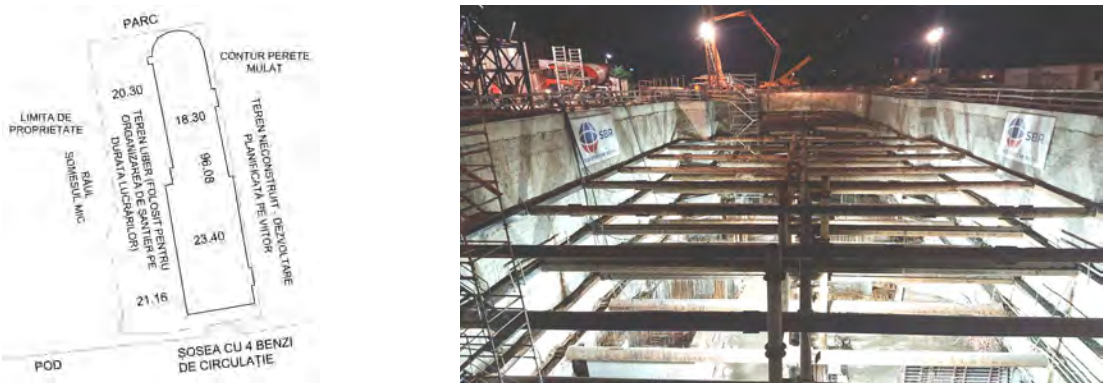

Figure 1: left: General construction site layout, right: construction site photo

2. Initial design and proposed solution

The initial project consisted of 5 basements of about 2.80 meters height each and a general reinforced concrete raft of 1.00 meter thick, resulting in an overall excavation depth of 15.60 meters.
The chosen support solution consisted of 60 cm thick diaphragm walls, with a depth of 23.75 m, supported with 3 rows of horizontal struts at the depths of 5.00 m, 8.00 m and 12.50 m. Design and execution works were performed according to current regulations both Eurocode 7, (ASRO, 2004), corresponding national annex, ASRO (2007) and Romanian regulations, ASRO (2015), NP120 (2014).
The diaphragm wall and the capping beam were completely built. General excavation was also started, with about a quarter of all excavation works completed (figure 1, left: general construction site layout).
Temporary strutting systems were also partially installed on the first, second and third row, along with the semicircle area on the northeast.
The excavation was monitored using 10 inclinometers installed in the diaphragm wall down to its base. The maximum horizontal displacements recorded were 32 mm, at a depth of 10.50 m, satisfying design presumptions.
During the process of authorizing the superstructure, local authorities demanded an increase in the number of parking spaces. After a feasibility study, the developer decided to choose a configuration of the structure with 7 basements and an automated parking system.
This led to a substantial increase in the depth of the excavation, from 15.60 m to 20.70 m. Furthermore, due to the automated elevator foundation systems designed, the excavation depth increased to 22.20m locally.
After studying several configurations, the chosen solution combined the already installed strut support system with additional struts, fixed on steel waler beams, resulting in 6 levels of struts (figure 2: strutting system configuration).

Additionally, reinforced concrete beams below the excavation level were designed and a 7th row of struts was installed, in the elevators area.
The solution was configured taking into account the need to maintain the bending moments in the diaphragm wall within the structural capacity of the diaphragm wall and to avoid excessive displacements that could cause cracks, water infiltration or even failure of a strut.

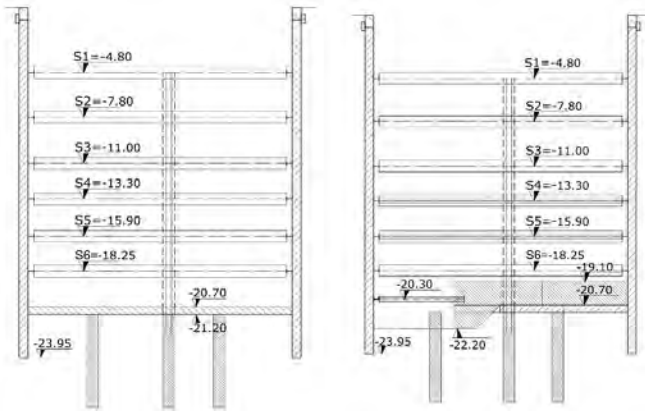

Figure 2: Strutting system configuration: a) general cross-section, b) cross-section through elevator pit

Buried reinforced concrete beams were designed to ensure the stability of the base of diaphragm wall at the stage of the final excavation. According to the calculations, without additional support, the diaphragm wall’s base displacements would have been excessive, in addition to the bending moments that exceeded its structural capacity. Besides these, the compression loads in the last row of struts would have been very. To prevent buckling, two piles (one at each end) were executed under each beam, designed according current regulations (ASRO, 2015).
Struts were arranged at a maximum distance of 5.00 m, with some variations so that there were no intersections with the future structural walls of the basements (this would have complicated the casting of these elements, due to the vertical reinforcement).
The configuration of the strutting system has been adapted to leave free areas necessary for the descent of the 12 m steel rebars for the necessary structural works and for the elements of the lower levels strutting systems, thus creating three areas of independent strutting.

3. Execution and monitoring

During the execution, the monitoring plan was rigorously followed. Independent contractors provided the results of monitoring for inclinometers and tensimeters mounted on struts.
The maximum measured displacement was 55 mm in a single inclinometer, while in the others maximum values of 25 mm were measured.
Values recorded on struts showed that the loads were exceeded by 10-50% on levels 2-5, while in the 6th row only 40% of the calculated load was recorded. The reason lies in the fact that during the excavation stages, deeper excavations were necessary to install steel waler and strutting elements (about 1.30 m below the level of strut’s axis).

4. Conclusions

The design was based on the observational method, with the ground parameters calibrated according to the measurements of the inclinometer from a partial excavation in the old enclosure configuration.
Extensive monitoring has been undertaken to ensure that displacements and loads on struts are maintained within predefined limits.
By adopting this challenging technical solution, an efficient structural system was obtained, in terms of execution and productivity perfectly adapted to the updated features of the project.

5. References

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NP 124-2010, *Normativ privind proiectarea geotehnică a lucrărilor de susţinere.*

Hybrid pit enclosure – bored piles and diaphragm wall – for a 18.5 meters deep excavation

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Summary: *In this article is presented a case study about a mixed pit enclosure consisting of bored piles and diaphragm wall for an excavation of up to 18.50 m from natural ground level, located on Primăverii Street, Cluj-Napoca. Design and build project aimed to safely facilitate the construction of a parking structure for Cluj-Napoca municipality 2 basements, 1 ground floor and 5 stories.*

Keywords: pit enclosure; hybrid; bored piles wall; diaphragm wall.

1. Introduction

Construction site is located on Primăverii Street, Cluj-Napoca, Cluj County has a trapezoidal shape, an area of approx. 1700 sqm and has an elevation height difference of 10 meters along the site length (figure 1).
In order to carry out infrastructure works, it is necessary to design and build a retaining system for deep excavation down to 18.50 m related to natural ground level. Property limit is near existing residential buildings, with different heights, without any basements and with raft foundation system.

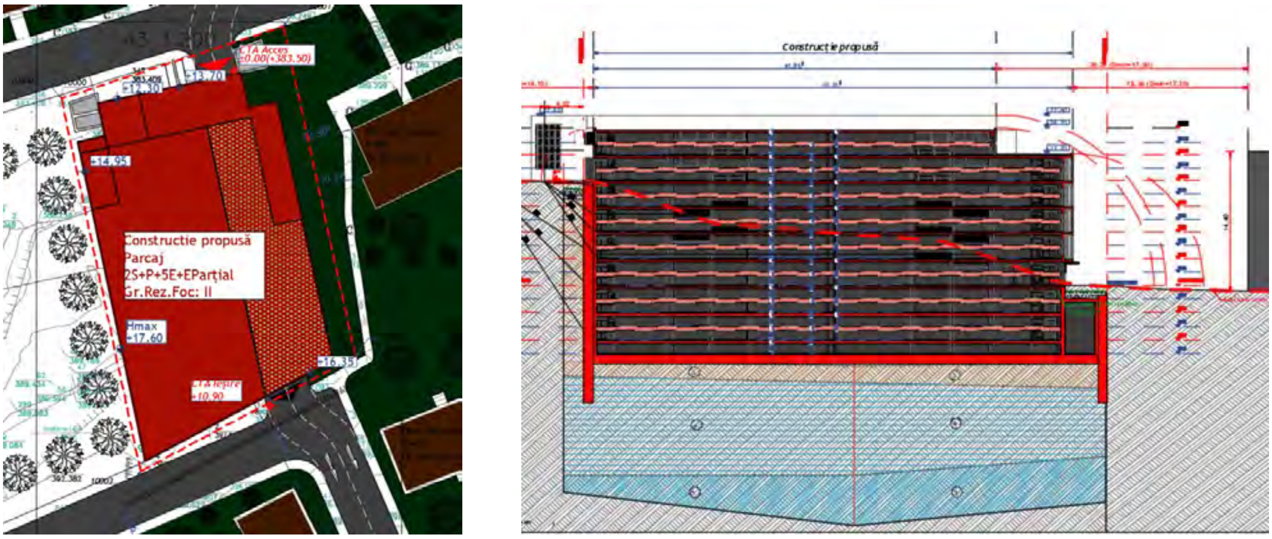

Figure 1: left: Parking general layout, right: architectural characteristic section

2. Retaining wall solution

The parking substructure is designed with slabs, beams, columns and reinforced concrete walls and with general raft foundation system.
Due to the elevation height difference of about 10 meters in the north-west direction, the ground conditions were quite different on both longitudinal and transversal axis, which led to the need to use two different technologies to be able to safely build the pit enclosure (figure 2). Basically, in north-west axis, ground conditions revealed a layer containing large boulders, a layer for which it was not feasible to make a diaphragm wall.
For this side of the site cased piles were chosen as the right technology for ensuring stability of drilling during concrete pouring.
Projects specifications and ground conditions, as well as the structural configuration of the newly designed construction imposed using a supporting system for the diaphragm walls, with steel struts arranged on 1-3 levels, depending on the characteristic section, resulting in an assembly that ensured the criteria of strength, earth stability and safety during the construction phase of the infrastructure.
Due to land systematization on the site and its location, working platforms were established at different levels which led to excavations and locally controlled back-fillings in order to reach designed working platform level.

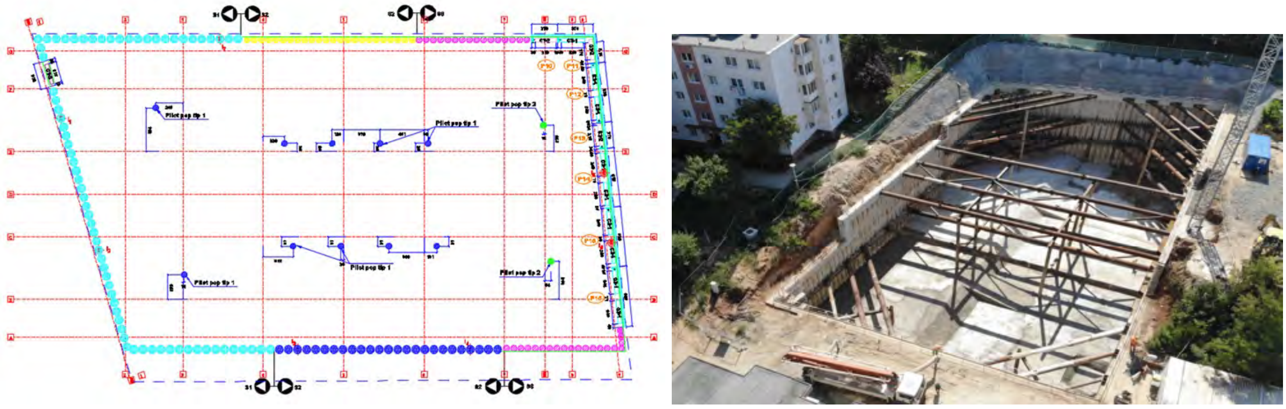

Figure 2: left: Pit enclosure layout – cased piles retaining wall and diaphragm wall, right: construction site photo

3. Building stages

The pit enclosure was built following different execution stages, according to ground conditions, architectural layout and structural system.

Initially, a general excavation of about 5 meters has been performed, followed by working platforms and guiding beams. After several sequences of pile execution from different platform levels, each lower that the previous one, the diaphragm wall was executed from the final working platform level, thus closing the perimeter.

After retaining works were finished, steel strutting system was installed in different stages, following the excavation sequences (figure 3: longitudinal section – deep excavation system).

In the end, after reaching the excavation level of 18.5 meters below natural ground level, general raft foundation was built, then further civil works followed, such as slabs casting, columns, reinforced concrete walls carefully meeting steel strutting elements dismantling.

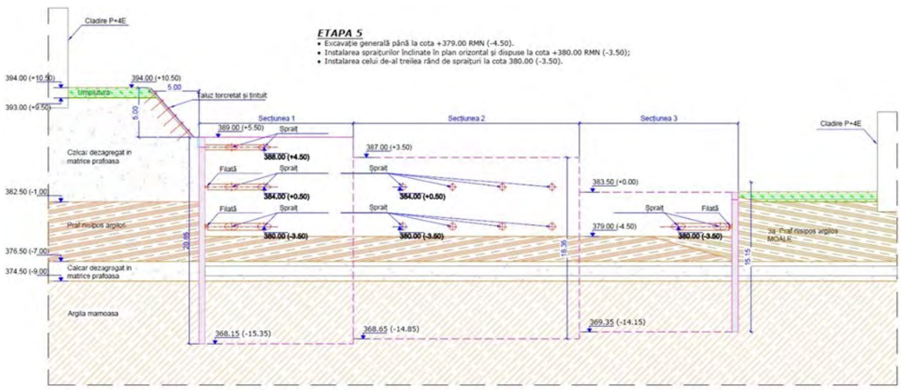

Figure 3: Longitudinal section – deep excavation system

4. Conclusions

By adopting the presented solution, the aim was to obtain an efficient structural system in terms of execution, productivity and technologies for carrying out the works, optimally adapted to the particularities of the project. The deep excavation support solution was conceived and designed based on the experience gained from similar projects, the use of advanced calculation methods, according to current regulations both Eurocode 7, (ASRO, 2004), corresponding national annex, ASRO (2007) and Romanian regulations, ASRO (2015), NP 123, NP 124 (2010) and NP 120 (2014).

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NP 123-2010, Normativ privind proiectarea geotehnică a fundațiilor pe piloți.

Soil improvement or piles? What is better for wind turbines?

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Summary: *The text examines the choice between two foundation solutions, soil improvement and piling, for wind turbines. It emphasizes the importance of early analysis, considering technical and economic factors, and collaboration with foundation slab designers. The study provides a case where soil improvement with Controlled Modulus Columns demonstrated potential cost savings compared to traditional piling methods.*

Keywords: soil improvement; piling; wind turbine; foundation slab; displacement columns technology.

1. Introduction

Dynamic developing of production of energy from renewable sources for next years, causes the needs of searching for optimal technologies for the construction of energy devices. Particular emphasis is placed on the construction of wind farms. The specificity of the structure and the location of the terrains on which wind farms are built often require the use of a solution such as deep foundation or improvement the ground, using ex. rigid inclusions – displacement columns. What is the difference between one solution and the other?
The construction method must be specified at the design stage. Depending on the decision made, the conditions of the foundation structure work change, and as a result bring changes into the dimensions and costs of constructing the foundation.

2. What is the difference between piling and soil improvement?

Deep foundation/piling solution - involves creating rigid reinforced concrete inclusions in the ground. The pile reinforcement is connected to the reinforcement of the foundation slab. The load is transferred to the load-bearing soil layers below, and the uplift forces are transferred along the pile shaft. The consequence of this solution is a smaller size of the foundation slab with a simultaneous greater use of reinforcing steel. After the piling works are completed, soil bearing capacity tests are performed on test plots. Most often, the following works are suspended until the tests are performed. The soil's load-bearing capacity is tested after the mixture reaches full strength, which takes up to 30 days.
Soil improvement – is done by concrete or reinforced concrete inclusions which are made in the subsoil. For this purpose, for example, displacement-type rigid inclusions concrete columns, as Controlled Modulus Columns (CMC), are used, which are then finished with a transmission layer in the form of a geomattress or a layer of stabilized soil. Columns can also have a gravel head, with thickness from 0.5 to 2-3 m. For such a system, the foundation is treated as being founded directly on an improved soil. The load is transferred through the transmission layer and columns to the load-bearing soil layers below, and the uplift forces are balanced by the size of the foundation. However, this solution requires an increase in the size of the foundation slab, but by not connecting the reinforcement of the columns with the reinforcement of the foundation slab, allows parallelly for a reduction in the amount of reinforcing steel. After the CMC columns are made, continuity tests are performed quickly and without any disruption to the schedule.

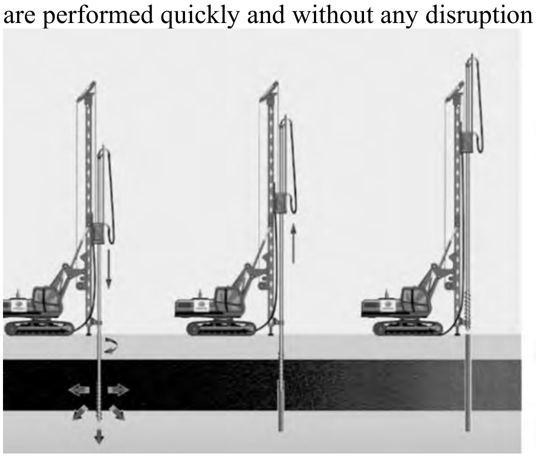

Figure 1: Scheme of CMC execution

CMC columns are made using a specially designed displacement auger, installed on a piling rig equipped with a head with high torque and static vertical pressure. The auger moves the soil horizontally to the axis of the hole, as it is shown of Figure 1. After moving the soil outside the hole for the column, the concrete mixture is injected (under pressure). As a result, the composite of soil and columns cooperating as an uniform structure with increased load-bearing capacity for direct founding the wind turbine.

3. Solutions comparison

It is needed to answer the question which solution is better in technical or economic terms. Of course, each case is different and each time an economic calculation should be made comparing the costs of piling technology with the smaller foundation slab versus the costs of ground improvement technology together with the bigger foundation dimensions, as it is shown on Figure 2.

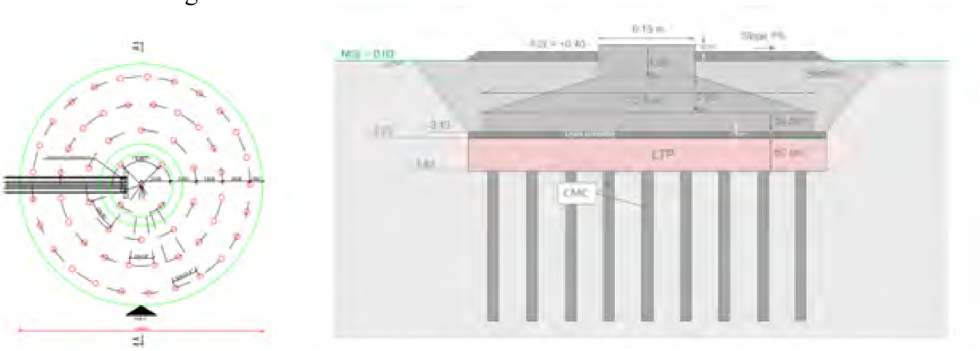

Figure 2: Example of a ground improvement solution under the wind turbine

The analysis of the technical and economic effectiveness of improving the ground for wind turbines, as well as a possible comparative analysis with the classic pile solution, should be performed already at the offer- or even pre-tender stage, in close cooperation with the designer of the foundation slab.
As an example, the comparison made for wind farm implemented in Poland in 2019, including 20 wind turbines is shown in table below. At the bidding stage, two foundation concepts were presented. The table below, developed in cooperation with the foundation slab designer, shows the differences in the amount of materials.

Table 1. Comparison of materials needed for piling and improving solution

	Amount of concrete per turbine [m3]	Amount of steel per turbine [t]
improving solution	405	120
pile solution	375	130

A foundation placed on a improved subsoil may seem more expensive, but after comparing the total costs of reinforced concrete works and improving the ground or executing piling works, it turns out that works executed as direct foundation on an improved soil are cheaper. In the discussed case, the savings were approximately 15%. When implementing an investment consisting of 20 turbines, generation of such savings provides measurable benefits, which confirms the greater profitability of constructing a wind turbines foundation on a reinforced base using CMC column technology.
It has to be remembered that whatever solution is ultimately proposed, it must meet the standard conditions and those defined by the turbine manufacturer, both in Ultimate limit states (ULS) and Serviceability limit states (SLS) stages. Improving the subsoil helps increase the bearing capacity of the subgrade, reduces settlement and tilt of the foundation, and ensures that the condition related to dynamic rotational stiffness is met. Proper strengthening of the ground allows for the safe installation of wind turbines.
In addition, acceptance tests are an important factor influencing costs. The improvement solution does not require costly load-bearing tests that delay the construction schedule.

4. Conclusions

In Romania, Menard has experience in establishing wind farms. One of them was the Ovidiu farm, built in 2010-2011, included soil reinforcement using CMC technology for 101 wind farms, with a total of 10,605 columns per investment. The second large project implemented by Menard is the Fantanele wind farm, 2009-2010, where 103 wind turbines were mounted on 10,815 CMC columns. The solution of placing wind turbines on a reinforced base is therefore not a new solution for the Romanian construction market. There is no clear answer to the title question. Therefore, when planning further investments of this type, it is worth taking into account every possible solution, not only the one we are used to.

5. References

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https://www.menard-group.com/

Geotechnical load-bearing capacity of the ground improved by columns

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Summary: *This article explores the geotechnical load-bearing capacity of ground improved by columns, emphasizing the complexity of analyzing such systems. It introduces a formula for calculating total design resistance and highlights the challenges in applying it. The text outlines extreme cases where simplifications are possible and discusses a simplified method for verifying bearing capacity. It draws from ASIRI recommendations and the Eurocode 7 standard and emphasizes the need for a comprehensive approach to soil improvement with columns.*

Keywords: ground improvement; CMC columns; new Eurocode 7; geotechnical load-bearing capacity; settlements.

1. Introduction. Improving the subsoil - a non-trivial matter

The ground is a highly non-linear, heterogeneous, anisotropic medium, difficult to study and precisely describe. If we also take into account vertical elements introduced into it (e.g. Controlled Modulus Columns - CMC), with much greater stiffness, which are intended to strengthen the subsoil, the matter becomes more complicated.
For soil improvement with columns, the Ultimate limit states (ULS) and Serviceability limit states (SLS) should be verified. In practice, when it comes to design and planning of ground improvement, the great emphasis is placed on the estimation of settlements. What is important to ensure the load-bearing capacity is the appropriate structural strength of the reinforcing elements (STR - structural load-bearing capacity) as well as preventing destruction, excessive deformation or uncontrolled movements of the reinforced substrate (GEO - geotechnical load-bearing capacity). The article presents possible methods of verifying the geotechnical load-bearing capacity (GEO) of the ground reinforced with columns.

2. Calculation of the bearing capacity of soil reinforced with columns - a simple but complicated formula

The total design resistance for soil reinforced with columns can be described by the following formula, now adapted to the design of the new Eurocode 7, part 3 (prEN1997-3):

$$R_{sys,d} = \frac{\sum_{i=1}^{n} R_{ri,i}}{\gamma_{R,ri}\gamma_{R,d}} + \frac{R_g}{\gamma_{R,g}}$$

$R_{ri,i}$	this is the load capacity of a single column „i”;
n	this is the number of columns;
R_g	this is the bearing capacity of the soil between the columns;
$\gamma_{R,ri}, \gamma_{R,g}$	partial design coefficients for the load-bearing capacity of columns and soil, respectively;
$\gamma_{R,d}$	coefficient of the computational model.

Only at first glance the formula seems simple, but in fact its application requires a thorough analysis of the entire model, taking into account the mutual interactions of individual elements of the reinforced base and taking into account all potential failure mechanisms with compatible displacements. In the system of columns and the surrounding soil, with the presence of a transmission layer, when scaling loads or reducing strength parameters, the load distribution on the columns and the soil between them changes. Moreover, the load-bearing capacity of the columns will be lost in the layer in which the columns are anchored, while the soil will reach its limit state at a higher level. The simplified methods of verifying the bearing capacity of the soil described below are practiced and allow for quick verification of the bearing capacity limit state, but the use of more advanced methods allows for the optimization of the design solution.

3. Extreme cases & simplified method

The designer has the right to simplify the formula when the analysed situation allows it. If we ignore the load-bearing capacity of the columns and the soil's load-bearing capacity turns out to be sufficient for the designed loads, the matter for the foundations will be simplified as follows:

$$R_{sys,d} = \cancel{\frac{\sum_{i=1}^{n} R_{ri,i}}{\gamma_{R,ri}\gamma_{R,d}} +} \frac{R_g}{\gamma_{R,g}} \qquad \gamma_{R,g} = 1{,}4$$

In this situation we will find ourselves in the so-called "Domain 2" (ASIRI;2012), in which the columns are designed only to reduce settlements, in this case, taking into account the load-bearing capacity/stability of the foundation structure itself, the columns are not needed.

The second extreme case can be used in systems without a transmission layer, where the column head directly supports a rigid foundation. The calculations may then omit the bearing capacity of the soil between the columns, but it must be demonstrated that the columns are able to carry the full load. Then, the soil's load-bearing capacity will be checked according to the formula analogous to that for pile foundations:

$$R_{sys,d} = \frac{\sum_{i=1}^{n} R_{ri,i}}{\gamma_{R,ri} \cdot \gamma_{R,d}}$$

Extreme cases are relatively simple, but it will often be necessary to take into account both the bearing capacity of the both medium: soil and the columns.
To verify the bearing capacity of the soil, a simplified method is often used, the aim of which is to demonstrate that the force balance equations are met and that the design bearing capacity is not exceeded, both in the columns and in the soil between them. It is necessary to demonstrate that:

- the unit load transferred to the ground between the columns does not exceed the design load-bearing capacity of this soil,
- the load per column does not exceed the external or internal load capacity of the column,
- the unit load transferred to the column head does not exceed the permissible stress due to the limit stresses above the column head - in a system with a transmission layer, determined on the basis of the Prandl mechanism or the cones mechanism,
- the balance of loads is valid.

This method can be used using analytical, empirical and numerical methods, in practice they are often combined.
More advanced methods require a deeper analysis, but a detailed assessment of the bearing capacity of the soil allows for a more optimal solution. This direction is mainly pursued by people with experience that allows them to properly select a soil testing program and assess the reliability of the method and model used in given soil and water conditions.

4. A special case of an embankment - where STR meets GEO

The embankment will be a special case where an analysis of the global stability of the system is necessary. If we are designing an embankment, stability should be verified using the "3" calculation approach, e.g. using strip methods, remembering about appropriate load factors and appropriate coefficients reducing strength parameters. The condition for using columns in stability calculations is to ensure their internal load-bearing capacity by verifying the necessity and possibly designing appropriate reinforcement using the "2*" calculation approach, because a broken or discontinuous column does not prevent the loss of stability of the embankment.
In the case where the stability of the structure is not met for the soil without columns, an analysis can be carried out in which the columns are theoretically replaced by the force acting on their tops. In practice, other methods of stability analysis are also used, and the global stability in the case of embankments founded on concrete/cemento-soil columns (such as Deep Soil Mixing - DSM or CMC) will be directly related to the bending and shear strength of these columns.

5. Advanced GEO load capacity verification

Programs using the Finite Element Method (FEM) are not yet perfect, but this field is rapidly evolving and becoming the most powerful design tool, not only in geotechnics. This kind of calculations provide a wide range of possibilities for accurate analysis, and therefore, they are tools for optimizing geotechnical solutions. It is difficult to judge when their use will be as reliable as well-proven analytical or empirical methods. However, looking at the possibilities offered by FEM, it is difficult to deny that using correct numerical models it would be possible to determine the exact geotechnical load-bearing capacity of the entire system of columns and the surrounding soil. Such an analysis could reflect the failure mechanism taking into account lithological variability, load variability, edge areas, non-linear phenomena, load redistribution and others. In this way, the safety margin of the structure using the recommended calculation approach (e.g. incremental loads or gradual reduction of strength parameters) can be determined.

6. Conclusions

The article was based on *ASIRI – Recommendations for the design, construction and control of rigid inclusion ground improvement; 2012* and the draft amended version of the Eurocode 7 standard prEN1997-3, however, it covers one selected fragment of design verification and only selected methods. It should be emphasized that in order to strengthen the ground with columns, it is also very important to verify the structural load-bearing capacity. Additionally, the design of soil improvement also takes into account verification of the serviceability limit state and the impact of settlements / deformations of the reinforced soil on the designed structure.

7. References

ASIRI – Recommendations for the design, construction and control of rigid inclusion ground improvement; 2012
Eurocod 7 standard prEN1997-3 (not-finished version)

Working platform for geotechnical works

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Summary: *The text discusses the importance of preparing safe working platforms before executing soil. It emphasizes the need for careful planning, taking into account factors such as existing and expected levels, proper determination of soil parameters, especially shear strength, taking care of and slope stability. The main stress is pushed into the safety of geotechnical works.*

Keywords: working platform; geotechnical works; safety regulations; stability calculations; soil parameters.

1. Introduction

Before executing soil improvement, prepare an appropriate and safe working platform is needed. If the improvement is performed on very weak soil or when the working level is significantly above or below the ground (excavations and embankments), earthworks, the working platform and possible drainage should be the subject of a detailed technical design. The quality and safety of geotechnical works, such as ground improvement or piling, strictly depend on the design and execution of working platforms.

2. Important factors

Choosing of working level is the result of factors such as: natural ground level, structure foundation level, groundwater table level, construction phase, utilities and others. The design of basic geotechnical works, working platforms, slope protection, excavation walls, embankments and drainage of excavation or terrain may be prepared as one complete or a few separate coordinated technical studies. Appropriate technology and organization of earthworks and proper development of the construction site are very important. It is also crucial that specialized geotechnical works are performed in accordance with applicable health and safety regulations.
A working platform is an earth structure, most often prepared as a layer of coarse-grained or stabilized fine-grained aggregates, created as a surface for the positioning and safe operation of heavy construction equipment. In the case of geotechnical works, the platform often works as a base for earthworks machines and equipment that consist of a heavy chassis and a high mast, such as piling rigs, pile drivers or cranes. This equipment has a high centre of gravity, so the requirements for the working platform are much higher than in the case of equipment to earth works such as excavators or loaders.

3. Works in neighbourhood to the slopes

The stability of excavations and embankments is secured primarily by appropriate, safe inclination of the excavation slope. In simple cases, with low height and low load on the slope edge, the safe slope of the excavation walls can be determined based on general guidelines. Even small edge movements can cause the work platform to tilt excessively or cause the platform to be removed from under the trucks of equipment. This may result in a threat to life and property, damage to the earth structure, as well as damage to neighbouring objects as a result of the machine falling.
In the case of geometric restrictions, e.g. related to land development, it may be necessary to use specially designed excavation wall protection as: a Berlin wall, a piling wall, a sheet pile wall or a diaphragm wall. The stability of the support must be ensured at every stage of the works, therefore all transitional situations must be considered and, if necessary, recalculated.
The distance of heavy equipment, e.g. a piling rig, from the edge of the slope should be at least 1.5m, while excavators min. 0.6m. It is recommended not to use slope inclination higher than 1:1.5, unless the design stability is verified each time. Design documentation, including stability calculations, is required for all slopes over 2 m high in the case of piling rigs and 4 m high in the case of lighter equipment. If additional protection of the excavation walls is used, such as sheet pile walls and Berlin walls, appropriate design documentation should be prepared each time. In each case, stability calculations should be based on the parameters of the natural and fill soil based on field or laboratory tests carried out using modern methods in accordance with Eurocode 7 (Part 2 - Identification and testing of the subsoil), not on the normative ones. The selection of tests should be the result of close cooperation between the designer and a geologist, and the final decision regarding the selection of parameters for calculations should be made by the designer and adapted to the calculation model, and the calculations should take into account the phases of excavation and embankment as well as the influence of groundwater and drainage.

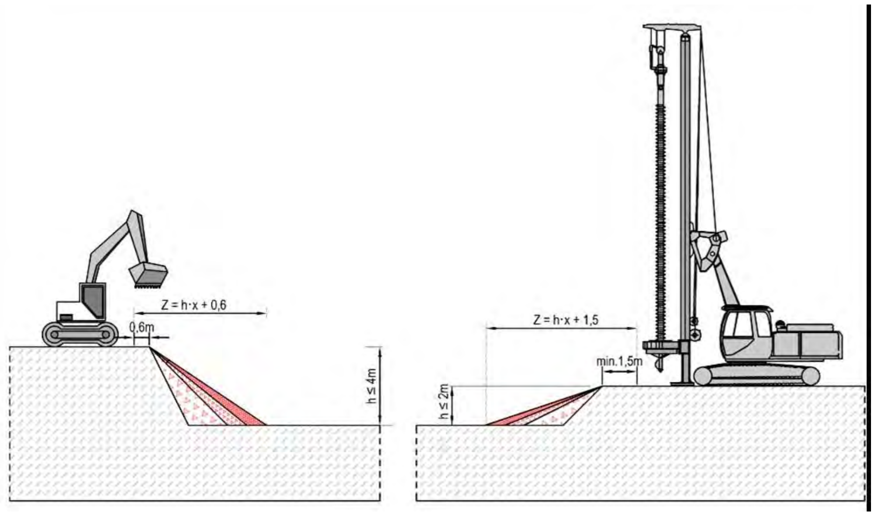

Figure 1: Distance from the slope edge

4. Works on the soil with very low bearing capacity

Soils with particularly low parameters require very precise determination of the parameters first. When designing working platforms on organic and fine-grained soils, shear strength is a particularly important parameter. Determining this parameter requires taking samples of appropriate quality and performing laboratory tests, e.g. in a triaxial compression apparatus. Alternatively, field tests can also be performed using appropriate quality probing, e.g. with a constant shear rate probe (so-called Vane test) or static CPTU probing with a large diameter cone or with a round tip.

In special cases, the platform implementation methodology requires very careful planning. When the bearing capacity of the soil is very low, it may be necessary to build the platform in several layers. The working platform, which is used to transfer loads from machines, itself generates a significant load on weak soil. This issue should be taken into account in the calculations and individual elements of the construction site development and stages of work should be properly planned. In the first stage, in order to improve the load distribution and to prevent mixing of the embankment material with the soil, a layer of geotextile is spread directly on the layer of low marsh vegetation. The first layer of aggregate with a relatively small thickness (usually about 0.5 m) is spread with bulldozers by pushing the aggregate from the front. Each subsequent stage may require time while the soil consolidates under the weight of the previous platform layer. Acceleration of consolidation can be achieved by installing prefabricated vertical drains VD, which can be made from a transitional work platform, provided that calculations are carried out to verify the safe operation of the machine used to install the drains. Then, the next or subsequent layers of the working platform are gradually made. After obtaining the appropriate thickness, it is possible to introduce heavy equipment to the area.

5. Conclusions

To sum up, the process of preparing a construction site for heavy equipment for geotechnical works requires appropriate preparation of working platforms. This issue requires appropriate analysis on many levels: logistic, scheduling, geotechnical (calculations), economic and others. In addition to them, one should also take into account: drainage, collisions, power lines and other utilities, an appropriate surface for maneuvers and many other aspects that, when properly planned, significantly improve the safety and effectiveness of geotechnical works.

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SECTION VII

ROADS, BRIDGES and RAILWAYS

The use of Augmented Reality in the assessment of the bridge technical condition

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Summary: *The last years have been an important period for the developments of the IT industry. With the growing demand for information about the surrounding reality, various devices have been created that (mobile phones or different gadgets), offer the user the possibility of direct interaction with object and retrieval of information about them.Augmented Reality (AR) technology can also be used for administrative purposes, an example being the assessment of the bridge technical condition with the involving of as many experts as possible, for a precise assessment and elimination of human errors. This article aims to provide introduction information implementation of AR technology in monitoring the bridge operational behavior.*

Keywords: Augmented Reality (AR); expertise; bridges; Civil Engineering.

1. Introduction

The development of IT technology in recent years has led to the creation of new tools designed to bring together different design and image recording programs in order to facilitate the understanding and visualization of new projects, mainly those in the field of construction or evaluation of existing constructions in operation.
Identifying the needs of the users, the need to develop two distinct fields of research and innovation was found, respectively: Virtual Reality (VR) and Augmented Reality (AR) technologies.
The first type of technology developed, namely VR technology; it is based on the integration of users in a virtual world, created by the computer (Schiavi et al., 2022). In the field of construction, VR has enjoyed success due to the ease of presentation of construction and rehabilitation projects, with beneficiaries being able to see how the intended investment objective will look. These facilities are based on the drawn part of the projects, in 3D format. With the help of a pair of VR glasses, the beneficiary can visualize the project as if it were built, realizing more easily the dimensions chosen, the way the construction will be exploited, but also any possible vulnerable points that may appear during the execution of the works.
Compared to VR technology, Augmented Reality (AR) offers the user the possibility to have access to information about already executed constructions, constructions that have been previously filmed with the help of special 360° cameras (Chen et al., 2019). This technology can be mainly used for evaluating the technical condition of a construction, offering the possibility of several experts in the field to have access and view the structure, and any possible design, execution or degradation errors can be easily identified during exploitation. AR technology can also be successfully used by construction managers, who can assess the need for intervention on the structure much faster, just from the office, based on information captured from the site by unqualified personnel.
The article aims to briefly present the AR technology. The paper will describe how the technical condition of a metal bridge located in the city of Iași was evaluated, based on the images captured with a 360° camera and the use of VR glasses.

2. Use of AR in Civil Engineering

If VR involves the presentation of a reality created by a virtual environment, AR brings additional information to the surrounding reality by superimposing various information considered important over images analysed by means of various electronic devices such as mobile phones (images captured in real time with a photo/video camera), tablets or even VR glasses. Additional virtual elements can be images or bubbles with additional information. From a technological point of view, AR includes the use of Multimedia devices, 3D modelling programs, Real-time Tracking, sensors, intelligent interaction, etc. (Chen et al., 2019).
AR is also widespread in the field of construction, both in the case of office buildings and houses, and for the design and execution of communication paths. This technology provides an improved perspective on projects, leading to increased efficiency in the execution of works, in a first step.
Also, another extremely important field of use nowadays is construction safety. In this case, AR comes to the aid of the workers by providing a much more rigorous training regarding the existing risks within the construction sites. Engineers

can visualise the technical projects directly on site, making them more aware of the presented risks. (Li et al., 2018).
In the field of bridge maintenance, this information is extremely important, technology can come to the aid of the administrator by facilitating access to data regarding the last inspections carried out, the way the structure was built, the maintenance works performed, etc.

3. The first steps in the use of AR in our country – Metal railway bridge in the city of Iași

In order to ensure the operational safety of the bridges, the administrators are obliged to constantly carry out maintenance and repair works of the structures in operation (Gimiga, 2022, Gimiga et al., 2022). These types of works also include those for evaluating the technical condition, works that are currently carried out by the field trip of a technical expert and the visual verification of the main resistance elements of a bridge.
The team of Bridges disciplines from the Faculty of Construction and Installations in Iași, observing the trend of researchers in the field, started research work with the aim of developing a new, easier methodology for evaluating the technical condition of bridges. At this moment, the methodology in use involves the travel of the technical expert to the site, a stage that consumes precious time and involves some additional costs for the beneficiary.
The new methodology involves moving a single person to the location and capturing the images through the 360° camera. The images are downloaded and analyzed in the office phase.
This method was also applied in the case of evaluating the technical condition of a metal railway bridge located over the Bahlui river in the municipality of Iași (Figure 1). Due to the specifics of the work, not all elements can be viewed only through the camera used. For hard-to-reach areas, such as those above water, a drone equipped with a full HD camera was used.

Figure 1: View of the bridge

The images thus recorded were downloaded in the office phase. Then, they were analysed by the whole team, simulating a technical evaluation, which can be carried out by a technical expert in the field.

4. Conclusions

The new VR/AR technologies come to the aid of builders and administrators by offering new possibilities for viewing works in the design phase, as well as those already in operation. These new tools will represent one of the most important steps made in recent years in the field, revolutionizing current approaches. The implementation cost is not high, facilitating rapid expansion. The advantages of using VR/AR technologies, especially AR, far outweigh any sceptical approach of possible users or beneficiaries.
The article will present a review on the state of research and use of AR technology in the world, with applications in the construction industry and monitoring the operational behavior of bridges.

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Solutions for reinforcing a rigid road pavement. Case study

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Summary: *This paper presents a solution for the reinforcement of a rigid road pavement, located on the national road DN29A, between km 4+207-23+010. The case study involves analysing the in-service behaviour of this outdated road pavement, starting with on-site sampling, carrying out laboratory tests and, finally, establishing the solution for the reinforcement of the road, in order to ensure traffic flow in optimal conditions of safety and comfort.*

Keywords: concrete pavement; reinforcement; road structure; concrete class; residual service life.

1. Introduction

Increased economic development has led to the need to expand the transport infrastructure and consequently the fleet of vehicles in use. The road structure is the fundamental component of roads, made up of road surfaces and framing lanes. It is composed of successive layers of stony materials, as far as possible local materials (Gimiga et al 2021), which may or may not be stabilized by binders, using current technologies and being dimensioned by complying with the standards in use. Thus, road pavements with a concrete layer composed of cement concrete are considered rigid road pavements.
The road pavement, as the main resistance element of a road, has a bearing capacity which is determined by the intensity and composition of the served traffic. The basis for classifying road pavements is how they react to imposed loads. During operation, roads are deteriorating and maintenance works are needed to keep them in an optimal condition (Scutaru et al 2019).

2. Materials and laboratory samples

Cement concrete, which is used in civil construction, has a wide range of technical and economic advantages. Nowadays it is also widely used in road construction. Cement concrete for road construction is used in road pavement layers, road surfaces and airfield runways.
The road sector under investigation is part of the national road DN29A, is located between kilometre positions 4+207 and 23+010 and is on the administrative territory of Suceava County. It is a secondary national road sector classified in technical class IV, and in cross section it has two traffic lanes, one in each direction, two framing lanes and two road shoulders.
Since 1970 the road has been upgraded with a 20 cm thick cement concrete surface. As part of the maintenance works, in order to regenerate the old and damaged road surfacing, repair works with bituminous treatment were carried out in 2018, and in October 2022 repair works on the road surfacing were carried out by laying asphalt pavement.
From April to May 2023, 20 cores were taken and weighed and measured in the laboratory, then the asphalt mix layer on top of the cores was removed. This resulted in cylindrical cement concrete cores which were again weighed, measured and tested in the laboratory in order to determine the splitting tensile strength (Figure 1). The characteristic thickness of the cement concrete coating (CNADNR, 2004), and the characteristic splitting tensile strength were also determined in order to establish the indication of the existing cement concrete.

3. Results and Discussion

In order to determine the reinforcement solution, cores were harvested from the existing cement concrete cover and the class of the existing cement concrete pavement was determined according to (CNADNR, 2004). The results of the rolling surface flatness in transverse and longitudinal profile as well as the roughness with the SRT pendulum are also presented. On the basis of these results, according to the standard (CESTRIN 2022), the technical condition was established, resulting in the reinforcement of the existing road pavement as mandatory works.
Thus, two solutions for the reinforcement of the existing road pavement were established: one by milling the existing surface course and creating a foundation layer of mixed stabilised recycled materials (with hydraulic binder and foamed bitumen) and three asphalt layers, respectively the second option using the existing surface course and reinforced

according to (CNADNR, 2004).
These structures were dimensioned according to the Romanian standard (AND 1999) and the structures were checked for freeze-thaw action (ASRO 77, 90). At the same time, the two varinates were analysed through a multi-criteria analysis and the optimal solution was chosen.

Figure 1: The failure mode of carrot No 20

4. Conclusions

In this paper, solutions for the reinforcement of a rigid road pavement were presented, starting from site sampling, laboratory testing and a multi-criteria analysis leading to the choice of the optimal solution.
By reinforcing this road section, the aim is to increase the load-bearing capacity of the road pavement, ensure greater comfort and safety for vehicle traffic and increase the service life for both current and future traffic.
This work is part of an extensive research program in the field of existing rigid road structures with outdated life service developed within the Department of Transportation Infrastructure and Foundations, Faculty of Civil Engineering and Building Services of the "Gheorghe Asachi" Technical University in Iasi.

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C70 International Conference
"Tradition and Innovation - 70 Years of Constructions in Transilvania"

A modernising proposal for an unpaved street

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Summary: *A one-lane, 423-m long unpaved street, develops along a valley with a highly variable river flow. The street platform is generally 3.50 to 3.75 m wide. A 50 m-long section has a 1.00 to 1.70 m wide platform, prohibiting cars or trucks from passing through. The purpose of this paper is to analyse the main possible methods to modernise this street and bring it up to an acceptable technical state, including two possibilities to ensure an acceptable carriageway width for the entire street length.*

Keywords: street design; intubation; corrugated steel pipe; minipiles.

1. Introduction

A one-lane, 423-m long street, develops along an existing valley. The street is currently unpaved and is located in a touristy area. The street platform is generally 3.50 to 3.75 m wide, with very few platform extensions allowing two vehicles to pass one another. From a functional point of view, the street is a category IV street, in an suburban area.
The horizontal alignment consists of several straight sections, connected with curves without a specific or designed geometry. On the left hand side of the street, there are residential properties. On the right hand side, the street platform is mostly separated from the river valley by an existing retaining wall. The river flow is highly variable and closely depends on the rain and/or melting snow quantity and intensity.
A 50 m-long section has a 1.00 to 1.70 m wide platform, meaning that cars or trucks cannot pass through. On the left, there are building walls or existing fences, whereas on the right there's the valley retaining wall. Only pedestrians and bicycles can pass through this section. The street is unpaved and the existing terrain is covered in grass.
The street platform is generally 3.50 to 3.75 m wide, generally allowing only one vehicle row at a time. On very few occasions, the road platform width reaches 5.00 m. There are no sidewalks or cycling paths.
Also, concrete electricity poles have been identified inside the carriageway width, posing a danger to road safety.
On the first 200 m, the street platform consists of regularly maintained gravel. Occasionally, this is infested with clay. On the following 150 m, the road structure consists of grass-covered clay. Grass and other plants are found extensively. The final section consists of clay-infested gravel. Being unpaved, the road is prone to erosion, potholes and other specific distresses. Random drainage, non-existent geometric arrangements, unpaved road structure and freeze-thaw accelerate the rate of distress. There are no ditches or similar structures designed to collect rainwater. Existing culverts are semi-functional and become overwhelmed in the case of large water volumes.
Motorised, bicycles and pedestrian traffic is difficult and subject to low speed and inadequate conditions. Proper access to the area for emergency vehicles cannot be ensured. Mobility and accessibility improvement is necessary for all traffic participants, as well as a lifestyle upgrade for all locals and visitors. The main purpose of this paper is to analyse the main possible methods to modernise this street and bring it up to an acceptable technical state, including two possibilities to ensure an acceptable carriageway width for the entire street length.

2. Methods

A horizontal design improvement was carried out, using a dedicated software application. The improved carriageway was designed for a speed of 20 km/h, with a 2.75-m width. Curve widenings were designed where existing platform space allowed it. The street would be maintained as a category IV street, in an suburban area.
Crossing platforms were designed where appropriate. These platforms are at least 2.00 m wide, in order to accommodate passing vehicles. Keeping the carriageway inside the available public space, as well as limiting the number of concrete poles that needed relocation, were the main constraints when the horizontal design was performed.
Structural design was also performed, using the standard software application used in Romania for non-rigid structural design. Two newly proposed structures were analysed and designed, according to the existing gravel thickness and quality. The two proposals were also checked for freeze and thaw action.
Rainwater collection improvements were also proposed, using precast concrete elements.
The most problematic issue was arranging the section between km 0+220 and km 0+270, with a 1.00 to 1.70 m wide available street platform area. Both the minimum carriageway width, as well as a minimum necessary space to accommodate the river flow had to be ensured. The main constraint was the available cross-section space, which was very limited, with a minimum of 6.00 m. The available cross-section space was bordered on both sides by existing

residential buildings and/or fences (Figure 1).

Figure 1: Existing street carriageway and valley (km 0+220 – km 0+270)

Geotechnical, topographical and hydrological studies were performed. The latter was completed by the Romanian National Hydrology Institute and provided a 39.6 m^3/s maximum water flow, with a 1 % insurance (INHGA, 2021), which needs to be accommodated at all times.

3. Results and Discussion

The performed horizontal design provided an adequate solution to improve the mobility and accessibility for all locals and visitors using motor vehicles, bicycles or travelling by foot. Access for emergency vehicles would also be ensured. Road structural design provided two options (Table 1):

Table 1. Road structure options

# option	Structural course, material	Thickness [cm]
1	Wearing course, BA16	5
	Upper subbase, crushed gravel	25
	Lower subbase, ballast	30
	Existing gravel	*min. 10*
2	Wearing course, BA16	5
	Upper subbase, crushed gravel	25
	Lower subbase, ballast	25
	Subgrade, gravel	*min. 15*

Regarding the section between km 0+220 and km 0+270, with a 1.00 to 1.70 m wide available street platform area, the first solution was intubating the valley, using a helically corrugated 3 mm-thick S250 steel pipe. The maximum structural dimensions are: 3.53 m width and 2.49 m height. The structure is set on a 30-cm thick compacted platform and is covered in a bituminous membrane and geotextile. This solution allows a comfortable horizontal alignment street design. A 2.75 m-wide carriageway can be ensured trough this section, with the option of providing both a sidewalk and grass-covered area as well.
The second option consists of two drilled concrete minipile walls, with reinforced concrete beams on top. The riverbed would also be covered in concrete. A 2.35 m-wide and 1.60 m-high free valley space would be necessary for the maximum river flow to pass through safely. A metallic guardrail would sit on top of the minipile wall next to the street platform (Ciont et al. 2023).

4. Conclusions

Currently, road and pedestrian traffic is problematic on this one-lane, 423-m long unpaved street, which develops along a valley with a highly variable river flow. An electronic horizontal design provided an adequate solution to improve the mobility and accessibility for all locals and visitors, as well as emergency or maintenance vehicles. For the 50 m-long section that currently has a 1.00 to 1.70 m wide platform, two options were proposed in order to ensure both the minimum carriageway width, as well as a minimum necessary space to accommodate the maximum river flow provided by the hydrological study.

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The influence of concrete casting sequences in the construction of multiple-span composite steel-concrete bridges

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Summary: *The paper analyzes, from an execution technology perspective, the superstructure of a bridge with a total length of 110 meters comprising a total of 4 spans, 2 x 35 meters and 2 x 20 meters, supporting one of the lanes of a Class 1 technical road (motorway). The deck is constructed as a composite steel-concrete structure, with four steel girders with variable cross-section dimensions along of the bridge. Five different models of the same superstructure are proposed, each with a different method of concreting, and based on the analysis results, the stresses and deformations state will be compared.*

Keywords: composite bridge; concrete casting sequences; multiple-span bridge.

1. Introduction

The superstructure of a bridge with a total length of 110 meters comprising a total of 4 spans, 2 x 35 meters and 2 x 20 meters, supporting one of the lanes of a Class 1 technical road (motorway) is analyzed in terms of its behavior during its erection, also considering the actions occurring during concrete pouring and curing. The deck is constructed as a composite steel-concrete structure, with four steel girders with variable cross-section dimensions along of the bridge. Five different models of the same superstructure are proposed, each with a different method of concreting, and based on the analysis results, the stresses and deformations state will be compared (Chindris II, 2021).

The five modes of model consideration, inspired by the way these types of superstructures are typically treated in design, are presented as follows.

a) Variant 1. The steel deck is constructed in a single phase, and the concrete pouring is also done in a single phase. This variant represents a conventional analysis, assuming that the steel deck is positioned on the substructures in a single stage, and concrete pouring is also carried out in a single stage. It represents the simplest and quickest way to model but is also the least accurate in terms of the result, as it only shows the final values of stresses and displacements.

b) Variant 2. The steel deck is constructed in multiple phases, while the concrete pouring is still done in a single phase. This variant represents an analysis of the steel deck in phases (in five phases), assuming it is assembled in sections, with concrete pouring done in a single stage. This variant provides additional information regarding the behavior of the metal component during the assembly.

c) Variant 3. The steel deck is constructed in phases, and concrete pouring is also done in phases, following the method 1 of pouring. This variant represents an analysis of the steel deck in phases (five phases), assuming it is assembled in sections, and concrete pouring is also done in phases (14 pouring sequences), in sections of 7 or 8 meters in length, starting from one end of the deck to the other (Figure 1a).

d) Variant 4. The steel deck is constructed in phases, and concrete pouring is also done in phases, following the method 2 of pouring. This variant represents an analysis of the steel deck in phases (five phases), assuming it is assembled in sections, and concrete pouring is also done in phases (14 pouring sequences), in sections of 7 or 8 meters in length, with a customized pouring order. (Figure 1b)

e) Variant 5. The steel deck is constructed in phases, and concrete pouring is also done in phases, following the method 3 of pouring. This variant represents an analysis of the steel deck in phases (five phases), assuming it is assembled in sections, and concrete pouring is also done in phases (14 pouring sequences), in sections of 7 or 8 meters in length, with a customized pouring order. (Figure 1c)

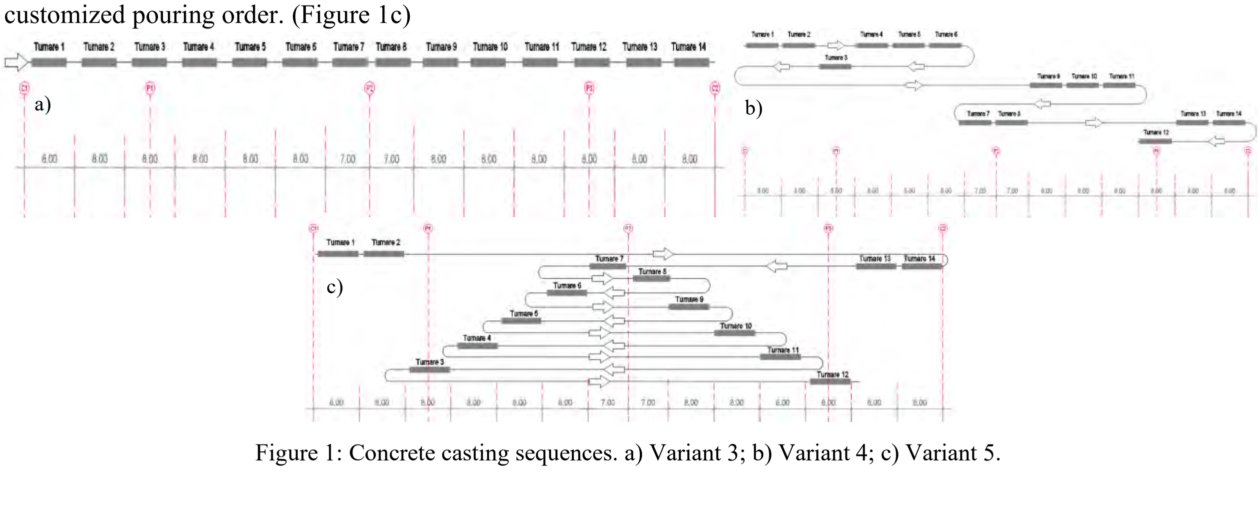

Figure 1: Concrete casting sequences. a) Variant 3; b) Variant 4; c) Variant 5.

2. Methods

The model is created in the midas Civil v2021 software, is constructed using beam-type elements, and the deck is made up of four main beams with composite steel-concrete sections arranged in the x-axis direction, as well as rectangular transverse elements arranged in the y-axis direction, which are used to distribute the transverse loads from traffic. To analyze a structure in construction stages, it needs to be fully modeled, with temporary and final support conditions applied, along with specifying dead and live loads. All of these are added in groups of elements, supports, and loads that are activated and deactivated based on the considered stage/stages. Elements, supports, and loads can simultaneously belong to multiple groups.

Element groups can be activated at any stage, with properties that account for the passage of time. Load groups can be activated/deactivated at any time during the construction stages. Support groups can be activated/deactivated at any time, in either the deformed or undeformed position of the element nodes.

To create the model, certain functions of the program are used, such as the "beam end release" function, "construction stage," as well as "Composite Section for Construction Stage".

With the help of these functions, we can temporarily release a beam-type element from certain forces or bending moments, specify all construction stages, and specify in which of the stages the steel component of a section appears and in which stage the concrete component of the same section appears.

3. Results and Discussion

Looking at the results summary and the graphs derived from them, it can be observed that under the same loads, we have different values for displacements and bending moments due to different construction sequences (Figure 2). By using a construction phase analysis, the state of displacements and forces can be monitored at any given time, allowing for continuous process improvement. For example, by choosing casting method 3 (Option 5) instead of casting method 1 (Option 3), a reduction of approximately 50 mm in self-weight and live load displacements can be achieved (31.1% of displacements in method 1). This can be a decisive factor in serviceability limit state checks.

Similarly, in the case of bending moments, in conventional analysis, only the final composite section is dimensioned, without taking into account the stages where concrete does not contribute to the composite action but rather acts as a load on the steel section. In the case of bending moments, various phase configurations can be chosen to achieve a lower-intensity state of forces. For example, by selecting casting method 2 (Option 4) instead of methods 1 and 3 (Options 3 and 5), a reduction of approximately 700 kNm at the end of the concrete casting sequences can be obtained, representing 16.5% of the moments in methods 1 or 3.

Figure 2. Results summarized in cumulative displacements and bending moments by phases

4. Conclusions

For a superstructure with moderate and balanced spans, such as the one under study, it is noticeable that significant differences in displacements and stresses can occur. However, for a bridge with large spans and unique configurations, if these stresses are not analyzed, they can potentially lead to the collapse of the structure even during the assembly phase, despite meeting all the rigor of ultimate limit state and serviceability limit state checks in the final phase.

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Performance based design for bridges waterproof systems

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Summary: *The use of high-performance waterproofing systems is recommended in terms of maintenance costs calculated over the lifetime of the bridge, even if they have a higher initial purchase cost. In order to optimise the performance of a waterproofing system, aspects that may cause vulnerabilities or failures of the waterproofing system should be considered.*

Keywords: Waterproofing systems; waterproofing membranes; infrastructure works; bridges; IZO-35.

1. Introduction

In the course of the technical expertise on bridges, it was found that most of the degradations of the bridge superstructure resistance elements, are caused or amplified by the degradation of the waterproofing and asphalt layers on the bridge. Membrane/foil waterproofing systems applied to bridges, must meet the requirements of strength, elongation, adhesion to the substrate, impermeability, high and low temperature resistance, chemical resistance, durability. Any deficiency in any of the characteristics listed above, may lead to loss of waterproofing properties and exposure of the beams and bridge slabs to the action of water and chemical anti-icing agents, with considerable negative effects in terms of the cost of repairing the damage.

2. Materials

In this paper, the main characteristics of a high-performance waterproofing system, which was applied on bridges in 2000-2002, with a tested service life of more than 20 years, was improved in 2020-2023. The waterproofing system consists of a primer layer, an adhesive layer, a waterproofing membrane made of rubber reinforced with polyester fabric and a membrane protection layer. The waterproofing system analysed, has been designed in such a way, that all the component parts perform above the average performance of waterproofing systems currently used in Romania.
The primer layer is completely waterproof and very adherent to the concrete substrate, sealing the pores and microcracks in the concrete and acting as a support layer for the adhesive layer with which the waterproofing membrane is bonded.
The adhesive layer applied above the primer and below the waterproofing membrane, is elastic and completely waterproof, with increased adhesion to the primer layer and waterproofing membrane. The waterproofing membrane has superior strength to other waterproofing systems, because it is reinforced with polyester fabric on both surfaces, the breaking force of a 5cm wide strip, being more than 7 times the limit imposed by the standards, 6 KN where the minimum permissible limit is 0.8 KN (AND 577-2002).
Even if the polyester fabric reinforcing the rubber layer breaks, the elasticity of the rubber recorded in the tests, far exceeds the admissibility condition of the standards (after breaking the polyester fabric of the membrane, the specimen continued to elongate until the initial length of 62 mm, reached the value of 680 mm, at which point the test was stopped, because the maximum displacement of the test device has been reached.
The waterproofing membrane is protected at the top, with a layer of adhesive, in which quartz sand is embedded by sprinkling. The protective layer is completely waterproof and adherent to the asphalt layers, that will be laid over the waterproofing. Each of the 4 successive layers of the waterproofing system, constitutes an effective barrier against water, the rubber layer having a tested durability of more than 20 years and a tested resistance to low temperatures of -35 ºC, where the standard allows the use of waterproofing that resists a minimum temperature of -10 ºC (AND 577-2002).
The adhesion recorded in the tests was 2 to 3 times higher than the minimum allowable limit of 0.5 MPa required by the standards (AND 577-2002).

3. Results and Discussion

This paper presents the test results of the waterproofing system applied to a bridge, in Beclean, Bistrița Năsăud county. In the tests performed, values between 1.91 - 3.12 KN (Technical Report Strabag SRL) were obtained for the adhesion of the membrane to the concrete sports layer, with an average between 2.42 - 2.89 Mpa (Technical Report Strabag SRL). It should be noted that the only value below 2 KN was obtained in the case of a specimen where the concrete failed, so the lower value of adhesion was not caused by a deficiency of the waterproofing system but by a failure of the concrete support layer.

When calculating the adhesion value in MPa for the 5 cm diameter stud, the values obtained were in the range of 1.0-1.6 MPa, whereas the minimum allowable value is 0.5 Mpa (Technical Report Strabag SRL).
For the rubber layer of the 2 mm thick waterproofing membrane, the initial specimen of 62 mm length reached 680 mm at the time of the test stop without breaking, the elongation being 997 % (ΔL > 40 %).
Degradation of the waterproofing system applied to bridges, leads to corrosion of the reinforcement in the bridge's beams and slabs, resulting in concrete degradation, in which case the repair work exceeds several times the price initially paid for the purchase of the IZO-35 high-performance waterproofing system (Figure 1).

	
The deterioration of the Calvaria bridge in Cluj-Napoca, after the use of a regular waterproofing, requires the replacement of the asphalt layers, the replacement of the waterproofing, as well as costly repairs to the main beams and infrastructure.	Bridge on DN 1C at Bunești, to which was applied the rubber recipe used in IZO-35. The photos were taken more than 20 years after waterproofing. No need to rebuild the asphalt layers and waterproofing on the bridge.

Figure 1: Bridge using regular waterproofing (left) compared to a bridge insulated with high-performance waterproofing (right).

4. Conclusions

There are patented and produced in Romania ultra-performance waterproofing systems, with a tested lifetime of over 20 years, elongation > 900 % (Δladm ≥ 40 %), breaking strength 6 KN (Fadm ≥ 0,8 KN), adhesion over 1 MPa (σadm ≥ 0,5 MPa), (AND 577-2002), starting from prices of 20-25 euros/sqm + VAT .
Ordinary waterproofing systems can be purchased in Romania at half the purchase cost of the IZO-35 system (Technical Agrement 001SC-07/065-2023), but the double life span compared to that required by regulations, as well as the tested resistance to temperatures of -35 ºC, make this waterproofing system an optimal choice in terms of reducing bridge maintenance costs.

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Development of the integrated road infrastructure safety investment program in Romania

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Summary: *In order to achieve a safer road infrastructure, Romania is taking sustained action to achieve similar levels of road safety performance, and these actions are also based on sustainability and resilience policy documents, developed and approved by Romania for this purpose and the paper aims to present briefly the methodology of carrying out a safety analysis on the road infrastructure using the data provided by the police as black spots including the social costs following these crashes, by carrying out cost-benefit and multi-criteria analyses according to the safe system approach.*

Keywords: Road infrastructure safety; road accident; black spot analysis; Cost-benefit analysis; multi-criterial analysis.

1. Introduction

According to Eurostat data, road safety in the European Union has improved considerably in recent decades. Over the last decade, the road fatality rate (number of deaths per million inhabitants) has fallen from 68 (in 2010) to 44 (in 2021), with a decrease of around 37% in fatalities, compared to the European Union target of reducing deaths and serious injuries by 50% by 2020. On the other hand, according to the 2021st Road Safety Annual Report, prepared by the Road Directorate of the Romanian General Inspectorate of Police, compared to the level recorded at the european level, Romania recorded a 31% decrease in road fatalities between 2011 and 2020 (from 2,377 to 1,646 persons), but in the EU ranking for 2020, in terms of the rate of road fatalities expressed per 1 million inhabitants, Romania ranks first, with 85 deaths per 1 million inhabitants, even if there is an improvement in performance compared to 2019 (96 deaths/1 million inhabitants).
According to the Romanian Road Authority web page, the determination of black spots is performed using the Kernel density method applied with geographic information system technology, considering one or more attributes of the recorded crashes and the historical period of time (5 years). Romania's National Road Safety Strategy 2022-2030, which is set out based on the Safe System principles, has a total budget of about EUR 617 million and is going to be implemented through the National Resilience and Recovery Programme and the Operational Transport Programme. Objective 65 of the National Resilience and Recovery Programme is to reduce the number of black spots in both urban and rural areas, including a specific investment action plan to reduce them by 48% (by 2026, compared to the initial number of 267 black spots in 2019.

2. Developing Road Safety Investment Program

The overall objective of the Road Safety Investment Program project was to contribute to the improvement of road safety in Romania, and hence to contribute to the reduction in fatalities and serious injuries on Romanian motorways and national road network. Accordingly, the purpose of the project was:

- to support the development of a Road Safety Investment Programme in Romania.
- to undertake a pilot road safety rating assessment in Romania.

A list of potential road safety investments with an estimated value of about EUR 677 million was prepared by the National Road Company in 2019, based on the above-mentioned road crash data analysis. The aim of the project was to prepare a first phase of the Road Safety Investment Programme with total budget of about EUR 100 million eur. Thus, in order to achieve the objective of reducing the consequences of road crashes, the National Road Company has embraced the European Commission's proposal to develop the Road Safety Investment Programme, financed by the European Investment Bank.
Three types of investments, which are considered crucial to increase road safety was decided to finance, as follows:

- channelization of junctions (i.e., reworking of junctions without changing their type),
- roundabouts,
- interchanges.

As Romania was missing a methodology for ranking investment interventions in road safety projects, one of the challenges in developing the Road Safety Investment Program was to develop a suitable, transparent, and verifiable methodology. The prioritization of projects started from the road crash data for the years 2015 - 2019 and a primary list of investment proposals identified and proposed by the National Road Company with geographic information system localization and technical solutions were produced.

The National Road Company provided for analysis the primary data and information which were analysed. The initially proposed lists of 526 locations were reviewed and analysed from technical and engineering perspective and other categories of investments were also investigated by analysing the crash data provided. At that early stage of analysis, it was realized that neither separation of opposite traffic flows by the means of median barriers had been considered, nor the building of third (and climbing) lanes. All the data referring to the locations with a high concentration of crashes are junctions, so they were initially grouped into four types to be assessed from the point of view of potential road safety measures for improvement. As a result of the technical analysis, a list of 229 locations – black spots, located on the Romanian national roads network, were recommended for further Cost – benefit analysis (cost-benefit analysis).
cost-benefit analysis were carried out for all of the considered locations and proposed safety measure per location.
For each of the locations under investigation the following costs and benefits were considered:

- Financial costs, further converted into economic,
- Social benefits from avoided road accidents, which were estimated as the difference between the accident costs in „Do nothing scenario” and „With project scenario”.

Given the high economic value of a human life (EUR 975 thousand as of 2020 forecasted to increase up to EUR 2.3 million by 2045) and relatively low investment and operation and maintenance costs, the cost-benefit analysis calculations proved to be extremely sensitive to whether fatalities have occurred at the respective location in the considered historical period. In case of no fatalities, the Economic Internal Rate of Return was often below the threshold of 5%, while for the remaining cases, the Economic Internal Rate of Return of over 75% of the locations exceeded 100%, which is an indicator of extremely high economic profitability.
Missing an officially adopted methodology for prioritizing the investments aiming to improve road safety, an ad-hoc approach was elaborated based on the best international practice and it was systematically applied to the considered locations. Scoring systems and relative weighing systems were proposed, discussed and adopted. Applying the so-defined multi-criterial analysis approach to the 229 locations resulted in a list of locations ranked by their priority. The first 89 ranked locations with total financial investment costs of EUR 100.02 million were selected to be implemented within the first phase of the Road Safety Investment Program. The main objective of the Road Assessment Programme method is the improvement of road users' safety by proposing cost-effective investment plans. A complete survey (inspection) of 267 km of the road network in Romania and preparation of the video survey data were performed according to the International Road Assessment Programme Survey and Coding Specification.
The Star Rating results for infrastructure safety are presented for different road user (on a 1 to 5 star' scale) – vehicle occupants, motorcyclists, pedestrians, and cyclists. Only 3% of the surveyed network was awarded 5 stars, and 7.9% was awarded 4 stars for the vehicle occupants. On the other hand, 27.6% of the network gained only 1 star. The rating for motorcyclists is worse since 45.2% of the network length belongs to the one-star high-risk category.
In order to produce a road safety investment program and later a User Defined Investment Plan by applying International Road Assessment Programme (iRAP) approach, the figures for countermeasure costs and value of death and injury collisions are the same as those used in cost-benefit analysis analysis and Investment Plan mentioned above.

3. Conclusions

Two types of road safety assessments were provided in this project. The first one is based on technical/ engineering safety assessment, prepared by road safety engineers with the support of cost-benefit analysis and Multi-Criteria Analysis,which aimed to select the best interventions among the all considered. The second method applied was according to the iRAP assessment methodology.
Following the completion of the Pilot Road Safety Rating Assessment, 267 km of roads were surveyed and coded and a Road Safety Investment Program was produced giving a range of suitable countermeasures.
Whilst it was difficult to directly compare the economic benefits from Phase 1 road safety investment program to the those produced in the ViDA software, there was a strong correlation between recommended treatments, and both showed positive BCRs.
The User Defined Investment Plan process demonstrated the importance of performing a „sense check” of the results in order to produce a robust investment plan.

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Integrated land-use and transport planning and modelling. An example in Cluj-Napoca, Romania

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Summary: *The paper presents an example of successful reconversion of an industrial site located in the built-up area of Cluj-Napoca, into a mixed-use area. Integrating transport planning concepts, Sanex platform would be the first transport-oriented development (TOD) designed in Romania based on TOD principles identified both in the Romanian law and the technical scientific literature. The model was developed to estimate the impact on the local traffic.*

Keywords: industrial site redevelopment; Sanex platform; transit-oriented development; Northern Mobility Corridor; Cluj-Napoca.

1. Introduction

Transport-oriented development (TOD) is the concept used in urban planning to empower the sustainable urban growth. A TOD model designs dense and compact urban development with residential, business and leisure areas within

vate cars

-use area
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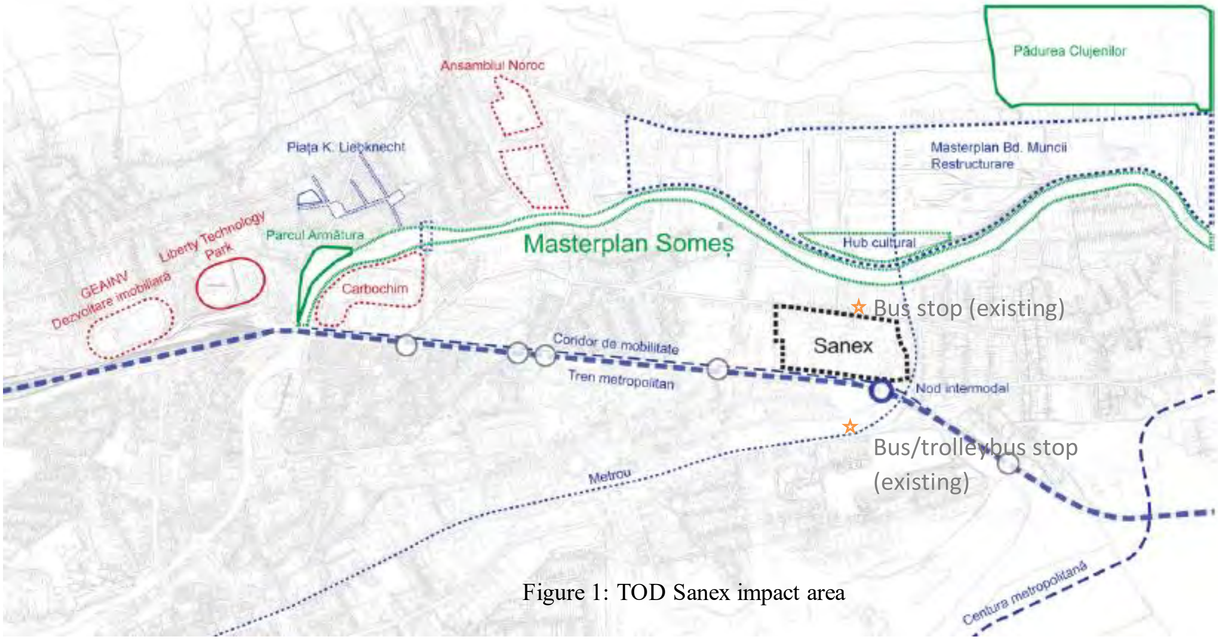

Figure 1: TOD Sanex impact area

A four-step methodological framework was refined in this research in order to analyse the impact of TOD developments following the basic steps (Cadar et al. 2023): (1) Traffic analysis; (2) Trip generation; (3) Model; (4) Impact estimation. The methodology was aiming to support the modelling step in the analysis so that less impact on the built environment and urban mobility would be achieved. It could also provide support in the sustainable urban reconversion planning of the post-communist cities which are in the process of urban growth.

3. Results and Discussion

TOD Sanex will concentrate the mixed-use area of high density within a radius of up to 800 m from the mass public transport facilities (Figure 2), corresponding to a 5÷10 minute walk and will ensure increased pedestrian accessibility by reducing the area of land dedicated to cars. The availability of multiple activities on the platform is a magnet for inner movements, associated with a reduction of trips in connection to the city.

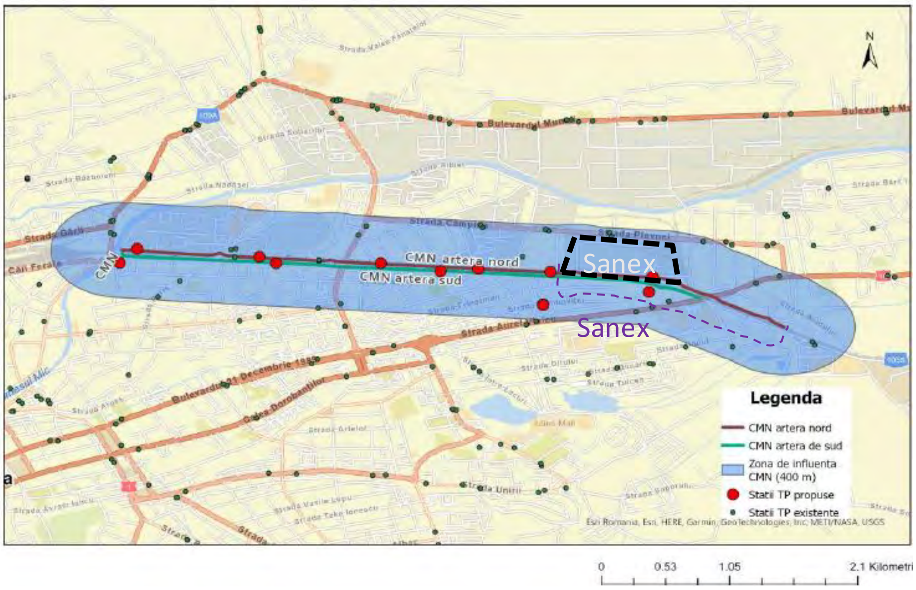

Figure 2: Public transport facilities development in correlation to CMN

TOD Sanex will generate additional local traffic volumes of significant value in comparison to the present flows. However, the results of the analyses prove that the induced traffic doesn't have a considerable impact on the conditions of the local traffic in any of the two scenarios – present scenario or both variants of the second scenario with the redevelopment. The estimated V/C ratio, level of service and delays in the two scenarios show that induced traffic can be integrated by the current street network, which has a different reserve capacity on different links. Thus, the network could operate in appropriate conditions.

4. Conclusions

Sustainable urban growth is generated in Cluj-Napoca by employing the TOD model in the design of Sanex platform redevelopment. The results of developing a multifunctional area including housing, shopping, services, offices, leisure and so on in the proximity of public transport facilities helps reduce newly generated private traffic in connection to the city, shorten the trip lengths and reduce travel times for people. Moreover, it will offer more affordable housing near basic facilities and services.

TOD Sanex is expected to generate additional local traffic volumes conducting to significant increasing traffic flows. However, the conducted analyses demonstrated that the traffic induced by TOD Sanex should not impact the local traffic conditions considerably. The estimated V/C ratio, level of service and delays in the two scenarios - present time or in case of redevelopment were computed. The results demonstrated that newly induced traffic could be integrated by the street network, due to the reserve capacity on the links, with one exception Aurel Vlaicu Street which is already in an unstable condition. Therefore, the network could operate in appropriate conditions.

Furthermore, Scenario 2 in connection to the completion of CMN denoted that implementing Sanex redevelopment along with Sanex CMN has a major impact on the development of the area and the life quality as well as on the accommodation of the additional traffic resulting from the urban redevelopment. Furthermore, the municipality will also benefit from the public-private partnership in construction of CMN which will be financed partially from private investments.

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Urban Noise: Intersection Types and Speed Breaker Impact

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Summary: *This study examines urban noise pollution in Cluj-Napoca, Romania, focusing on various intersection types and the impact of speed breakers. It reveals that intersection types significantly affect noise levels, with controlled intersections being noisier due to frequent stops and accelerations, while uncontrolled intersections are quieter. Speed breakers, especially plastic ones, noticeably increase noise levels, especially in the lower frequency range. These findings offer insights for quieter, healthier cities.*

Keywords: Urban Noise Pollution; Intersection Types; Speed Breakers; Noise Impact; Cluj-Napoca.

1. Introduction

Urban areas grapple with the dualities of convenience and challenges, with noise pollution being a pervasive concern. This study delves into the influential factors contributing to urban noise propagation, focusing on different intersection types in Cluj-Napoca, Romania. Additionally, it explores the impact of speed breakers, essential safety features, on noise levels, aiming to enhance the quality of life.
Excessive urban noise, primarily from road traffic, adversely affects health and well-being, leading to various health issues, including cardiovascular diseases (EEA Report No 22/2019; Passchier-Vermeer et al. 2000). Cluj-Napoca, a growing city, contends with rising noise levels despite ongoing mitigation efforts.

2. Influence of different types of intersection in noise pollution

The first part of the study centres on influential factors contributing to urban noise, particularly at intersections. Different intersection types, including signalized, uncontrolled, and roundabouts, were analysed. The three studied locations were as follows: a signalized intersection between Fabricii Street and Bucureşti Street (location 1), the roundabout on Calea Mănăştur-Câmpului (location 2), as well as an uncontrolled intersection between Eugen Ionesco Street and Lunii Street (location 3).The research reveals that traffic flow interruptions significantly impact noise levels, with controlled intersections experiencing higher noise within the 50-200 Hz frequency range due to frequent stops and accelerations (Marusceac and Ciotlaus, 2019). Conversely, uncontrolled intersections exhibit lower noise levels, emphasizing the importance of optimizing traffic flow in urban planning as seen in Figure 1.

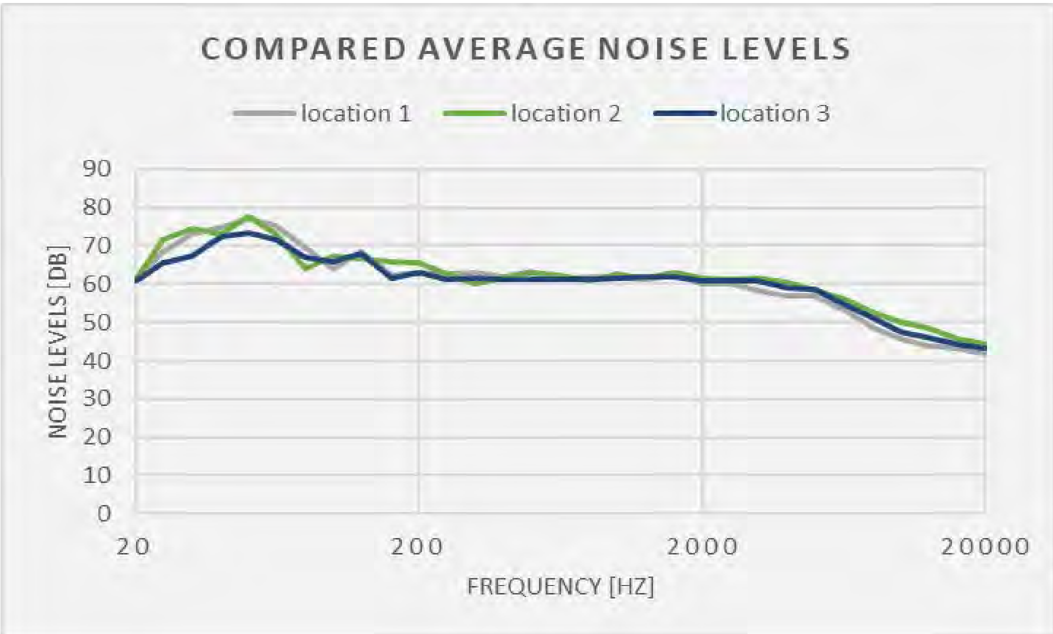

Figure 1: Compared average measured noise levels

3. Influence of speed breaker in noise pollution

The second part of the study investigates the influence of speed breakers on noise pollution (Bachok et al. 2016; Haroon et al. 2022; Marusceac et al. 2022; Shanika and Upul, 2011). Two types of speed breakers: plastic-rubber compound thresholds and asphalt thresholds were studied under various conditions. The analysis demonstrates that speed breakers substantially affect noise levels, particularly in the lower frequency range (50-100 Hz) (Janusevicius et al. 2015). This can be observed in the graph below that plastic thresholds have the most significant impact longer asphalt speed humps exhibit less noise increase, furthermore, asphalt speed bumps have a significant influence on the higher frequencies.

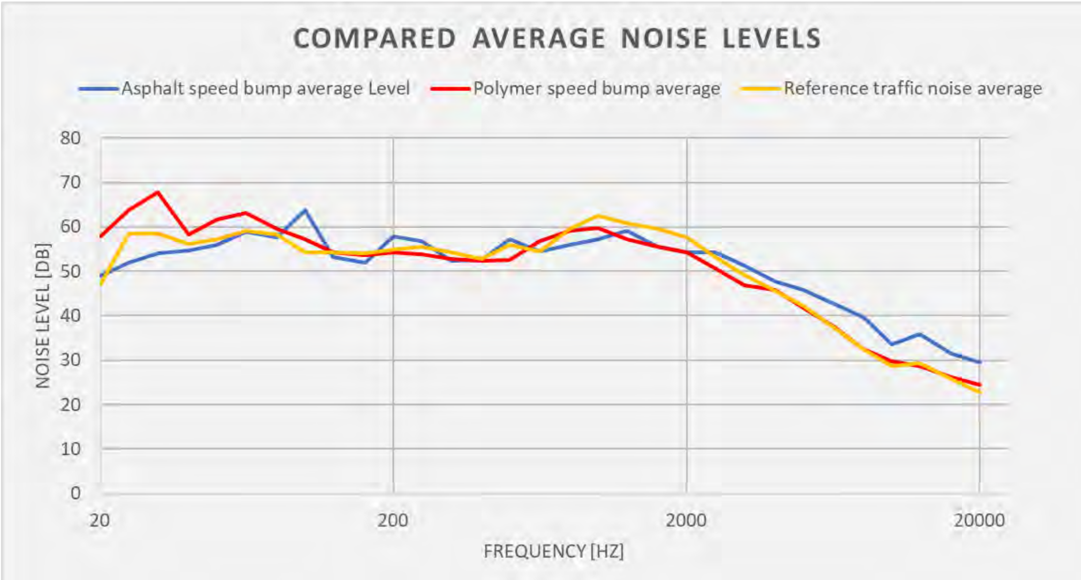

Figure 2: Comparative average noise levels for plastic and short asphalt thresholds

4. Conclusions

This research underscores that both intersection types and speed breakers significantly impact urban noise levels. Understanding the nuances of noise generation and mitigation across different frequencies is vital for urban planners and policymakers. These insights contribute to creating quieter, healthier, and more liveable urban environments, where influential generating factors and speed breakers are considered in noise mitigation strategies.

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C70 International Conference
"Tradition and Innovation - 70 Years of Constructions in Transilvania"

Suburban accessibility improvement analysis using traffic modelling

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Summary: *The main purpose of this paper is to analyse the impact that a new street would have on the existing residential suburban street network, as well as establishing its design parameters. A calibrated electronic model was used both to model the street network and to evaluate the existing traffic conditions and the two proposed evolution scenarios. The newly proposed street's design parameters were established. It was found that it contributes not only to a significant accessibility improvement for the analysed residential neighbourhood, but also to a reduction in average traffic volumes on the main existing street connection.*

Keywords: traffic modelling; software application; automatic traffic counters and classifiers; traffic study; road network.

1. Introduction

Traffic engineering represents the transportation engineering part that handles the planning, organising and design of road traffic operations, road networks, terminals and user interaction analyses. Therefore, a traffic study is a key element both in road and street design and rehabilitation works, as well as in organising traffic networks and handling traffic conditions.
The main purpose of this paper is to analyse the impact that a new street would have on the existing suburban network, as well as establishing its design parameters. The analysed suburban area is part of a large city in Romania (approx. 220,000 inhabitants) and mostly includes a rectangular network of residential streets. Currently, the connection to the central area and rest of the city is ensured by a main four-lane street (called in this paper street #1, which is also a section of the secondary national road network) and a secondary two-lane street (called in this paper street #2, which is part of a regional county road, connecting a few villages). These two streets run parallel to each other, with street #2 to the north. To the south of street #1 and the analysed residential area, a major industrial area is bordered by street #3, which is a two-lane street with heavy traffic. This area extends alongside a major four-lane street (called street #4), which is also parallel to street #1 (to the south of it).
Traffic parameters exhibit a pendular pattern, with local peaks during the morning and afternoon. Transit is mainly concentrated on streets #1 and #4, which are connected by the city ring road.
A new connection (street #0) is proposed between streets #2 and #3, overpassing street #1 (with no proposed intersection between them). Current traffic patterns and volumes have been evaluated using automatic traffic counters and classifiers (ATCCs). The network was modelled both in the current situation, as well as using a 15-year timeline. The latter includes two scenarios: without street #0 on one hand (scenario S-0), as well as with the proposed connection (scenario S-1). Traffic parameters were evaluated and compared between each other, in order to analyse the impact that street #0 would have on the existing suburban network, as well as establishing its main design parameters.

2. Methods

Current traffic patterns and volumes have been evaluated using ATCCs installed on streets #2 and #3. The ATCCs were overviewing two existing roundabouts, which represent the proposed street #0's north and south end, respectively. The electronic regional traffic model (FIP Consulting, 2022) was available for this study. The model was built using the PTV Visum traffic modelling software application. In this study, the model was calibrated using the most recent traffic evaluation.
The existing traffic conditions were analysed, based on current measurements and on-site evaluation.
For the 15-year timeline, firstly the S-0 „without project" scenario was evaluated (Figure 1). This scenario assumes that no network change would be implemented in the analysed area of influence. Recent development and evolution tendencies would be maintained over the perspective timeline, without introducing new network links and/or connections.
Then, the S-1 „with project" scenario was performed using the PTV Visum traffic modelling software application (Figure 2). A new link was introduced in the existing network, according to the street #0 proposal.
Annual average daily traffic (AADT) values on street #0 were extracted from the electronic model. These values were used to evaluate the hourly traffic volume, based on which the newly proposed street's category, number of necessary lanes and main design parameters were established.

2025 timeline *2040 timeline*

Figure 1: Road network model, S-0 evolution scenario (FIP Consulting, 2022)

2025 timeline *2040 timeline*

Figure 2: Road network model, S-1 evolution scenario (FIP Consulting, 2022)

3. Results and Discussion

The AADT values extracted from the electronic PTV Visum model (FIP Consulting, 2022) for street #0 range from 5,100 passenger cars/day (year 2025) to 8,040 passenger cars/day (year 2040). Based on these values, hourly traffic volumes ranging from 224 pass.cars/hour/lane to 354 pass.cars/hour/lane resulted, meaning that the new proposed street (#0) can be classified as a category III street (Ordin M.T. 49, 1998), with two traffic lanes. Sidewalks and cycling lanes would also be designed. Traffic loads used for street structural design were also extracted from the model.
Introducing the new connection (street #0) between streets #2 and #3, overpassing street #1, contributes to a reduction in AADT values on main street #1 ranging between −11 % (year 2025) and −17 % (year 2040). Furthermore, the analysed residential area accessibility is significantly improved through the new street.

4. Conclusions

A comparative study on suburban accessibility improvement analysis was performed. A calibrated electronic PTV Visum model (FIP Consulting, 2022) was used to evaluate both the existing traffic conditions, as well as the two estimations in scenarios S-0 and S-1, respectively.
The new proposed street can be classified as a category III street, with two traffic lanes, sidewalks and cycling lanes. The new connection contributes not only to a significant accessibility improvement for the analysed residential neighbourhood, but also to a reduction in AADT values on the main existing street connection (street #1) from −11 % to −17 %.

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SECTION VIII

LAND MEASUREMENTS

Management of construction modulation activities using tools Geographic Information System (GIS) and Building Information Modeling (BIM)

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Summary: *For the modulation of constructions, several main stages are recognized as an evolution over time, of which we mention two: the 1800s, when in the USA they started concerns that had the purpose of modulating the constructions used in the conquest of the west and the second moment is around the year 1960 when the construction of prefabricated modular housing blocks began throughout Eastern Europe. GIS and BIM are starting, lately, to contribute to the efficiency of modulation through a better management of spatial information. The paper will make a presentation of the current state of GIS/BIM implementation in the modulation of constructions, presenting the vision of the authors in this field.*

Keywords: GIS; Prefabrication; Building Modularity; BIM; Spatial Information Management.

1. Introduction

The momentum that modulation in constructions has taken, lately, is precisely due to the variety of different categories of constructions that can be realized through this methodology, as well as the advantages, of which the significant reduction of pollution in conditions of greatly reduced execution costs is constituted as a main argument. A large part of what constitutes building modulation is constituted as geographic spatial information, presenting two main characteristics: each component has a mappable spatial reference in rectangular coordinates and also contains attachable attribute information.

2. Methods

Geographic Information System (GIS) has established itself as the main IT tool for managing spatial information and lately, together with BIM (Building Information Modelling), it is starting to contribute to the efficiency of modulation through a better management of spatial information. A first example can be the management of the MEP (Mechanical, Electrical, and Plumbing) integration in the modular elements and another example is the coordination of the assembly of the modules, considered layers of the GIS system thus formed. Although BIM and GIS are powerful tools used in construction modulation due to individual, distinctive characteristics and capabilities, however, only by combining the characteristics can a competitive informational mix be reached in the informational management of construction modulation. E.g., GIS provides georeferenced data, which enables 3D analysis, spatial analysis, and querying and BIM provides a detailed database of object-oriented parametric information for the building and represents it in a 3D model, a feature that GIS lacks. Research efforts to leverage the integration of BIM and GIS in the construction management process are progressing, starting from the earliest concerns regarding the contribution of BIM.

3. Results and Discussion

GIS and BIM can be integrated into the entire cycle of making an investment, from the feasibility study to post-execution monitoring, passing through the phases of design, preparation, and launch of production and execution (Figure 1.). Building modulation certainly requires, at this stage, the integration of these technologies. Some of the stages that require strict monitoring are:

- Integrating installations into prefabricated elements,
- Assembly of prefabricated elements and formation of modules,
- Transporting the modules to the installation site,
- Checking the integrity of the modules in the pre-assembly phase,
- Assistance in putting the modules into operation and verifying the assembly, including pre-assembled installations, but also other equipment,
- Monitoring of the entire 3D geometry throughout the execution cycle,
- Post-execution monitoring, at this stage, using Structural Health Monitoring (SHM) technologies,

There are many common components, on the one hand, to any investment execution project, on the other to modulation, but the authors consider that the creation of GIS and BIM integration models also requires their adaptation for each case launched in execution.

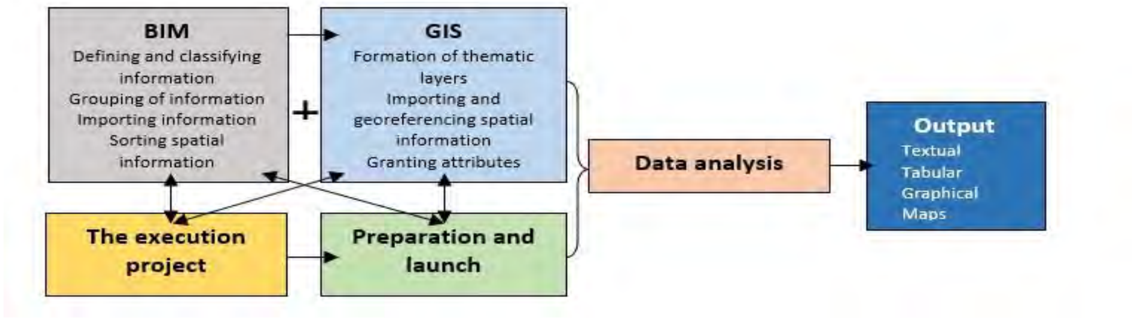

Figure 1: Integration of GIS and Bim information technologies in construction modulation

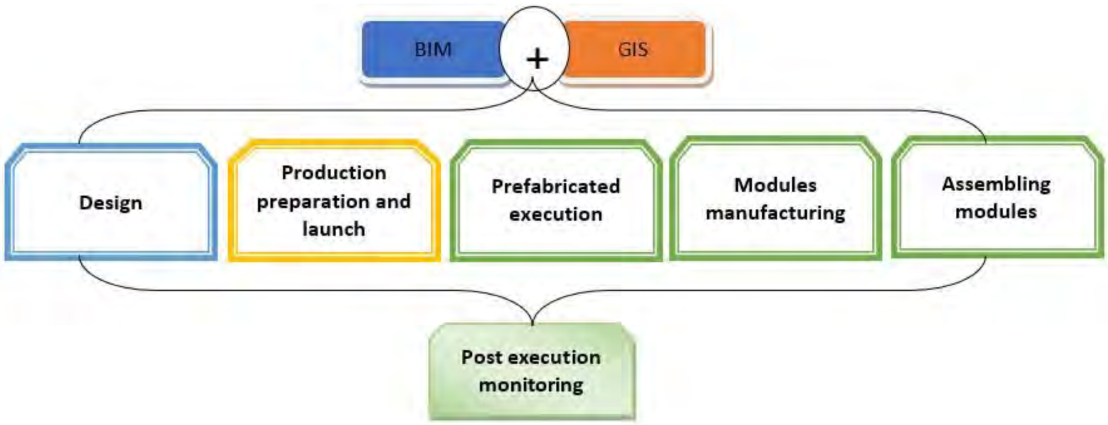

Figure 2: An overview of the possible contribution of GIS and BIM in construction modulation

4. Conclusions

This paper is part of ongoing research that aims to improve the current model of GIS and BIM applications in construction management in general and construction modulation in particular. Future work will focus on augmenting the integrative GIS + BIM model to maximize its benefits. There are already certainties that the integration of BIM and GIS in construction modulation will enrich the current management and control tools of all phases from conception to tracking behavior over time by adding a wide range of new functions.

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Monitoring road infrastructure works for the bypass of Zalău Municipality using remote sensing images and data

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Summary: *The current system of road communication infrastructure of Zalău Municipality and of the peri-urban area is incomplete in relation to the type of transit traffic, especially that of heavy traffic to the north and northwest directions to Satu Mare and Oradea, respectively Baia Mare. Currently. heavy traffic transiting Zalău Municipality to Satu Mare, Baia Mare transits the city on the network of existing streets under the administration of the local council of Zalău Municipality, achieving daily traffic jams and long waiting times at traffic light intersections in the city, with negative effects on city residents and negative impact on the environment due to pollutant emissions and noise pollution. As an object of research, satellite remote sensing was used to monitor the objective of the case study through spectral images, and by calculating the spectral indices, the anthropogenic impact generated by the construction of the bypass variant was mapped.*

Keywords: monitoring; infrastructure; remote sensing; spatial analysis; multispectral imaging.

1. Introduction

Road infrastructure is essential for the well-being and economic health of all nations, so a large number of civilian investments are made in road construction and maintenance (Feng, S., et.,2019, 2021)
Remote sensing is applied in various fields of activity, such as construction of land information, monitoring of road infrastructures, disaster management, environmental monitoring, inspection of various installations and exploration (mining, gas). The satellite images acquired from the study area realistically captured the spatial and temporal changes of the environment along the bypass of Zalău fig.1 before and during construction. However, these images had to be normalized before they could be used to assess spatial and temporal changes in environmental conditions, as the images were acquired at different points in time, which could lead to different natural conditions in vegetation and climate (Fluet-Chouinard, et., 2015; Navon, R., Shpatnitsky, Y., 2005)

Fig 1 The bypass of Zalău Municipality

2. Methods

For this study we chose the method of obtaining images by active means because active remote sensing is individualized by multispectral means (Achim, 2021). These multispectral images are raster images that capture on certain spectral regions of red, blue, green, close IR (Infrared) color (Imbroane, 1999)
We used the spectral bands of Sentinel-2 images provided by the European Space Agency ESA, data that are available on the Copernicus Open Access Hub and the Copernicus Data Space Ecosystem in our research (Achim, 2021)
Sentinel-2 images provide a versatile set of 13 spectral bands spanning from visible and near infrared to shortwave infrared, with 4 spectral bands at 10 m, 6 bands at 20 m, and 3 bands at 60 m spatial resolution.
For this study, GIS (Geographic Information System) and SNAP (Sentinel Application Platform) (Vorovenci, 2015) techniques and methods for obtaining images by remote sensing were used, which are individualized by multispectral

images of red, blue, green, close IR(Infrared) 4 batches of Sentinel 2 S2A, S2B satellite images were analysed between 2020-2023 from different seasons.
The research used the spectral bands of Sentinel-2 images provided by the European Space Agency ESA. The PCA (Principal Component Analysis) component for tapes (B1, B2, B3, B7, B9, B10, B11) was analysed because this method transforms image data into a new set of images that can better illustrate essential information. PCA is also used in many remote sensing applications including identifying changes, uses, and covering trains. After PCA analysis, the images were classified in the open-source QGIS Desktop software, with the resulting classified images forming a pixel mosaic belonging to a specific class/theme, which is the thematic map of the original image.
For monitoring surface works, the normalized index for NDVI (Normalized Difference Vegetation Index) vegetation with the range of values from -1 to was used.1. The NDVI index can be calculated based on stellar images taken with different sensors for Sentinel 2.

3. Results and Discussion

After processing the 4 batches of images, the NDVI vegetation index was calculated. The negative values of NDVI (values close to -1) correspond to water.; values close to zero (-0.1 to 0.1) generally correspond to arid areas of rock, sand or snow; Low, positive values represent shrubs and pastures (about 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching1). The analysed area falls between the values (-0.1 to 0.1) that correspond to the changes to the bypass of Zalău Municipality presented.
The results obtained for the 4 satellite images obviously show a change in vegetation, the negative correlation of the NDVI shows that the lower the value of biomass embedded in the land use/cover class.
This approach to monitoring infrastructure works by satellite remote sensing using Sentinel 2 multispectral images helped us detect the progress of remote work on a larger scale. In order to have certainty of the facts, periodic topographic measurements are mandatory in order to be able to compare field data with those from satellites. In conclusion, this study managed to combine the notions of remote sensing with those of topography and geographical information systems. Using GIS techniques and overlaying satellite images, the impact on environmental components and anthropization of a study area can be mapped.

4. Conclusions

One of the most valuable, extensive and important resources in Romania is road infrastructure. The assessment and monitoring of road infrastructure is essential for maintaining a safe and efficient road system. There are several surface and underground indicators of stress and defects that are observed using traditional geotechnical engineering methods. Although effective, many of these methods can be time-consuming, laborious, destructive, expensive, and can only provide information for limited areas. The use of remote sensing techniques offers new potential for builders to evaluate large areas, often in no time. Although remote sensing techniques can never entirely replace traditional geotechnical methods, they provide an opportunity to reduce the number or size of areas requiring site visits or manual methods. Using remote sensing methods to assess road infrastructure and transport networks during and after natural or man-made disasters can also provide comprehensive information for emergency managers.

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The need to create a 3D cadastre

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Summary: *During last two centuries population density has increased considerably resulting in a more intensive use of the land. This phenomenon increased the importance of property which also changed the perception of people in relationship with land. This change required a system in which land ownership was clearly and indisputably established.*

Keywords: 3D cadastre; land, property; administration; property register.

1. Introduction

The existing pressure on certain lands, especially in areas of business, commercial and industrial centers has led to an overlapping and interconnection of constructions. This is why, at the moment, there is a challenge when registering these constructions in a simple cadastral plan, with a cadastral registry that records information on 2D plots. Initially, the cadastral registry appeared to help with land taxation. Currently cadastre offers and improves efficiency of land transactions by offering them security.

2. Methods

3D technology is in a continuing evolution with the changing paradigms of urban planning and land policy, because it affects not only the way the city is seen but also the way property rights are described by other restrictions in space. As a result, a new urban legal framework based on 3D laws and 3D property registers will be needed to describe objects in space instead of flat outlines. 3D laws affect the rights in space, not in the projection plane and in this context it is possible to define 3D land policies.
Such a system refers to "cadastre" although there are currently several systems with different names in the world that hold similar responsibilities such as cadastral registry, cadastral system, land records, property register or land register. There is no single form of cadastre. For this reason, it is impossible to define, in a universal way, the cadastre which is concise and comprehensive having the distinctive characteristics of a technical registration of parcels located in any territory, but also legal registrations regardless of the fiscal nature of the property.

3. Results and Discussion

Even when property rights over complex constructions are established according to existing legislation, problems may arise in their description and appearance. The challenge is the registration of overlapping and interconnected constructions when following their design on the ground, on a simple cadastral plan, in a cadastral register that contains information about 2D parcels.
The question that arises is whether the traditional cadastre, existing on a large scale today, based on two-dimensionally represented parcels, is suitable for recording all types of situations that occur in the modern world, or should the cadastre develop a 3D approach?

Figure 1: National road DN 1 over the A10 highway

The property, in these cases, is located one above the other (Figure 2) or it is possible that a property crosses another property underground and/or above ground. Therefore it shows the need for the cadastral registry to expand into the third dimension. Through the cadastre, the rules should be established and the rights over the properties should be legislated in the previously presented cases.
The growing interest recognized for a 3D cadastre worldwide is the result of a multitude of factors, such as:
- the obvious increase in property value;
- the lack of spaces located on the ground of intensively populated or industrialized centers and those that are in a continuous development;
- the need for new access roads, parking lots, roads and alternative routes needed in intensively populated areas, thus calling for their location underground or above ground;
- more tunnels, passageways, wiring and pipelines underground parking lots, buildings built over roads and highways, highways built over buildings and even through them, intersections of uneven roads and railways (Figure 1);
- modern architectural development, thanks to the propulsion given by technological and scientific evolution;
- the 3D approach in other fields (3D GIS – Geographic Information Systems, 3D planning, 3D scanning devices and tools, software for processing and viewing 3D data) that make the approach of a 3D cadastre feasible from a technological point of view.

For example, a 3D image of the basic element and the actual area ratio for a set of parcels would facilitate the land management use of tools such as levies for the purchase of building rights. To support a 3D legal framework it is necessary to have spatial data systematized on 3D cadastres, which create and maintain up-to-date spatial databases and volumetric representations of cities, as well as the 3D property register where each property and its restrictions are identified and documented.

Reality 2D cadastral plan

Figure 2: Representation of reality in 2D plane

4. Conclusions

Despite its promise as an urban planning tool and extensive research in practice to date, no country has a true 3D cadastre with full functionality. The concepts involved in the evolution of this new process should be based on the field of land administration which provides support for 3D representations. Even if the technologies used to measure, represent and collect information are evolving towards 3D, urban and land legislation still perceives the city as a flat land surface. The competent authorities with decision-making in urban environment follow the advancement of procedures regarding the 3D visualization of buildings and existing restrictions on properties.

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C70 International Conference
” Tradition and Innovation - 70 Years of Constructions in Transilvania”

Observation of Landslide Phenomena and Amplitude Analysis Using Remote Sensing and UAV Technology

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Summary: *Today, when technology plays an increasingly significant role in all fields, we can use it to collect and analyze a larger volume of data in a shorter time. The Unmanned Aerial Vehicle technology, through photogrammetric and remote sensing methods, provides data about the shape and dimensions of land surfaces, even in the most rugged areas A similar area with a risk of landslides exists in the surface area of the Totruş mine in the town of Târgu Ocna, and through modern means, an analysis of the condition and shape of the area affected by land collapses has been conducted.*

Keywords: Landslide; UAV; 3D model; photogrammetry.

1. Introduction

The first writings about salt extractions in the area of Târgu Ocna date back to 1380 when the extraction was done from bell-shaped pits. From 1870 to 1941, in Moldova Veche mine, the exploitation was made in four trapezoidal chambers with a central pillar. In 1936, a new salt mine, Moldova Nouă, was opened and this one has an adit. The Trotuș mine currently utilizes small chambers and square pillars; a method used since 1967. The longevity of using this method is due to its stability. Furthermore, our focus is on the bell-shaped pits which due to the passage of time and the old extraction methods, landslides, and collapses, which are common phenomena in mining area, have occurred.

2. Methods

For these types of phenomena, measuring and determining their amplitude can be difficult and even dangerous. Today, by utilizing Unmanned Aerial Vehicle (UAV), a type of aircraft that is operated without a human pilot on board, and remote sensing methods, we can make observations in hard-to-reach areas and process precise topographical data for any region (Goel et al., 2011). The data collection was performed using a drone with Real-Time Kinematic (RTK) mode and a camera with a 4/3 sensor, offering a 20 MP resolution. Ground control points were uniformly placed on stable surfaces and tracking points were distributed in the study area, determined using RTK, Figure 1.

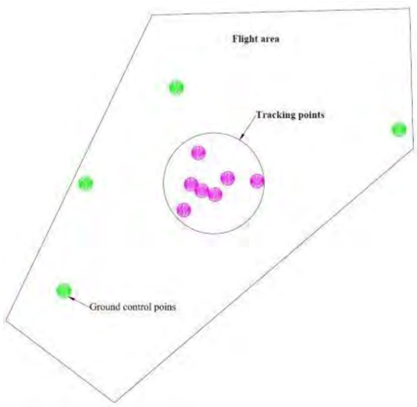

Figure 1: Distribution of ground control points (personal source)

Due to a level difference of over 130m between the upper ventilation shaft and the mine access shaft, the flight was conducted from a flat area near the landslides, at approximately half of the level difference. The flight plan was polygonal, with an 85% image overlap, a flight altitude of 150m, and the camera oriented at 90°. The image processing was performed using dedicated software, and to achieve the necessary precision and bring the images into the national coordinate system of Romania, coordinate transformation was necessary. Verification was done using previously determined ground control points, some of which were part of the surface geodetic network of the mine (Oniga, 2017).

3. Results and Discussion

Following image processing, an orthophoto map, Figure 2, with resolution of 4.2 cm/pixel was obtained, along with a 3D digital terrain model with resolution of 8.4 cm/pixel with a density of 142 points per square meter. So, from the studied surface, 809 images were captured, from which, after processing, a total of 426,439,192 points were extracted, forming the dense point cloud (Popescu, 2017). These data were used for analyzing terrain deformations and will serve as a reference for future observations to determine the phenomena occurring more precisely in this area.

Figure 2: Location of the section through the landslide cone (personal source)

4. Conclusions

It is obvious that by applying photogrammetric and remote sensing methods, we can extract important data from hard- to-reach areas. Through these methods, precise measurements and observations can be made regarding the amplitude of landslide phenomena compared to natural terrain, Figure 3. From future observations, data will be extracted, which overlayed with the existing data, will provide an obvious analysis regarding the amplitude and speed at which the landslide phenomenon occurs.

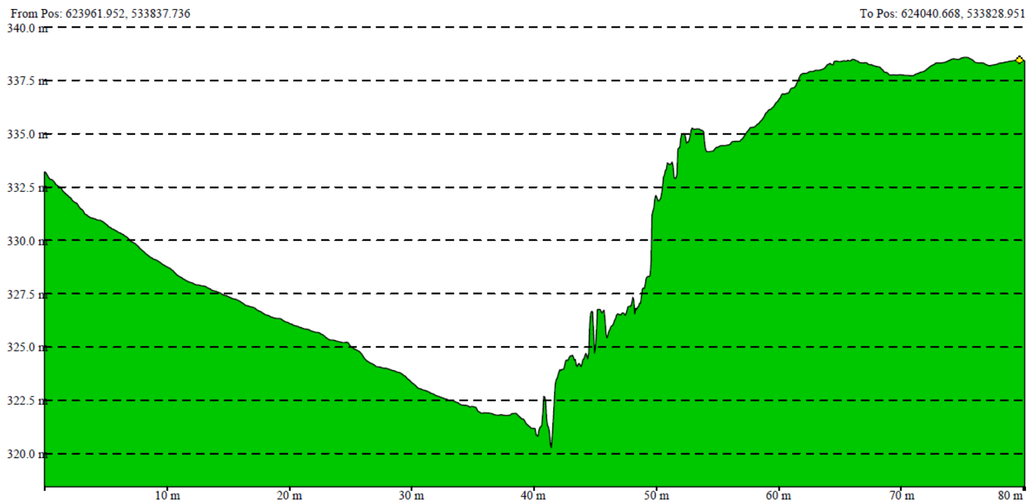

Figure 3: Profile of the section through the landslide cone

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Land surveying with entry level UAV and GIS spatial analysis for efficient building planning

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Summary: *Civil engineers and architects cope with terrain uncertainty. Topography links architecture and landscape, thus the design stage rely on accurate and comprehensive field data. Besides topo-geodetic instrumentation used in land and construction surveying, unmanned aerial vehicles (UAVs) are becoming popular for surveys, topographical plans, and digital elevation models. In addition to the cadastral and technical surveys necessary for the design process, an UAV survey enables additional deliverables for Geographic Information System (GIS) spatial analyses. These orthophoto maps, larger-scale and denser topography representations, digital surface and terrain models, slope, aspect, and solar radiation maps provide valuable insight for the construction process. The present research highlights the advantages of such implementation, with an accuracy assessment on a terrain before and after vegetation removal.*

Keywords: land survey; mapping; UAV; photogrammetry; GIS.

1. Introduction

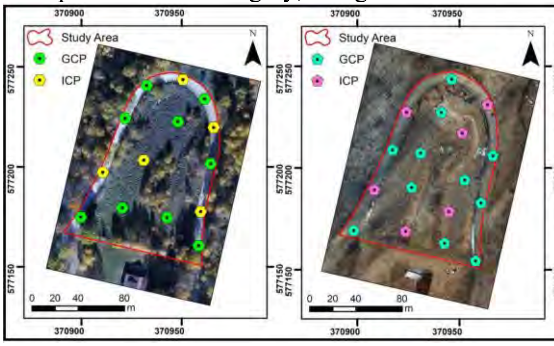
The construction industry is one of the most important economic sectors, accounting for a large part of the economy in most nations. Though vital to the economy, this sector suffers from lower productivity in some stages. UAVs offer aerial perspectives that are difficult to obtain with conventional terrain instruments, giving civil engineers and land surveyors new possibilities for surveys and analysis important for the design process (Bi et al. 2017). This research provided a spatial methodology for integrating budget drone systems with the GIS processing of the derived UAV deliverables to create a spatial analysis and complementary terrain data for construction design. Along with traditional data gathering with topo-geodetic instrumentation and outputs, this approach offers additional perspectives on coverage size and GIS-generated maps to aid the architectural and civil engineering team in decision-making.

2. Methods

The technical survey project involves the survey of a mountainous land parcel, which due to plentiful vegetation coverage was measured with vegetation for initial feasibility study, and after the vegetation removal in order to obtain accurate digital elevation model of the terrain (Figure 1). Due to time consuming labour of field measurements, along with the global navigation satellite system (GNSS) instrumentation a UAV survey mission was employed.

Figure 1: Aerial view of the study area with and without vegetation; instrumentation and cadastral documentations

By triangulating images captured using high-quality cameras, photogrammetry can convert two-dimensional pictures into three-dimensional models (Agüera et al. 2017). A variety of standard photogrammetric software applications can be used to process UAV imagery, using the structure from motion (SfM) method and different flight parameters (Figure 2).



UAV and flight metrics.	Vegetation present	Vegetation removed
Aircraft	DJI Mavic Pro	DJI Mavic Pro
Flight Date	October 2021	February 2022
Mapping Flight Speed	4 m/s	4 m/s
Sensor	4K RGB camera with 12.35 MP; FC220_4.7_4000x3000 f/2.2	4K RGB camera with 12.35 MP; FC220_4.7_4000x3000 f/2.2
Fly height ground level (m)	60 m	60 m
Image Forward Overlap (%)	85%	85%
Image Side Overlap (%)	75%	75%
Image Overlap	>9	>9
Number of GCPs and ICPs	14 (placed inside/surrounding the area of interest)	17 (placed inside/surrounding the area of interest)
Ground Resolution	~2.52 cm/px	~1.62 cm/px
RMSE X,Y,Z	0.026 m X, 0.029 m Y and 0.068 m Z	0.020 m X, 0.019 m Y and 0.029 m Z
RMSE 3D	0.041 m	0.023 m

$$RMSE_X = \sqrt{\frac{\Sigma_{i=1}^{n}\left(X_i^{DSM} - X_i^{GNSS}\right)^2}{n}}, \quad RMSE_Z = \sqrt{\frac{\Sigma_{i=1}^{n}\left(Z_i^{DSM} - Z_i^{GNSS}\right)^2}{n}},$$

$$RMSE_Y = \sqrt{\frac{\Sigma_{i=1}^{n}\left(Y_i^{DSM} - Y_i^{GNSS}\right)^2}{n}}, \quad RMSE_{3D} = \sqrt{\frac{\Sigma_{i=1}^{n}\left[\left(X_i^{DSM} - X_i^{GNSS}\right)^2 + \left(Y_i^{DSM} - Y_i^{GNSS}\right)^2 + \left(Z_i^{DSM} - Z_i^{GNSS}\right)^2\right]}{n}}$$

Figure 2: Orthophoto of the study area with and without vegetation; flight metrics and formulas used

3. Results and Discussion

The accuracy of the UAV-SfM approach has been examined in Figure 3. Previous research discovered that consistent decimetre-scale vertical accuracy can be attained with SfM, with even centimetre level accuracy when optimal conditions are available. The achieved accuracies are adequate for a preliminary feasibility survey when the terrain is covered by vegetation, ranging from 6 cm on the road and bare ground, to over 60 cm in the places with high grass. In the second mission when the terrain was stripped of vegetation, the obtained accuracies were very good, of a few cm.

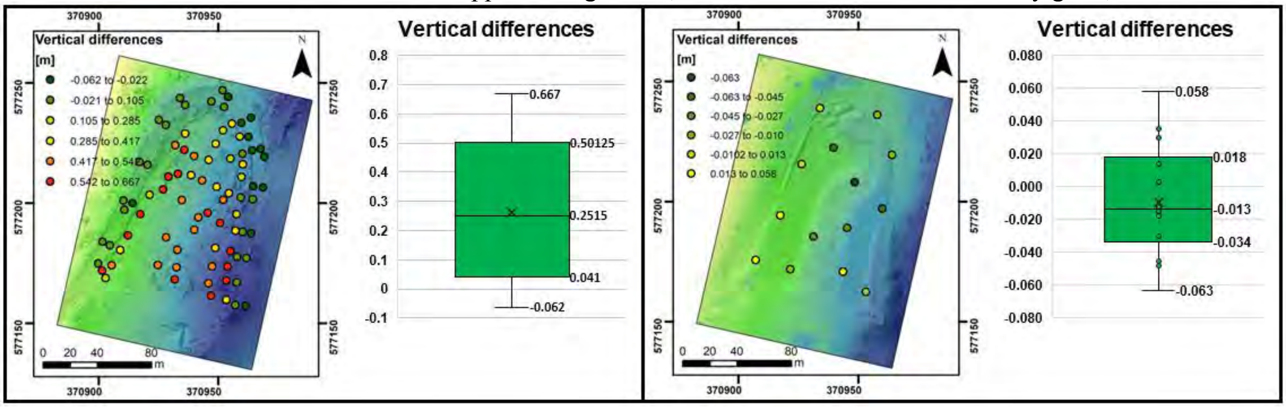


Figure 3: Accuracy analysis between the UAV derived DTMs (with/without vegetation) versus the field GNSS surveyed points

GIS can be used to examine terrain properties, the overall landscape scene, and the potential and constraints for building planning. The emphasis was on integrating a GIS-based application alongside land surveying in order to highlight the interrelationships between landscape and building potential. The technical steps of the GIS spatial analysis using the UAV derived data was to generate terrain deliverables within the constraints of relief (Fonstad et al. 2020). A raster database and themed maps for digital terrain model (DTM) elevation, aspect, slope, and solar radiation were produced, that provide significant insight useful for construction planning, with numerous additional useful metrics (Figure 4).

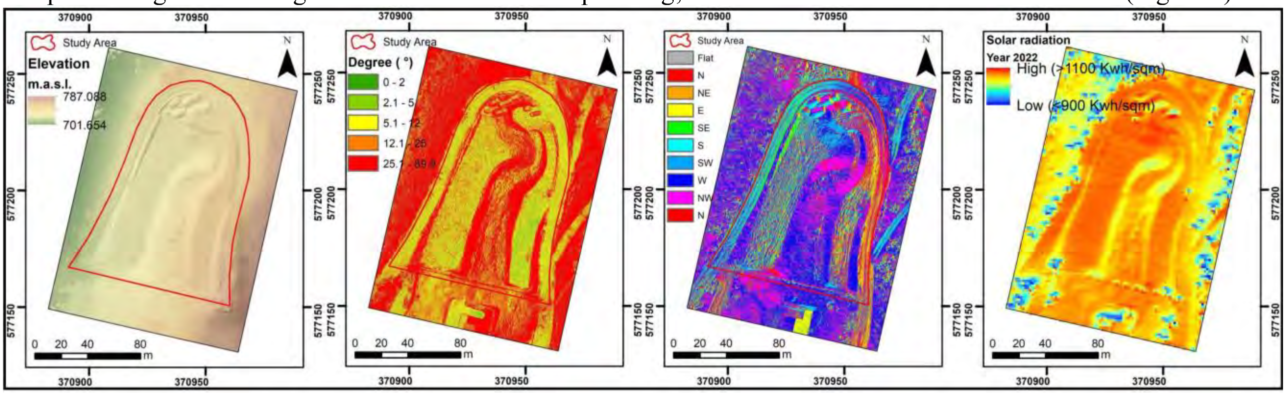


Figure 4: GIS based elevation, slope, aspect and solar radiation maps for the study area, using the UAV derived DEM.

4. Conclusions

UAVs have been actively developed for several decades, and many different activity domains have seen a quantum leap in terms of technology and usability. To resolve uncertainties that can occur before, during, and after construction, large-scale surveys are frequently utilised in civil engineering. UAVs give industry professionals new perspectives on their work or the problems they face, and can be used to supplement field data collection. It is determined that the employment of UAVs and GIS spatial analysis can significantly enhance the process of efficient building planning.

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The Evolution of Building Behavior Tracking from Static to Cinematic and Integration in Structural Health Monitoring

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Summary: *Static monitoring is employed when there are no substantial changes in the structure and extrapolation may offer data on the continuation of compaction processes, landslides, or any other deterioration. Cinematic monitoring is costly, hence researchers in the area are focusing on less expensive solutions, particularly management SHM systems. As a result, such an activity is only activated for essential goals, such as enormous bridges, extremely tall buildings, nuclear structures, gyms, multimedia buildings, or dams.*

Keywords: Static monitoring; Cinematic monitoring; Structural Health Monitoring; Landslides; Bridge; very tall Buildings.

1. Introduction

Tracking the behavior over time of land and constructions has always been a distinct branch of engineering surveying. Although work in this field, finding movements of resistance elements tracked in a regime close to the static, a few millimeters per year, has been integrated into Structural Health Monitoring, it is clear that any construction in the category of large bridges or very tall buildings should be monitored both in static regime, as a result of subsidence, landslides and the rheology of construction materials, and in dynamic regime, the effect of wind, sunshine or bridge traffic (Rădulescu AT, Rădulescu GMT, 2012).

2. Methods

In time, the monitoring of bridges and tall buildings became practically the engine for the development of SHM tools, methods, and technologies, or manager monitoring systems. Conducting an inventory of current methods used we can see that the market offers a multitude of options, the most important being: 3-D laser scanning, accelerometers, acoustic emissions, automated laser scanning, chain dragging, concrete resistivity, digital image correlation (DIC), electrochemical fatigue, electrical impedance (for corrosion), electrical resistance strain gauges, fatigue life indicators, fiber optic sensors, global positioning (GPS), ground penetrating radar (GPR), tilt and slope, ultrasonic C-scan, and vibrating wire strain gauge systems. The classical topographic methods, which operate in static mode, are known verifying the heights by means of middle geometric leveling, tracing and verifying in the plane by means of angular intersections, or using the complete topographic station, which allows the precise measurement of distances, not only of angles. The main disadvantages are the need for the permanent presence of the operator loco-object, and especially the discontinuity of information. The application of modern, unconventional topographic methods that operate in continuous kinematic mode to the construction of bridges with high pillars or suspended, which required knowing their behavior under the action of wind, non-uniform sunlight, or traffic, allowed for the development of modern, unconventional topographic methods that operate in continuous kinematic mode. The new technologies were then used to the building of high structures, dams, and railway monitoring.

3. Results and Discussion

Developing new general manager systems of structural monitoring involves going through the following stages:

a. Identifying the general components of structural monitoring systems (Figure 1.),
b. Establishing connections between components,
c. Performing critical analysis, ex. SWOT, for each component, sub-assemblies, and overall system,
d. Analysis and permanent updating of the list of tools on the market in terms of establishing coverage of each,
e. Configuring new general manager systems of structural monitoring based on previous research.

Thus, the following factors contributing to the rapid development and technical progress of SHM are identified (Bisby 2006; Dong 2010; Rădulescu, 2017):

- The recent advancements in sensing technologies with high-speed and low-cost electronic circuits, and the development of highly efficient signal validation and processing methods (e.g. fiber optic sensors (FOSs) and smart materials);
- Ongoing developments in communication technologies, wide use of internet and wireless technologies;
- Developments of powerful data transmission and collection systems, and data archiving and retrieval systems; and
- Advances in data processing, including damage detection models and artificial intelligence algorithms.

Four important pillars can be specified as directions for future research (Glisic, 2004; Rădulescu, 2017; Merit, 2011):

1. Structural health monitoring (SHM): monitoring methods for civil structures and infrastructure
2. SHM data management and analysis: system identification, damage detection, visualization
3. Advanced sensing technologies: long-gauge and distributed fiber optic sensors, sensors based on large-area electronics
4. Structural analysis and smart structures: deployable and adaptable structures, innovative structural systems

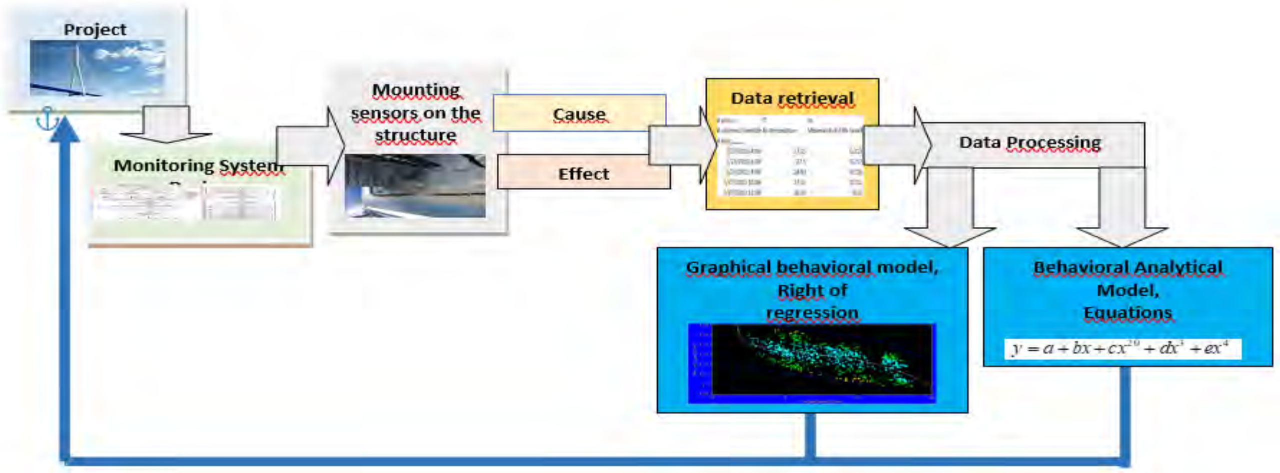

Figure 1: Flowchart of the Structural Monitoring in a Cinematic Regime

4. Conclusions

In conclusion, the development of the field was aided by developments in recording, transmission, collection, archiving, and processing technology. In fact, these are the main components that form the structural monitoring manager systems. In the future it is expected that SHM systems shall provide early warnings of impending structural damage or catastrophic degradation, thus improving the health of monitored structures (Roberts, 2000). This means we must turn all monitored buildings into smart structures with SHM monitoring throughout their life. A less developed chapter in specialized literature is that of configuration SHM manager systems for the execution of buildings and the link between execution and post-execution - the subject being a new chapter of research at this level. Kinematic monitoring remains expensive and relatively, perhaps for this reason, little and sequentially applied. Thus, a bridge with exceptional characteristics should be monitored continuously throughout its lifetime, but currently, only sequential studies are done. The concern of the authors is that by establishing manager systems with a much lower cost, kinematic monitoring can be done as often as it becomes necessary if it is necessary.

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C70 International Conference
”Tradition and Innovation - 70 Years of Constructions in Transilvania”

Current status of structural monitoring: A bibliometric literature review

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Summary: *Tracking the behavior of constructions over time is a defining activity for any type of construction thus obtaining the necessary data to see if they meet the requirements of stability and sustainability. In these days in which urbanization is achieved in a fast flow, it is essential to monitor construction project. Whether monitoring is the impact on buildings surrounded by new construction, underground infrastructure or high-structure projects, the solutions and results provided by the construction tracking process, carried out in the execution stage and / or in their operation, allow communities to progress and thrive without endangering people and goods. The research results show that this topic is a topical one and more and more studied, for example, the number of scientific articles published on this subject has doubled in the last 3 years compared to previous years.*

Keywords: structural monitoring; building; bibliometric analysis.

1. Introduction

The research that has been carried out so far shows that this activity of tracking buildings over time is a priority in each territory and is carried out in accordance with the specific provisions in force. Scientifically, of the published research works, the emphasis and the data provided as results of the monitoring process have as research objective the standard buildings of a country/city. A bibliometric analysis carried out for this purpose shows that this subject, of the process of tracking constructions over time, is a topical one and more and more studied. The development of geodetic engineering technology has brought an addition to this process, and studies conducted using modern data collection methods have become intensely debated in various scientific papers published in journals and publications.

2. Methods

In accordance with the research objectives, the procedures applied include a bibliometric analysis that is based on the selection of the best articles. The selection of the articles under investigation was made based on the PRISMA method (Preferred Re-porting Items for Systematic Reviews and Meta-Analyses).
The bibliometric analysis was performed in two stages that include the process of querying the scientific database using keywords and the process of examining the works by selecting the articles from the classified database depending on the search filters applied.
The data used in the bibliometric analysis were provided by querying the ISI Web of Science database. This process was performed using keyword search filter. The keyword used in this study was „structural monitoring “.
The data provided by the scientific database contain all types of resources required for the study, such as the title of the article, the name of the author, the keywords and the bibliographic sources. Due to the greater unifromity of the data provided and exported, the ISI Web of Science platform was further used.

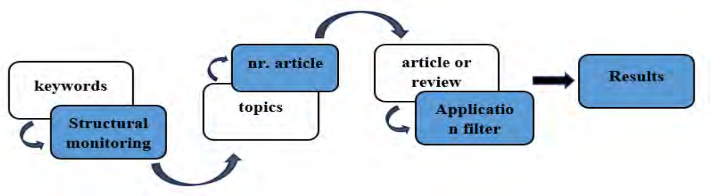

Figure 1: The data colection

3. Results and Discussion

In order to achieve an evolution of interest for this activity of time tracking of constructions, an analysis of the articles published on this subject was made. Using the data provided by the ISI Wos scientific database and the Office package (Microsoft Excel), a graph of the evolution of the number of publications for the studied topic was created. The graph in the figure 2 was generated for each category of articles provided by the database using the keyword and application of the article sorting filter in the last 15 years.

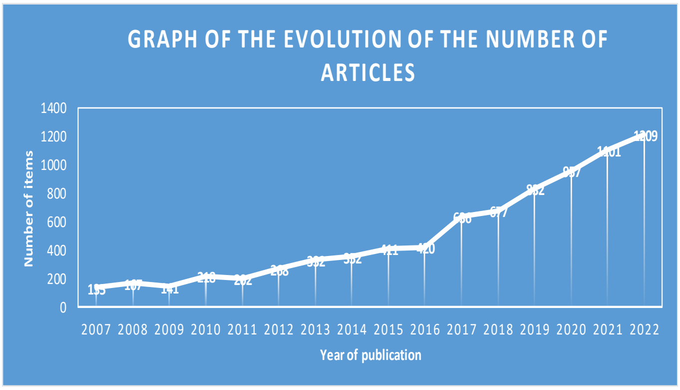

Figure 2 : Graph of the evolution of publications

The data presented by this graph indicate an increase in the number of annual publications of articles and an increased interest in the topic of tracking the behavior of constructions over time. When the database is not integrated using the search criterion, the year of publication of the articles is shown that since 2007 and 2008 the interest has been ascendant to evolution. Since 2010, the trend in the work that addressed this research topic has started to grow, excluded from this increase is the year 2011 which shows the opposite having 16 publications less than the previous year.

Until 2016 there are fluctuations in the number of published works. Starting with 2017, according to the chart, there is an increased interest for this field having a number of publications almost double compared to previous years, and in 2022 the number of published scientific papers reached 1209.

The analysis of the database using the aforementioned filters highlights a ranking of countries in relation to the number of publications on this topic and which have as keyword „structural monitoring“. According to the chart in Figure 3, China is the country that is in the top of the ranking with the most published works that use the keyword. The ranking is followed by India which includes a total of 2159 papers published so far. Romania is positioned close to the bottom of the ranking with a total number of 23 works, almost 100 times less than the first place.

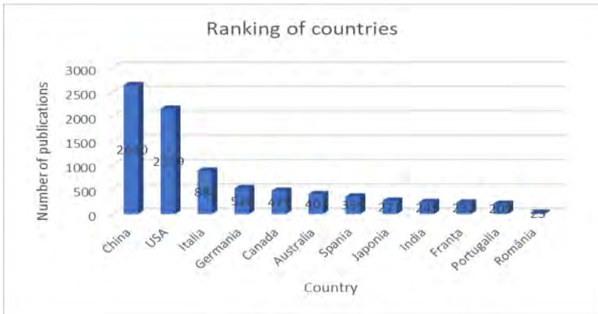

Figure 3 : Ranking of countries according to the number of publications

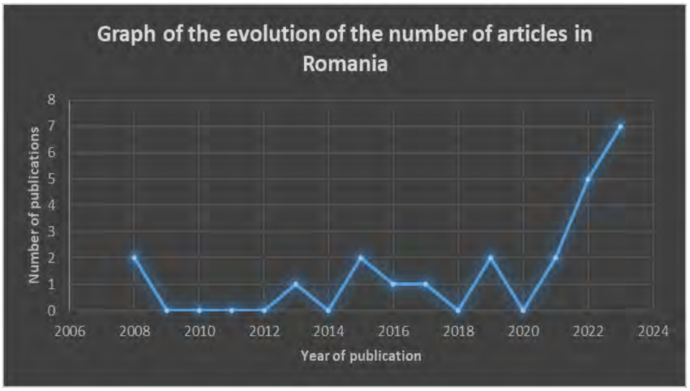

Figure 4 : The graph of the evolution of publications in Romania

Using the same database from the scientific platform and the sorting filter Romania, a record of the number of published works was made. The data provided are reported in the last 15 years and indicate a total of 23 papers published on this topic so far. In Romania, compared to the number of articles published in this regard, it is observed according to the graph in figure 4 that the trend of increasing interest in this subject began in 2021. Interest was felt in 2015 and 2019 when the number of publications increased, but in the following years showed a decrease according to figure 4.

4. Conclusions

Therefore, in the last 10 years there has been an increase in interest in this activity of time tracking of constructions. The analysis shows that this process and its awareness has become essential especially in the post-use of constructions, which shows us a growing trend of this activity in the future. In Romania, the subject of the monitoring of the behavior of constructions over time is on the rise in recent years, comparative with previous years, this aspect is also found in the number of scientific papers published on this subject.

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SECTION IX

EUt+ INNOVATIONS in CIVIL ENGINEERING

C70 International Conference
"Tradition and Innovation - 70 Years of Constructions in Transilvania"

European University of Technology EUt+: Civil Engineering Cluster Contribution

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Summary: *The European University of Technology EUt+ is a comprehensive and complex international alliance of eight partners with a common "Think Human First" approach to technology and education. As part of the EUt+, the Civil Engineering cluster, made of 5 partners, including the Faculty of Civil Engineering, Technical University of Cluj-Napoca, was among the firsts to provide a full mobility map of harmonized curricula for the students and teaching staff.*

Keywords: EUt+; Civil Engineering; mobility; students; teachers.

1. Introduction

The European University of Technology - EUt+ is the result of the alliance of eight European partners who share in common the "Think Human First" vision towards a human-centred approach to technology and the ambition to establish a new model of institution on a confederal basis. EUt+ is a comprehensive and complex international initiative with exceptional academic potential that involves responsible and well-organized approaches to achieving its goals. It is the result of the alliance of eight European partners: Cyprus University of Technology, Darmstadt University of Applied Sciences, Riga Technical University, Technological University Dublin, Technical University of Sofia, Universidad Politécnica de Cartagena, Université de Technologie de Troyes, Technical University of Cluj-Napoca. The mission is:
"As a University of Technology, our mission is first and foremost to serve society. Europe requires top-quality education for diverse groups, where talents translate into ability to act and react, experiment and invent, anticipate and transform. We empower our students to become technologically literate professionals and active European citizens. We ensure that they are well-qualified to enjoying rewarding careers playing a fruitful role in society, aware of the broader implications of technological development and of their responsibility towards global challenges. Everybody, regardless of background, should be able to study and succeed in our university" (Project EUt+, https://univ-tech.eu/).

Figure 1: Vision and common principles of EUt+ (Project EUt+, https://univ-tech.eu/)

2. Curricula conversion process

The EUt+ convergence process is designed to harmonise partners' national degree curricula, a preliminary step in the development of a European Degree. This process led by Work Package 3 (WP3) is actioned through the clusters of academics for each specialisation. European research must be driven by the diverse needs of our regions, aware of the global challenges of our times and capable of having a true impact on people's lives. We create knowledge connected with the economic, scientific, and political priorities of our respective regions, and in synergy with one another. The major transitions underway and the associated sociotechnical challenges require fresh thinking and new,
One of the main project objectives is to inspire and support students and staff from the partner universities in the EUt+ project to participate in mobilities across the 8 campuses. In order to facilitate the increased number of mobilities, the common Erasmus Office, fully staffed, fully operational and with adequate funding will provide a seamless and inclusive experience to all students and staff moving between the EUt+ campuses. Students will be empowered and motivated to move from one campus to another based on sound academic criteria that suit their individual learning

paths and training needs, while at the same time improve their linguistic skills and immerse in cultural activities, feeling at home in every campus.
At EUt+ level partners will jointly design, test, and implement services for mobile students and staff that are inclusive by default and allow a simple, fast, and straightforward process to live and study to any campus of the EUt+. A dedicated portal was launched to serve as a single digital point of entry to EUt+ campuses. Through the portal interested students and staff, responding to relevant calls for participation, will be able to apply for an EUt+ mobility.
The foundation stone of the conversion process is the common Competency Framework that was defined for all the European University of Technology Bachelor programs. The concept, developed during the March 2021 EUt+ Workshop, switches the focus from current curricula to competencies-based curricula. The list of mandatory competencies shared by all partners the EUt+ embeds a set of shared competencies that students should/could acquire during their academic path, at whichever EUt+ campus they choose to study. To harmonise the curricula, several specialized clusters were created, with the Civil Engineering Cluster in the first wave.

3. Creation and activity of the Civil Engineering EUt+ Cluster

The Civil Engineering Cluster was created with five participants: Technical University of Cluj-Napoca, Civil Engineering Faculty, the cluster leader, Cyprus University of Technology, Darmstadt University of Applied Sciences, Technological University Dublin and Universidad Politécnica de Cartagena. More than 100 courses were analysed and harmonised, resulting in a mobility map that allows students from any of these universities to make a mobility of one or two semesters. At the end, the students will receive a Certificate signed by the all rectors of the cluster’s universities.
The mobility was first designed using excel sheets. Because the amount of information contained in the original files is great, a computer friendly application for the mobility map was designed. The application form incorporates information on the specialization/programme, participating EUt+ partners and the objectives/targets of the cluster (see Figure 2 below). The final goal is to create a new specialized EUt+ degree programme and the applicants are asked to declare its alignment with EU skills development targets and market needs. Consistency with the features of the EUt+ degree is also sought - studies in language and culture, interdisciplinary qualifications, and civic engagement.

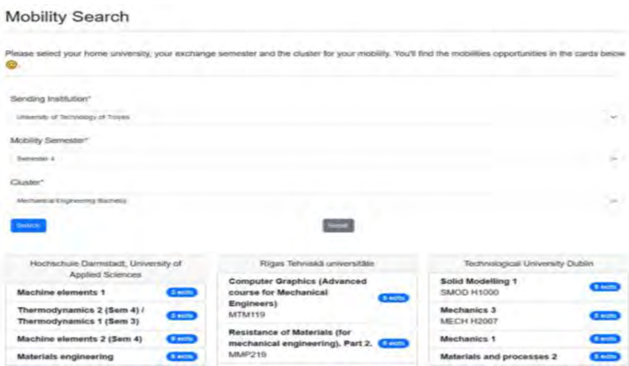

Figure 2: Application for selecting mobilities EUt+

4. Conclusion

The European University of Technology - EUt+ stands as a comprehensive and complex international consortium, comprising eight visionary partners who share a collective commitment to prioritizing humanity in technology and education. Possessing exceptional academic and research expertise, as well as the necessary resources for execution, the alliance aspires to pioneer a novel institutional model founded on a confederal framework. The distinguished members of this consortium are the Cyprus University of Technology, Darmstadt University of Applied Sciences, Riga Technical University, Technological University Dublin, Technical University of Sofia, Universidad Politécnica de Cartagena, Université de Technologie de Troyes, and Technical University of Cluj-Napoca.
The focal point of this initiative revolves around inspiring and assisting students and faculty members from the EUt+ partner universities to engage in cross-campus mobility experiences across all eight institutions, in various fields of specialization. Notably, the Civil Engineering cluster of five partners, including the Faculty of Civil Engineering, Technical University of Cluj-Napoca, emerged as one of the firsts in providing a comprehensive mobility plan featuring harmonized curricula tailored for both students and teaching staff. The ultimate objective is to craft a distinctive EUt+ degree program that aligns with the European Union's skill development objectives and addresses current market demands. Furthermore, a strong emphasis is placed on fostering language proficiency, cultural immersion, interdisciplinary competencies, and active civic participation, all of which are part of an EUt+ degree.

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Cleantech Entrepreneurship and Innovation in Civil Engineering Education

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Summary: *Civil Engineering and the construction sector are rapidly changing. Embedding Cleantech Innovation and Entrepreneurship in Civil Engineering curricula aims to empower students assess and evaluate value propositions in their engineering solutions as well as consider systemic changes in their own careers in order to play part in addressing global challenges, such as Climate Change. This contribution will highlight the efforts of an EIT HEI Initiative Project within the EUt+ Alliance as this was applied at the Cyprus University of Technology*

Keywords: Cleantech Entrepreneurship; Engineering Education; Innovation.

1. Introduction

Civil Engineering has transformed greatly from the Industrial Revolution where the aim was to use the powers of nature for the good of mankind, to its present state which aims to protect and maintain the natural and built environment with sustainable development in its heart. The changing goals, increasing populations, emerging threats (i.e. climate change) and high amplitude cycles in the economy pose new challenges to Civil Engineers and to Higher Education which plays a significant role in their training. This contribution highlights the development of a European HEI Initiative project funded by the European Institute of Innovation and Technology, titled Innovate European University of Technology (Inno-EUt+) where “seeds” of innovation and entrepreneurship were planted across 6 universities of the EUt+ University Alliance. Specifically this work will showcase how a new module was incorporated in the undergraduate degree in Civil Engineering at the Cyprus University of Technology.

2. Innovate European University of Technology – EIT HEI Initiative

Inno-Eut+ was a 2-year spin-off project feeding into the main European University Alliance named “European University of Technology” which brings together 7 technical universities from across Europe. Inno-Eut+ aimed at increasing the innovation capacity of the involved HEIs with an increase of aspiring entrepreneurs and spin-offs as a result of the common entrepreneurial curricula and good practices shared, as well as the support mechanisms which have been implemented in the respective HEIs. The project focussed on providing the necessary entrepreneurial and intrapreneurial skillset to both students and staff to identify value propositions in different contexts and find innovative solutions to challenges. In 24 months of the project duration more than 1900 students were trained and mentored which led to the creation of over 500 ideas. Furthermore more than 300 academic and non-academic staff were trained as well as 18 startups supported. The three main pylons of training of staff included:

- Train the trainer sessions based on the EIT Climate-KIC ClimateLaunchpad content (Blazer et al, 2020): This was mainly for academics and researchers in order to consider adding entrepreneurship training activities in their own teaching.
- Change Agents: A systems thinking course to create change agents within the EUt+ partners
- Inclusive Entrepreneurship & Universal Design for Learning (Mcquillan et al, 2022): Pedagogical approaches for Learning and Teaching to support academics in developing and delivering inclusive learning experiences.

Pushing through with a continuous training and mentoring scheme for academics “on the ground” provided trainees with confidence to pursue experimenting within these concepts in classes. Entrepreneurial learning activities were piloted in different modules across different bachelor and master’s modules including language classes. The pilots then followed some joint activities such as national and demodays, where students teams pitched in front of experts and participated in a European demoday which was accompanied by an entrepreneurship training activity. The rising interest in the activities spawning out of Inno-EUt provided the ground for the development of a bespoke module in the Civil Engineering Curriculum at the Cyprus University of Technology focussed on Systems Innovation and Entrepreneurship for sustainable applications, as an elective in the final year of studies.

3. Application of training programme in Civil Engineering undergraduate degree

The module for Sustainable Innovation and Entrepreneurship for Engineering Applications is a 4th year elective module in the Civil Engineering undergraduate course which aims at the understanding and application of the methodology of systems innovation by civil engineering students in order to analysed grand challenges and design new sustainable value propositions as a means to tackle these challenges. Using Problem Based Learning (Miliou et al, 2022), participating students develop basic knowledge, skills and competences in entrepreneurship, market research and sustainable development. The Learning Outcomes include:

- Understanding and application of systems thinking for mapping systems and defining challenges.
- Investigation and experimentation of solutions for tackling challenges.
- Definition of business ideas. Analysis of needs, market ideas and team creation.
- Analysis of Founder’s dream and the Deal.
- Developing Beachhead Markets.
- Calculation of climate cost of product and the improvement brought forward.
- Understanding ways of discovering and attracting clients
- Understanding of basic economics of a new startup product or service
- Development of presentation (pitching) skills.

In its first edition the module was well attended with 26 students. The module had a central theme around Circular Economy in the construction sector, which is one of the new challenges faced by the industry. Setting a central theme and using visual tools for systems innovation (Yiatros et al, 2022), students were able to map the challenges around Construction and Demolition Waste in Cypus, identify key stakeholders, barriers and opportunities for the transition to Circular Economy. Then in groups they had to consider a new product or a service for the construction industry, and through a structured process develop a lean startup plan for this. In this process, students had to talk to potential clients and other stakeholders as well as differentiate their product or a service against existing alternative solutions. Finally as part of the exercise, the students had to measure the decrease in emissions or pollution that would be the result of their product or service gaining ground in the market.

As mentioned earlier, this module aimed at shifting the mindset of engineering students, many of whom never considered an entrepreneurial path and are not comfortable presenting or defending an idea in the public. As a student mentioned in the survey “*.. I always knew I have something more to give but I didn't have the chance to do it. Following this program which is based on how to be entrepreneur I* managed to get my thoughts into action. *I was very lucky to participate in all of this and I thank my University for giving me this opportunity.”*

4. Conclusions

Embedding Cleantech Innovation and Entrepreneurship in Civil Engineering curricula aims to create new career pathways for students and provide them with opportunities to view traditional and new problems in a different way. The application of innovation and entrepreneurship training allows students to develop systems innovation and value proposition skills and can be used to introduce new applications or fields of civil engineering. It further allows the cross-pollination of ideas with students of different disciplines, enriching the experience for all participants. Early results from student satisfaction surveys have indicated high satisfaction from students and it is very promising that more students will show interest in participating in the programme.

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