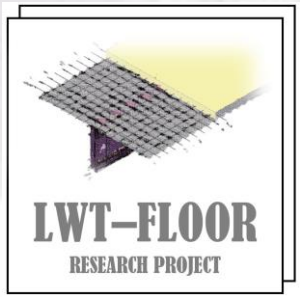
Opening Session - presentation of the LWT FLOOR project and overview of the realised activities - 3rd project year

Ivan Lukačević



1. Introduction

1. Introduction

Projekt LWT-FLOOR povezuje najnovije spoznaje u novoj, brzoj i produktivnoj tehnologiji točkastog zavarivanja i inovativna rješenja sprezanja hladno oblikovanog čelika i betona predlažući novu metodu izgradnje kao kombinaciju sastavljenih hladno oblikovanih čeličnih elemenata i betonske ploče. Ovaj ekonomičan i održiv sustav lagane međukatne konstrukcije nudi vitalne prednosti u smislu visokog stupnja predgotovljenosti, mogućnosti ponovne upotrebe i mogućih velikih raspona. Glavni cilj projekta je uspostaviti novu istraživačku grupu koja će posjedovati znanje i opremu za istraživanje novog sustava međukatne konstrukcije s fokusiranim znanstvenim interesima u potrazi za konkurentnijim nacionalnim i međunarodnim financiranjem. Kako bi se istražile i vrednovale komponente i sustav u cjelini, planira se opsežno eksperimentalno, numeričko i probabilističko istraživanje. U okviru istraživanja posebna pozornost će biti posvećena točkastim zavarima i inovativnim vrstama posmične veze s mogućnošću projektiranja za demontažu i potencijalom za buduće ponovne uporabe ili recikliranja na kraju životnog vijeka uključujući analize životnog ciklusa. Kalibrirani numerički modeli temeljeni na eksperimentalnim ispitivanjima sustava i njegovih komponenata omogućit će, uz primjenu probabilističkih metoda, procjenu prikladnosti sustava za veće raspone. Projekt će donijeti nove vještine istraživačkoj grupi i istraživačkoj instituciji, a pored toga obranit će se i dvije disertacije te objaviti znanstveni radovi u najcitiranijim časopisima. Ovaj inovativni projekt, koji osigurava čvrste veze između akademske zajednice i industrije, povećat će mobilnost i ojačati dugoročnu suradnju između dva sektora. Probabilističke analize i procjene ponašanja predloženog rješenja u životnom ciklusu međukatne konstrukcije bit će od ključnog značaja za pripremu prvog analitičkog prijedloga za izradu preporuka za projektiranje ovog novog sustava u okviru europskih norma.

The LWT-FLOOR project integrates state-of-the-art knowledge in new, fast and productive spot-welding technology and innovative cold-formed steel-concrete composite solutions proposing a new construction method as a combination of built-up cold-formed steel members and cast-in-place concrete slab. This cost-effective and sustainable floor system offers vital benefits in terms of a high degree of prefabrication, reusability and long spanning capability. The main objective of the project is to establish a new research group that will possess knowledge and equipment for research on new composite floor system with focused scientific interests in a search for more competitive national and international funding. In order to investigate and validate components and proposed system, the extensive experimental, numerical and probabilistic research is planned. Within research, a particular focus will be given to spot-welding connections and innovative types of shear connections with possibility of design for demountability and the potential of re-use or recycling at the end of design life through the application of lifecycle analyses. Calibrated and validated numerical models based on experimental tests of the system and its components will allow, through the application of probabilistic methods, evaluation of the system suitability for larger spans. The project will bring out new skills to the research group and the research institution, besides which two dissertations will be defended and scientific papers in most cited journals will be published. This innovative project, providing strong connections between the scientific community and industry, will increase the mobility as well as strengthen long-term cooperation between the two sectors. Probabilistic analyses and life cycle performance evaluation of the proposed floor system solution will be crucial for establishing the first analytical proposal for design recommendations of this new system within the European standards.

https://www.grad.unizg.hr/lwtfloor

PROGRAM // PROGRAMME

Vijećnica, prizemlje lijevo, Kranjčevićeva 2//Council chamber, ground floor left, Kranjceviceva 2

10h00 – 10h20	**REGISTRACIJA // REGISTRATION**
10h20 – 10h40	**Ivan Lukačević** **Otvaranje radionice – prezentacija LWT-FLOOR projekta i pregled realiziranih aktivnosti u 3. godini projekta** Opening Session – presentation of the LWT-FLOOR project and overview of the realised activities 3rd project year
10h40 – 11h00	**Ivan Ćurković**, Ivan Lukačević, Andrea Rajić, Vlaho Žuvelek **Projektiranje i izrada uzoraka čeličnih i spregnutih nosača** Design and fabrication of steel and composite girder specimens
11h00 – 11h20	**Marko Bartolac**, Ivan Lukačević, Ivan Ćurković, Andrea Rajić, Vlaho Žuvelek **Priprema laboratorijskih ispitivanja velikih uzoraka** Preparation of laboratory tests of large-scale specimens
11h20 – 11h40	**Andrea Rajić, Vlaho Žuvelek**, Ivan Lukačević, Ivan Ćurković, Janko Košćak, Marko Bartolac **3D skeniranje i priprema uzoraka čeličnih i spregnutih nosača za mjerenje sustavom GOM ARAMIS** 3D scanning and preparation of the steel and composite girders for measurement with the GOM ARAMIS system
11h40 – 12h00	**Andrea Rajić**, Ivan Lukačević, Ivan Ćurković, Marko Bartolac, Vlaho Žuvelek **Provedba i analiza laboratorijskih ispitivanja čeličnih i spregnutih nosača** Implementation and analysis of the steel and composite girders laboratory tests
12h00 – 13h00	**STANKA // BREAK**
13h00 – 13h20	**Marko Bartolac**, Ivan Lukačević, Ivan Ćurković, Andrea Rajić, Vlaho Žuvelek **Laboratorijska ispitivanja spregnutog međukatnog sustava LWT-FLOOR** Laboratory Tests of Lightweight Composite Floor System LWT-FLOOR
13h20 – 13h40	**Andrea Rajić**, Ivan Lukačević, Ivan Ćurković, Vlaho Žuvelek **Procjena ponašanja točkastih zavara kod hladno oblikovanog čelika** Performance evaluation of cold-formed steel spot weld connections
13h40 –14h00	**Vlaho Žuvelek**, Ivan Ćurković, Ivan Lukačević, Andrea Rajić **Analize posmične veze kod spregnutog nosača izvedenog hladno oblikovanim čelikom i betonom metodom konačnih elemenata temeljene na podacima ispitivanja** Finite Element Analyses of Demountable Shear Connection in Cold-Formed Steel-Concrete Composite Beam Based on Experimental Data
14h00 – 14h20	**Ivan Lukačević**, Andrea Rajić, Daniel Viorel Ungureanu, Raluca Buzatu **Usporedna procjene životnog ciklusa spregnutih sustava čelik beton – studija slučaja** A comparative life-cycle assessment of structural composite steel-concrete floor systems – A case study
14h20 – 14h30	**ZATVARANJE RADIONICE // CLOSING OF WORKSHOP**

https://www.grad.unizg.hr/lwtfloor

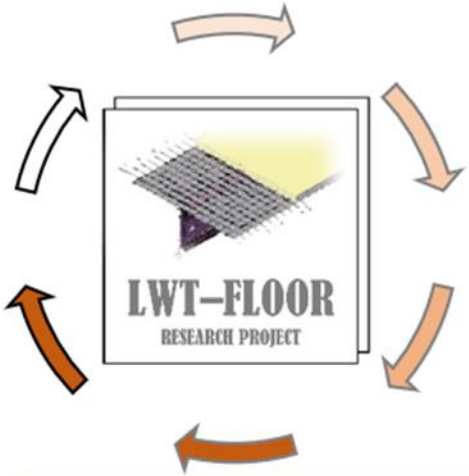
1. Introduction

O1 …to establish research group

ER1: Research group equipped with knowledge and instrumentation for specimen's preparation, experimental, numerical and probabilistic testing, understanding components and overall behaviour of the proposed system through the entire life cycle.

O2 …to investigate and validate, experimentally, numerically and probabilistically components of proposed system

ER2: Technical report with test results on materials and optimal welded and shear connections solutions.



O3 …to investigate and validate, experimentally, numerically and probabilistically proposed system

ER3: Technical report with results for the proposed system

O4 …to validate proposed floor system through on numerical parametric studies, probabilistic methods and life cycle analyses

ER4: Report with validation of FE models for different floor system typologies and results of numerical, probabilistic and life cycle studies of specimens with larger spans.

O5 …to establish an analytical proposal for design recommendations for this new type of floor system

ER5: Technical recommendations for design and fabrication will be proposed

O6 …to prepare project proposals and applying to other sources of funding

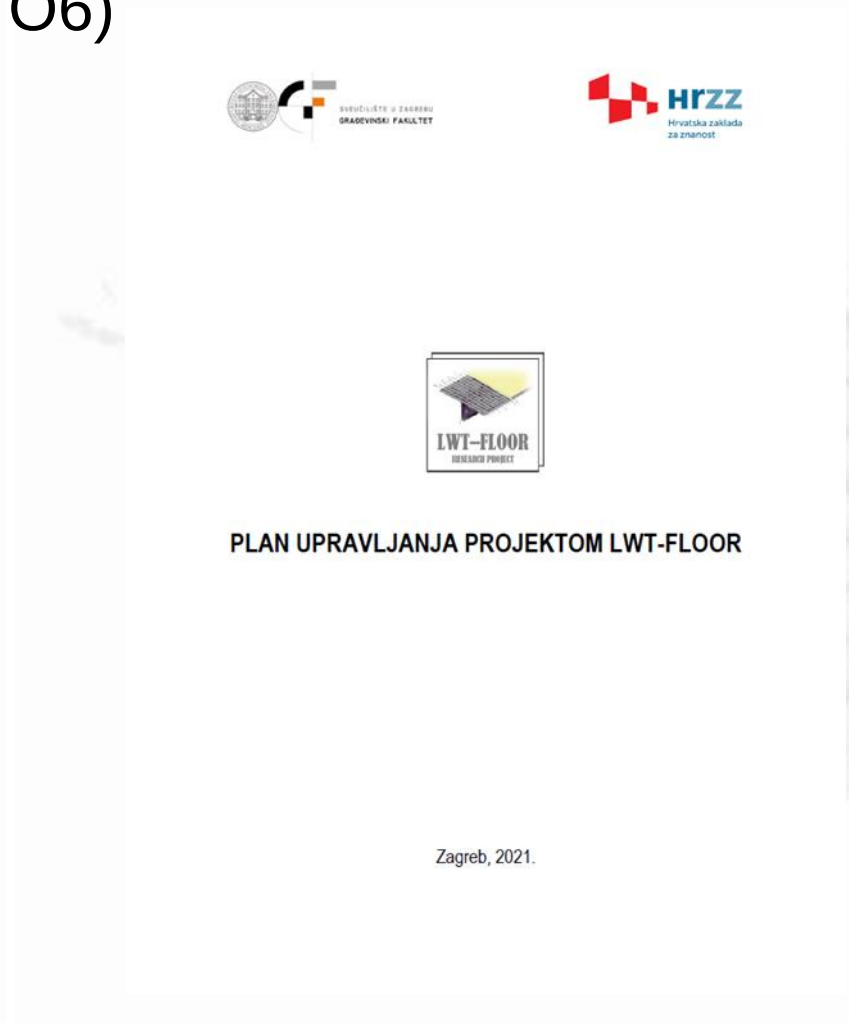
ER6: Research group as a centre of expertise self-sustained through other national and international funding sources.

2. Realised activities 1st year

1st Project Period	
Results to be achieved	RG member
D1. Defined project implementation management plan (O1 to O6) – finnished	IL
D2. Project Kickoff Meeting: Electronic data exchange facilities will be organized for communication data sharing (O1 to O6) – finnished	All
D3. Project webpage installation, profile of the project on the Academic Social Network Site and visual identity of the project (O1 to O6) – finnished	IL
D4. Presentation of project on the web site (O1 to O6) – continuous job...	IL, PhD Student (D)
D5. Literature delivered (O2 to O5) – finnished	IL
D6. PhD student employed; research group established (O1) – planed July 2021, realised Nov 2021	All
D7. 1st Research group coordination meeting (O1 to O6) - finnished	All
D8. Training for PhD student – Cold-formed steel (O2 to O5) – not realised due to delay of D6.	D
D9. Training for PhD student – Composite structures (O2 to O5) - not realised due to delay of D6.	D
D10. Design of specimens for testing and technical specification for fabrication (O2, O3) –finished	IL, D, MB, IĆ, IČ
D11. Fabrication of material specimens (O2) – finnished	IL, D, MB, IĆ, IČ
D12. Fabrication of spot-welded connections (O2) - finnished	IL, D, MB, IĆ, IČ
D13. Fabrication of shear connections (O2) - finnished	IL, D, MB, IĆ, IČ
D14. Presentation of the project results one or two papers (ICMS'21) and one or two papers (IABSE 2021) (O2) – EUROSTEEL 2021, WMCAUS 2021, IC-UBT 2021, LIMAS 2021	IL, D, IĆ, IČ, IČ
D15. Journal Paper SCOPUS WoS Q3, Q4 – state of the art paper (O2, O3) – finnished	IL, D, MB, IĆ, IČ
D16. 1st Workshop organised (O1 to O2) – finnished (17th of December 2021)	All

2. Realised activities 1st year

- D1. Defined project implementation management plan (O1 to O6)



SVEUČILIŠTE U ZAGREBU GRAĐEVINSKI FAKULTET

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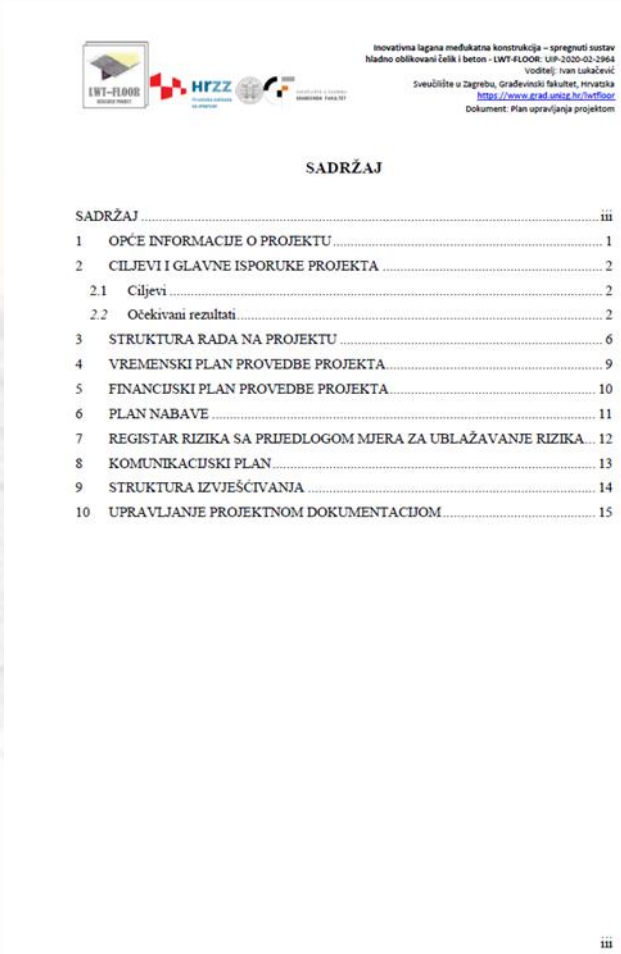
LWT–FLOOR RESEARCH PROJECT

PLAN UPRAVLJANJA PROJEKTOM LWT-FLOOR

Zagreb, 2021.



Inovativna lagana međukatna konstrukcija – spregnuti sustav hladno oblikovani čelik i beton - LWT-FLOOR; UIP-2020-02-2964
Voditelj: Ivan Lukačević
Sveučilište u Zagrebu, Građevinski fakultet, Hrvatska
https://www.grad.unizg.hr/lwtfloor
Dokument: Plan upravljanja projektom

SADRŽAJ

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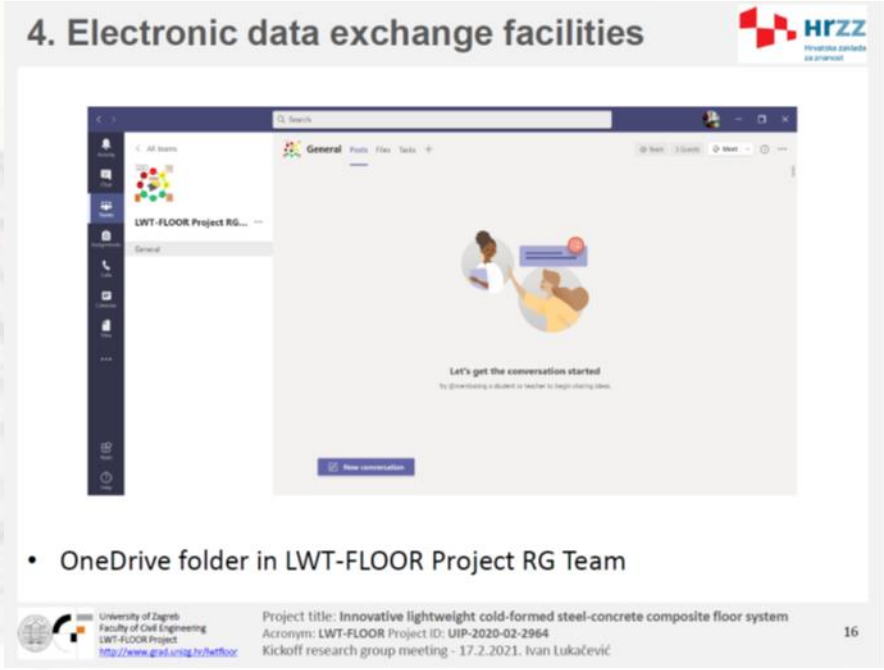
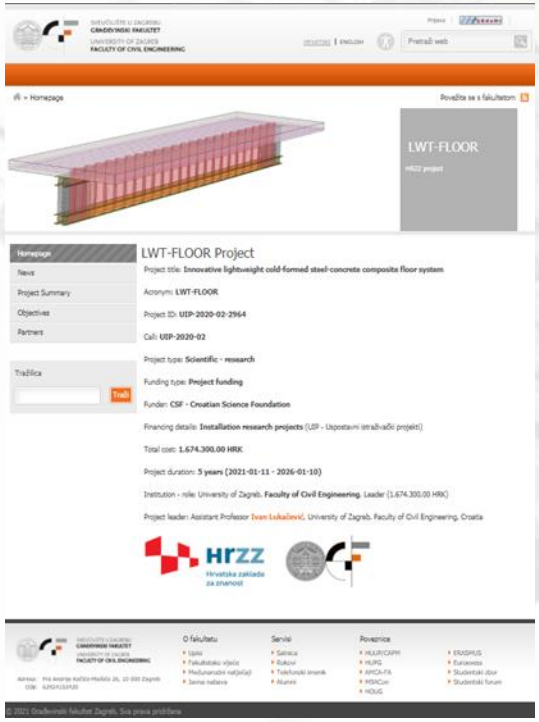
2. Realised activities 1st year

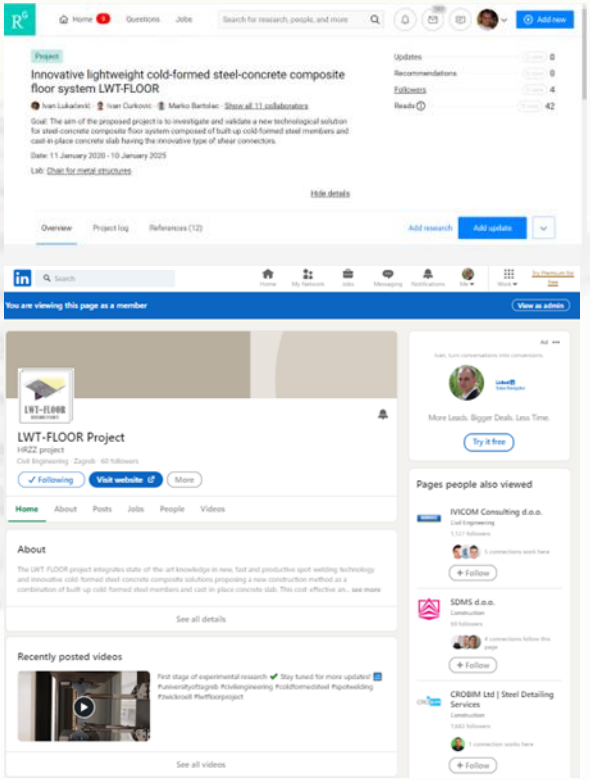
- D2. Project Kickoff Meeting: Electronic data exchange facilities will be organized for communication data sharing



2. Realised activities 1st year

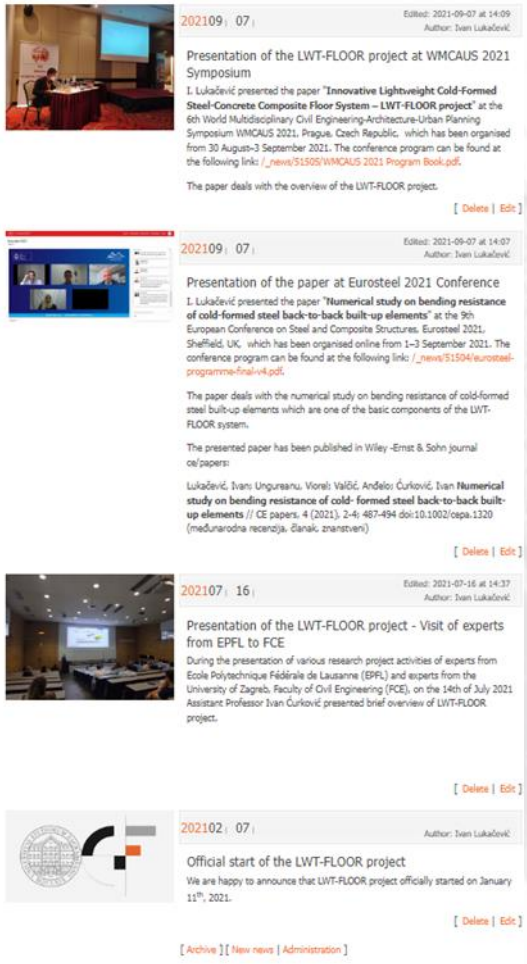
- D3. Project webpage installation, profile of the project on the Academic Social Network Site and visual identity of the project (O1 to O6)





2. Realised activities 1st year

- D4. Presentation of project on the web site (O1 to O6)



202109 | 07 | Edited: 2021-09-07 at 14:09 Author: Ivan Lukačević

Presentation of the LWT-FLOOR project at WMCAUS 2021 Symposium

I. Lukačević presented the paper "**Innovative Lightweight Cold-Formed Steel-Concrete Composite Floor System – LWT-FLOOR project**" at the 6th World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium WMCAUS 2021, Prague, Czech Republic, which has been organised from 30 August–3 September 2021. The conference program can be found at the following links: /_news/51505/WMCAUS 2021 Program Book.pdf.

The paper deals with the overview of the LWT-FLOOR project.

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202109 | 07 | Edited: 2021-09-07 at 14:07 Author: Ivan Lukačević

Presentation of the paper at Eurosteel 2021 Conference

I. Lukačević presented the paper "**Numerical study on bending resistance of cold-formed steel back-to-back built-up elements**" at the 9th European Conference on Steel and Composite Structures, Eurosteel 2021, Sheffield, UK, which has been organised online from 1–3 September 2021. The conference program can be found at the following links: /_news/51504/eurosteel-programme-final-v4.pdf.

The paper deals with the numerical study on bending resistance of cold-formed steel built-up elements which are one of the basic components of the LWT-FLOOR system.

The presented paper has been published in Wiley -Ernst & Sohn journal ce/papers:

Lukačević, Ivan; Ungureanu, Viorel; Vaičić, Anđelo; Ćurković, Ivan **Numerical study on bending resistance of cold- formed steel back-to-back built-up elements** // CE papers. 4 (2021), 2-4; 487-494 doi:10.1002/cepa.1320 (međunarodna recenzija, članak, znanstveni)

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202107 | 16 | Edited: 2021-07-16 at 14:37 Author: Ivan Lukačević

Presentation of the LWT-FLOOR project - Visit of experts from EPFL to FCE

During the presentation of various research project activities of experts from École Polytechnique Fédérale de Lausanne (EPFL) and experts from the University of Zagreb, Faculty of Civil Engineering (FCE), on the 14th of July 2021 Assistant Professor Ivan Ćurković presented brief overview of LWT-FLOOR project.

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202102 | 07 | Author: Ivan Lukačević

Official start of the LWT-FLOOR project

We are happy to announce that LWT-FLOOR project officially started on January 11th, 2021.

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[Archive] [New news | Administration]

202112 | 03 | Author: Ivan Lukačević

Presentation of the paper at 3rd International Conference on Lightweight Design of Engineering Structures – LIMAS 2021

I. Lukačević presented the paper "**Numerical Analysis of Lightweight Cold-Formed Steel-Concrete Composite Floor System**" at the 3rd International Conference on Lightweight Design of Engineering Structures – LIMAS 2021, Edinburgh, UK, which has been organised from 22-23 November 2021 online. The conference program can be found at the following links: https://asranet.co.uk/Conferences/LIMAS.

The paper deals with the overview of the LWT-FLOOR project and the results of preliminary numerical evaluations.

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202111 | 25 | Author: Ivan Lukačević

LWT-FLOOR project logo has been created!

LWT-FLOOR project logo has been created!

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202111 | 25 | Edited: 2021-11-25 at 08:48 Author: Ivan Lukačević

The LWT-FLOOR research group has been established!

The LWT-FLOOR research group has been established! From the 15th of November, a PhD student Andrea Rajić has been employed, and from the 22nd of November, she is officially a member of the LWT-FLOOR research group! Congratulations, Andrea Rajić!

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202111 | 19 | Edited: 2021-11-24 at 08:02 Author: Ivan Lukačević

Presentation of the paper at 10th International Conference on Business, Technology and Innovation 2021

A. Rajić presented the paper "**Behaviour of lightweight built-up cold-formed steel-concrete composite beam in bending**" at the 10th International Conference on Business, Technology and Innovation 2021 - sub conference 10th International Civil Engineering, Infrastructure and Environment Conference, Priština, Kosovo, which has been organised online from 29–30 October 2021. The abstract of the paper can be found at the following links: https://conferences.ubt-uni.net/2021/wp-content/uploads/2021/11/10th-International-Conference-on-Business-Technology-and-Innovat.pdf

The paper deals with the numerical study on bending resistance of built-up cold-formed steel-concrete composite beam.

The presented paper will be published in Conference procedings soon.

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202112 | 23 | Author: Ivan Lukačević

Merry Christmas and a happy and prosperous new year!

We wish you a Merry Christmas and a happy and prosperous new year!

LWT-FLOOR Project Research Group Members

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202112 | 23 | Edited: 2021-12-23 at 12:17 Author: Andrea Rajić

The first workshop of LWT-FLOOR project

On December 17th, the first LWT-FLOOR project workshop was held. We thank all the presenters and participants of the workshop.

The videos of workshop presentations and discussions will be published on the project web page soon.

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202112 | 20 | Author: Andrea Rajić

The first research group meeting

On 3rd of December, the first online meeting of the research group was held, at which the achievements of the project so far were presented, as well as the plans for the continuation of the project implementation. The current members of the project were introduced to the newly employed doctoral students and their roles in the project activities.

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202112 | 20 | Edited: 2021-12-20 at 13:28 Author: Ivan Lukačević

New research group member!

PhD student Vlaho Žuvelek become officially a member of the LWT-FLOOR research group. Congratulations, Vlaho Žuvelek!

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202112 | 10 | Edited: 2021-12-10 at 21:39 Author: Ivan Lukačević

1st Workshop LWT-FLOOR Project

1st LWT-FLOOR Project WORKSHOP will be organised at the University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia on 17th of December 2021, Online. Aims of the workshop are the presentation of the LWT-FLOOR project background, presentations and discussions about planned activities and recent results and presentation of other activities of the research group members and project advisors related to the composite and cold-formed steel structural elements.

A workshop flyer with the programme is available HERE.

The link for the live event via MS Teams is available HERE.

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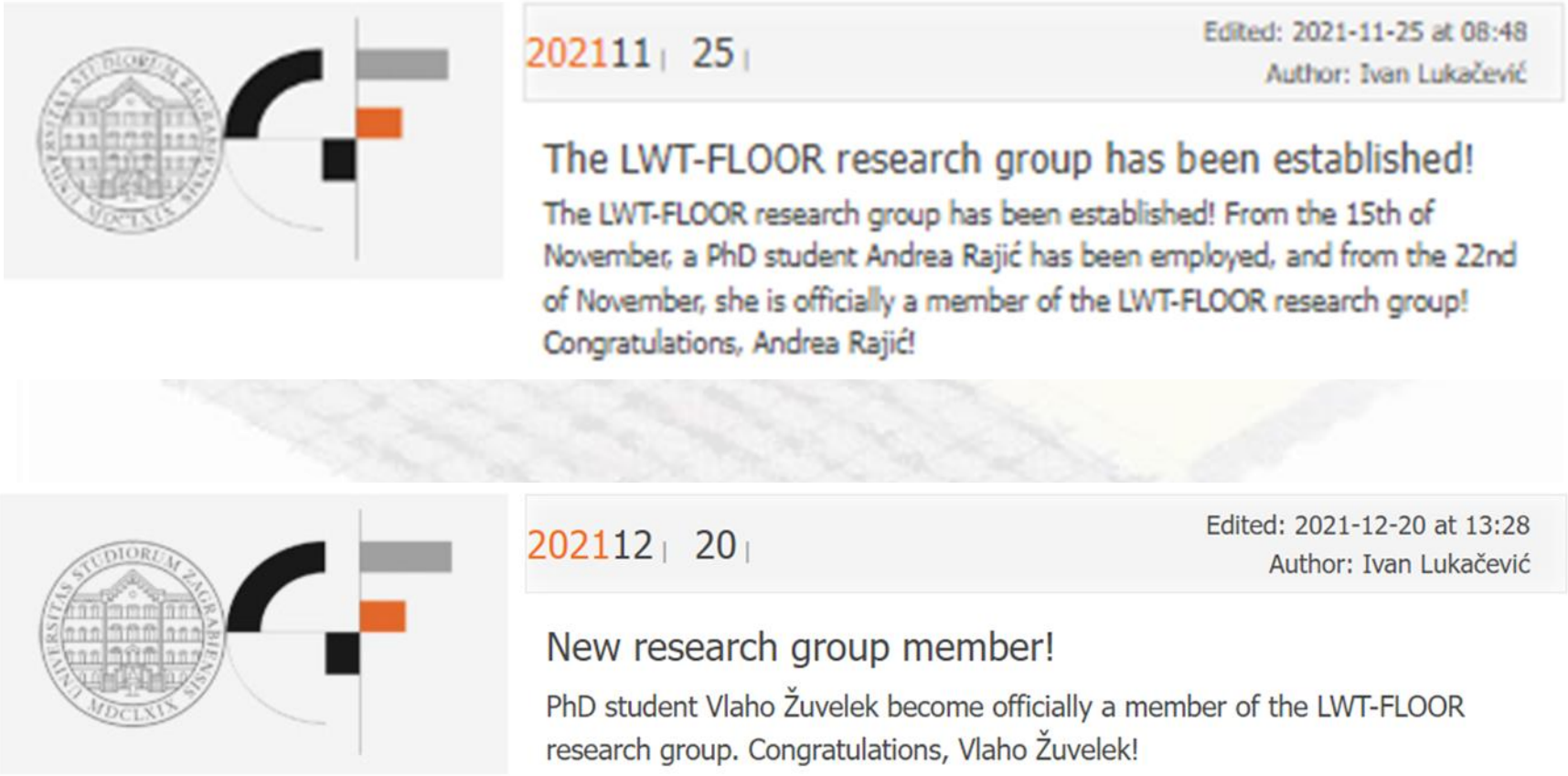
2. Realised activities 1st year

- D5. Literature delivered (O2 to O5)

2. Realised activities 1st year

- D6. PhD student employed; research group established (O1)



202111 | 25 |

Edited: 2021-11-25 at 08:48
Author: Ivan Lukačević

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202112 | 20 |

Edited: 2021-12-20 at 13:28
Author: Ivan Lukačević

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2. Realised activities 1st year

- D7. 1st Research group coordination meeting (O1 to O6)

Project title: **Innovative lightweight cold-formed steel-concrete composite floor system**
Acronym: **LWT-FLOOR** Project ID: **UIP-2020-02-2964**
1st research group meeting – 3.12.2021.

LWT-FLOOR Project

Innovative lightweight cold-formed steel-concrete composite floor system

Ivan Lukačević

University of Zagreb/Faculty of Civil Engineering
http://www.grad.unizg.hr/lwtfloor

2. Realised activities 1st year

- D10. Design of specimens for testing and technical specification for fabrication (O2, O3)

PROJEKTIRANJE UZORAKA ZA ISPITIVANJE I TEHNIČKE SPECIFIKACIJE ZA IZRADU LWT-FLOOR

Zagreb, 2021.

SADRŽAJ

2. Realised activities 1st year

- D11. Fabrication of material specimens (O2)

GRAĐEVINSKI FAKULTET

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LWT–FLOOR RESEARCH PROJECT

UZORCI MATERIJALA LWT-FLOOR

Zagreb, 2021.

Inovativna lagana međukatna konstrukcija – spregnuti sustav hladno oblikovani čelik i beton - LWT-FLOOR; UIP-2020-02-2964
Voditelj: Ivan Lukačević
Sveučilište u Zagrebu, Građevinski fakultet, Hrvatska
https://www.grad.unizg.hr/lwtfloor
Uzorci materijala

SADRŽAJ

2. Realised activities 1st year

- D12. Fabrication of spot-welded connections (O2)

SVEUČILIŠTE U ZAGREBU GRAĐEVINSKI FAKULTET

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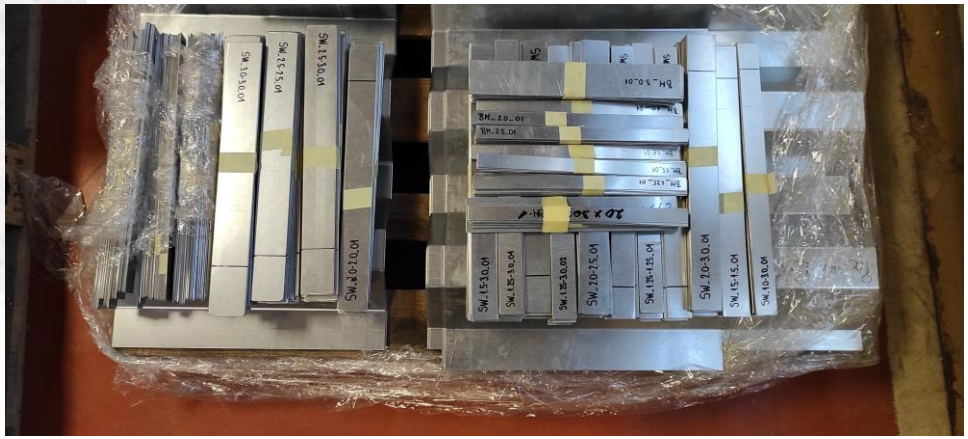
LWT–FLOOR RESEARCH PROJECT

UZORCI MATERIJALA LWT-FLOOR

Zagreb, 2021.

SADRŽAJ



2. Realised activities 1st year

- D13. Fabrication of shear connections (O2)

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LWT–FLOOR RESEARCH PROJECT

UZORCI POSMIČNIH VEZA LWT-FLOOR

Zagreb, 2021.

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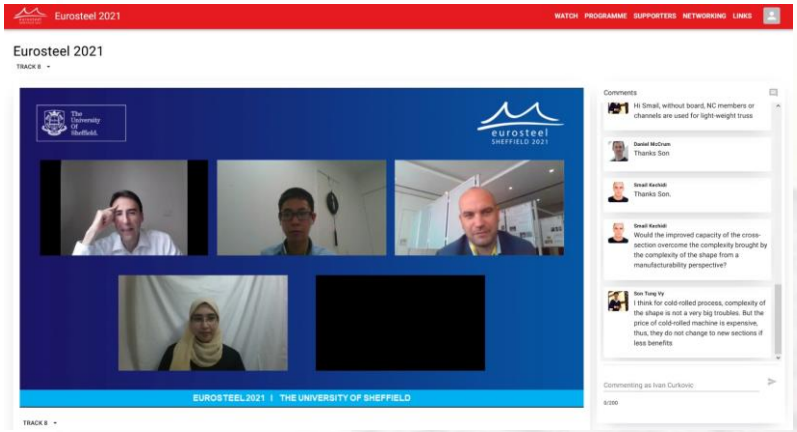
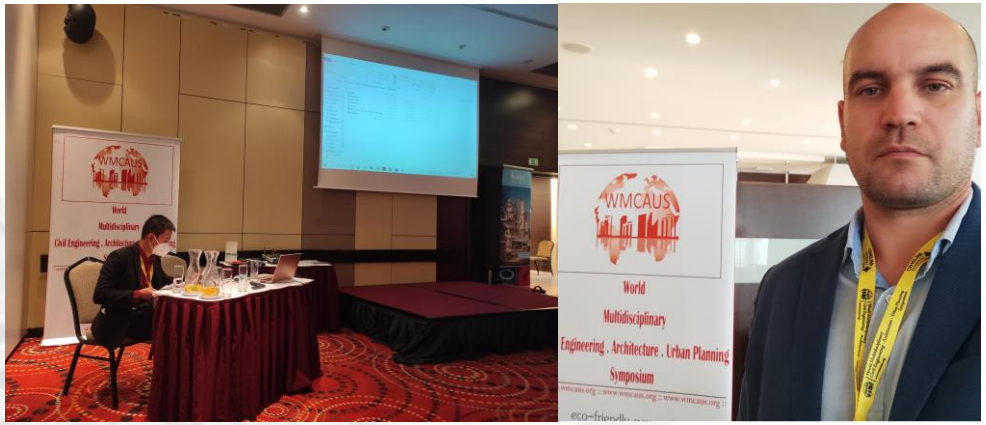
2. Realised activities 1st year

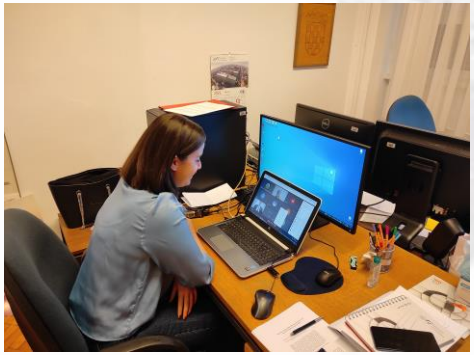
- D14. Presentation of the project results one or two papers (ICMS'21) and one or two papers (IABSE 2021) (O2)



EUROSTEEL 2021



WMCAUS 2021



IC-UBT 2021

LIMAS 2021

2. Realised activities 1st year

- D15. Journal Paper SCOPUS WoS Q3, Q4 – state of the art paper (O2, O3)

buildings

MDPI

Article

Lightweight Composite Floor System—Cold-Formed Steel and Concrete—LWT-FLOOR Project

Ivan Lukačević *, Ivan Čurković, Andrea Rajić and Marko Bartolac

Faculty of Civil Engineering, University of Zagreb, 10000 Zagreb, Croatia; ivan.curkovic@grad.unizg.hr (I.Č.); andrea.rajic@grad.unizg.hr (A.R.); marko.bartolac@grad.unizg.hr (M.B.)
* Correspondence: ivan.lukacevic@grad.unizg.hr; Tel.: +385-146-391-55

Abstract: In the last few decades, the application of lightweight cold-formed composite steel–concrete structural systems has constantly been increasing within the field of structural engineering. This can be explained by efficient material usage, particularly noticeable when using cold-formed built-up sections and the innovative types of shear connections. This paper summarises an overview of the development of the cold-formed composite steel–concrete floor systems. Additionally, it provides the background, planned activities, and preliminary results of the current LWT-FLOOR project, which is ongoing at the University of Zagreb, Faculty of Civil Engineering, Croatia. The proposed structural system is formed of built-up cold-formed steel beams and cast-in-place concrete slabs that are interconnected using an innovative type of shear connection. Preliminary analytical and numerical results on the system bending capacity are presented. Obtained results are mutually comparable. The resistance of the fixed beam solution is governed by the resistance of the steel beam, while pinned beam solution is governed by the degree of shear connection without the influence of the increased number of spot welds in the steel beam.

Keywords: cold-formed built-up steel; spot welding; steel–concrete composite system; floor system; finite element (FE) modelling

check for updates

Citation: Lukačević, I.; Čurković, I.; Rajić, A.; Bartolac, M. Lightweight Composite Floor System—Cold-Formed Steel and Concrete—LWT-FLOOR Project. *Buildings* **2022**, *12*, 209. https://doi.org/10.3390/buildings12020209

Academic Editors: Chiara Bedon, Flavio Stochino and Mislav Stepinac

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Published: 12 February 2022

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1. Introduction

One of the key strategies to reduce human impact on Earth is to completely rethink our present lifestyle, especially the one led in industrialised countries. One of the critical aspects of this new lifestyle is sustainability, including reducing raw material and energy consumption. This can be achieved through innovations that will maximise the values of the structural components and building materials during their lifecycle. Although a widespread, systematic approach is still lacking, individual scientific projects are well aware of this problem and provide relevant solutions. An excellent example of this is the application of the composite cold-formed steel–concrete solutions that significantly reduce material consumption and contribute to the aforementioned change of the present unsustainable lifestyle.

The known fact is that composite steel–concrete systems are generally one of the most cost-effective structural systems applied in multi-storey buildings. The main reason behind this is that composite steel–concrete solutions integrate structural efficiency and the speed of construction. The structural efficiency results from the effective usage of structural materials, namely steel and concrete, thus omitting their inherent disadvantages. On the other hand, construction speed is enhanced since propping and formwork installation can be significantly reduced or even completely avoided.

However, despite all the advantages and benefits of composite structural systems, so far, they have not had the chance to be applied to any greater extent, i.e., certainly not to the extent that they deserve [1]. According to Ahmed et al. [2], the main forces driving the research within the field of composite steel–concrete structural systems are related

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Innovative Lightweight Cold-Formed Steel-Concrete Composite Floor System – LWT-FLOOR project

Ivan Lukačević[1], Ivan Čurković[1], Andrea Rajić[1] and Ivan Čudina[1]

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Citation Ivan Lukačević *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1203** 032078

DOI 10.1088/1757-899X/1203/3/032078

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Abstract

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Abstract

To provide the foundations for economic and social prosperity, countries worldwide need to be making a term investment in their building assets. However, there is a lack of a systematic approach, such as manufacturing innovations, to maximize the values of building components and materials in its entire lifecycle. Steel-concrete composite floor systems are one of the most cost-effective construction systems for multi-storey steel buildings because they combine structural efficiency with the speed of construction. These advantages depend on the efficiency of combining steel and concrete structural elements to avoid their inherent disadvantages. This paper presents a solution that integrates state-of-the-art knowledge in new, fast and productive spot-welding technology and innovative cold-formed steel-concrete composite solutions. The solution proposes a new construction method as a combination of built- up cold-formed steel members and cast-in-place concrete slab. The proposed floor system offers key benefits in terms of a high degree of prefabrication, reusability and long spanning capability.

Export citation and abstract BibTeX RIS

2. Realised activities 1st year

- D16. 1st Workshop organised (O1 to O2)

3. Realised activities 2nd year

2nd Project Period	
Results to be achieved	RG member
D1. Presentation of project on the web site (O1 to O6) – continuous job…	IL, AR
D2. 2nd and 3rd Research group coordination meeting (O1 to O6) - 2nd Jully 3rd Today☺	All
D3. Training for one group member Introduction to Abaqus/Standard and Abaqus/Explicit (O2 to O5) – finnished	AR
D4. Training for one group member Abaqus/Explicit: Advanced Topics (O2 to O5) – finnished	AR or VŽ
D5. Training for one group member experimental deformation analysis (O2, O3) – finnished	AR or MB
D6. Technical report with test results on materials- 160 tests, see Application form (O2) – we are working on it	IL, AR, MB, IĆ, VŽ
D7. Technical report with test results on spot welded connections - 330 tests, see Application form (O2) – we are working on it	IL, AR, MB, IĆ, VŽ
D8. Technical report with results for tested types of shear connections - 30 tests, see Application form (O2) – we are working on it	IL, AR, MB, IĆ, VŽ
D9. Technical report with interpretation of results for tested types of shear connections - 30 tests, see Application form (O2) – we are working on it	IL, AR, MB, IĆ, VŽ
D10. Fabrication of full-scale steel specimens – 4 (3) specimens, see Application form (O3)– finnished	IL, AR, MB, IĆ, VŽ
D11. Fabrication of full-scale composite specimens – 4 (3) specimens, see Application form (O3) – we are working on it	IL, AR, MB, IĆ, VŽ
D12. Presentation of one or two papers (SDSS 2022) (O2) - finnished	AR, IĆ
D13. 2nd Workshop organised (O1 to O2) – End of 2022 (15th of December 2022)	All

3. Realised activities 2nd year

- D1. Presentation of project on the web site (O1 to O6)

2022 06 | 21 |

Edited: 2022-06-21 at 11:25
Author: Ivan Lukačević

Presentation of the LWT-FLOOR project and recent project activities the International scientific and technical conference «Modern structures of metal and wood»

A. Rajić presented the report "Innovative lightweight composite floor system – built-up cold-formed steel-concrete" at the International scientific and technical conference «Modern structures of metal and wood», Odesa, Ukraine, which has been organised online from 9–11 June 2022. The report can be found at the following link: https://odabamdipk.wixsite.com/sbornik/arhiveconf?lang=en

The recorded presentations from the conference can be found at the following link: https://odabamdipk.wixsite.com/sbornik/conferencess?lang=en

2022 06 | 13 |

Edited: 2022-06-21 at 11:06
Author: Ivan Lukačević

Push tests of innovative shear connection

Master students of the course Composite Structures (2nd year of graduate master study) on Wednesday, June 8, 2022, had the opportunity to attend a push-out laboratory test of innovative shear connection in the Laboratory for Structural Testing at the University of Zagreb, Faculty of Civile Engineering.

Before testing in the laboratory, the HRZZ project LWT-FLOOR is presented to students.

More information can be found here.

2022 02 | 12 |

Edited: 2022-02-12 at 16:20
Author: Ivan Lukačević

New paper related to LWT-FLOOR project has been published!

Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Bartolac, Marko **Lightweight Composite Floor System—Cold-Formed Steel and Concrete—LWT-FLOOR Project** // *Buildings*. 12, (2022) no. 2: 209; https://doi.org/10.3390/buildings12020209

2022 10 | 04 |

Author: Andrea Rajić

The International Colloquium on Stability and Ductility of Steel Structures

Two new research papers have been presented at the International Colloquium on Stability and Ductility of Steel Structures (SDSS 2022) held at the University of Aveiro, Portugal, on the 14-16 of September 2022. The paper "Numerical Investigation of Shear Connection in Cold-formed Steel-concrete Composite Beam" coauthored by Ivan Ćurković, Ivan Lukačević, Vlaho Žuvelek, Andrea Rajić has been presented by Assistant Professor Ivan Ćurković (https://onlinelibrary.wiley.com/doi/10.1002/cepa.1827). The paper "Parametric Finite Element Analyses of Lightweight Cold-formed Steel-concrete Composite Floor Beams" coauthored by Ivan Lukačević, Ivan Ćurković, Andrea Rajić, Vlaho Žuvelek has been presented by Research Assistant Andrea Rajić (https://onlinelibrary.wiley.com/doi/10.1002/cepa.1826).

2022 09 | 09 |

Author: Andrea Rajić

8th DOCTORAL SYMPOSIUM IN CIVIL ENGINEERING

A. Rajić presented the paper "**Analyses of LWT-FLOOR system bending resistance**" at the 8th Doctoral Syposium in Civil Enginnering which has been organised from 5-6 September 2022 at the Faculty if Civil Engineering, University of Zagreb, Croatia.

The symposium program can be found at the following link: https://master.grad.hr/phd-simpozij/2022/Program_Simpozij_2022-EN.pdf

2022 09 | 09 |

Edited: 2022-09-09 at 08:34
Author: Andrea Rajić

8th DOCTORAL SYPOSIUM IN CIVIL ENGINEERING

V. Žuvelek presented the paper **"Numerical study of shear connection in cold-formed steel-concrete composite beam"** at the 8th Doctoral Syposium in Civil Enginnering which has been organised from 5-6 September 2022 at the Faculty if Civil Enginnering, University of Zagreb, Croatia.

The symposium program can be found at the following link: https://master.grad.hr/phd-simpozij/2022/Program_Simpozij_2022-EN.pdf

2022 10 | 28 |

Author: Ivan Lukačević

Best Student Presentation Award at CFSRC 2022 Colloquium

PhD student and Research Assistant Andrea Rajić received an award for best student presentation at CFSRC 2022 Colloquium for the presentation of the paper "Numerical study of cold-formed steel-concrete composite floor system with demountable shear connectors". More info can be found here. Congratulations Andrea!!!!

2022 10 | 28 |

Edited: 2022-10-28 at 13:32
Author: Ivan Lukačević

Cold-Formed Steel Research Consortium Colloquium 2022 (CFSRC Colloquium 2022)

Three new research papers have been presented at the Cold-Formed Steel Research Consortium Colloquium 2022 (CFSRC Colloquium 2022) organised online at Johns Hopkins University by Thin-Walled Structure Group, Baltimore, USA, on the 17-19 of October 2022. The paper "Numerical study of cold-formed steel-concrete composite floor system with demountable shear connectors", coauthored by Andrea Rajić, Ivan Lukačević, Ivan Ćurković and Vlaho Žuvelek has been presented by Research Assistant Andrea Rajić (https://jscholarship.library.jhu.edu/handle/1774.2/67728). The paper "Numerical study of the behavior of the bolted shear connection in cold-formed steel-concrete composite beam", coauthored by Vlaho Žuvelek, Ivan Ćurković, Ivan Lukačević and Andrea Rajić, has been presented by Research Assistant Vlaho Žuvelek (https://jscholarship.library.jhu.edu/handle/1774.2/67727). The paper "Numerical parametric study on corrugated web built-up beams with pinned end supports", coauthored by Ivan Lukačević and Viorel Ungureanu, has been presented by Assistant Professor Ivan Lukačević (https://jscholarship.library.jhu.edu/handle/1774.2/67697).

2022 10 | 04 |

Edited: 2022-10-04 at 15:50
Author: Andrea Rajić

Presentation of papers at 9th gathering of young researchers in the field of construction and related technical sciences called COMMON FOUNDATIONS 2022

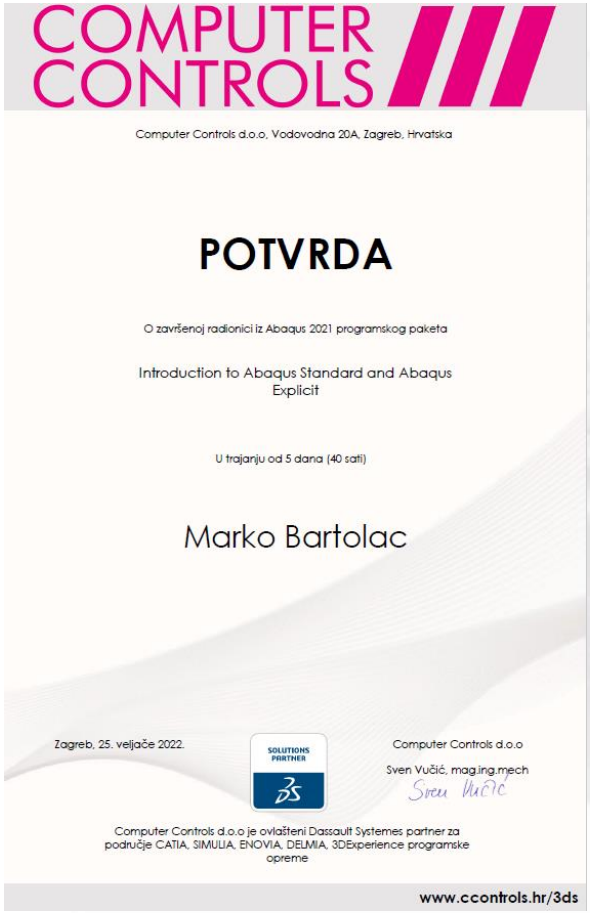
V. Žuvelek and A. Rajić presented their papers at the 9th gathering of young researchers in the field of construction and related technical sciences called COMMON FOUNDATIONS 2022 which has been organised from 28-30 September 2022 in Osijek, Croatia.

3. Realised activities 2nd year

- D2. 2nd and 3rd Research group coordination meeting (O1 to O6)

3. Realised activities 2nd year

- D3. Training for one group member Introduction to Abaqus/Standard and Abaqus/Explicit (O2 to O5)



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POTVRDA

O završenoj radionici iz Abaqus 2021 programskog paketa

Introduction to Abaqus Standard and Abaqus Explicit

U trajanju od 5 dana (40 sati)

Marko Bartolac

Zagreb, 25. veljače 2022.

Computer Controls d.o.o

Sven Vučić, mag.ing.mech

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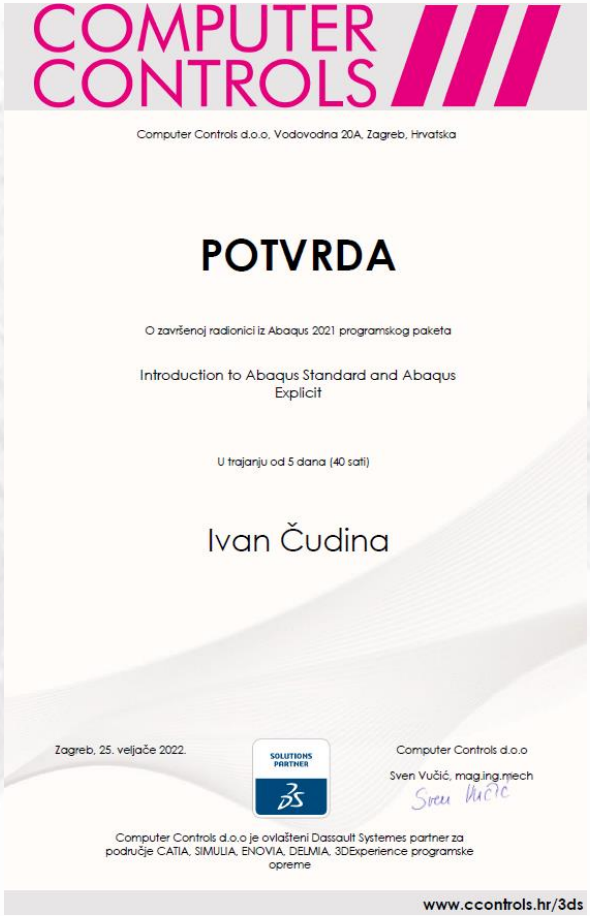

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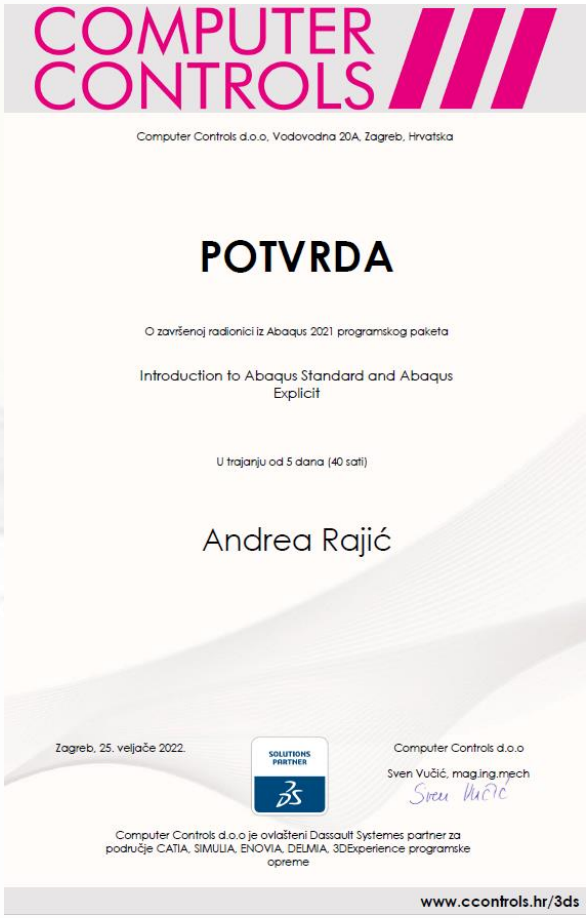

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POTVRDA

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3. Realised activities 2nd year

- D4. Training for one group member Abaqus/Explicit: Advanced Topics (O2 to O5)

Dassault Systemes and

INCEPTRA, LLC - USA

certify that

Vlaho Zuvelek

has completed the following course

ABAQUS/EXPLICIT: ADVANCED TOPICS, R2019

held in the UNITED STATES, on May 16-18, 2022

Instructor: Aaron Schwartz

Year - 2022

3. Realised activities 2nd year

- D5. Training for one group member experimental deformation analysis (O2, O3)

TRCpro d.o.o.
Vrečkova 2
4000 Kranj
Slovenija

Tel +386 4 2358310
Fax +386 4 2358311
email: hbm@trcpro.eu
web: www.trcpro.eu

IDDDV: SI 11495219 MŠ: 6421202000

CERTIFIKAT

što potvrđuje da jest

Marko Bartolac

pohađao obuku:

Mjerenje relativnih deformacija primjenom otporničkih tenzometara

TRCpro d.o.o.
24. i 25.11. 2022

Predavač:
Hotimir Ličen

TRC pro d.o.o. Vrečkova 2, 4000 Kranj

HBK PARTNER

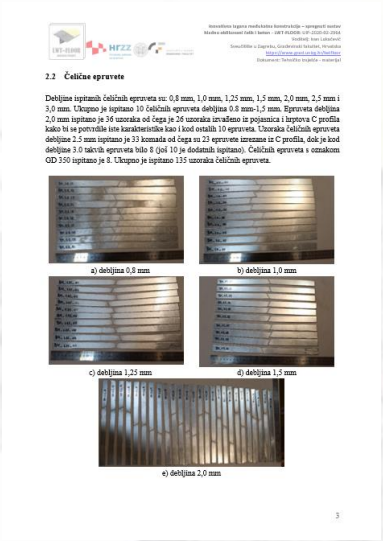
grad-unizg-MB_lu01_221125.docx 1/1

3. Realised activities 2nd year

- D6. Technical report with test results on materials- 160 (186) tests, see Application form (O2) – finished

TEHNIČKO IZVJEŠĆE S REZULTATIMA
ISPITIVANJA NA UZORCIMA MATERIJALA

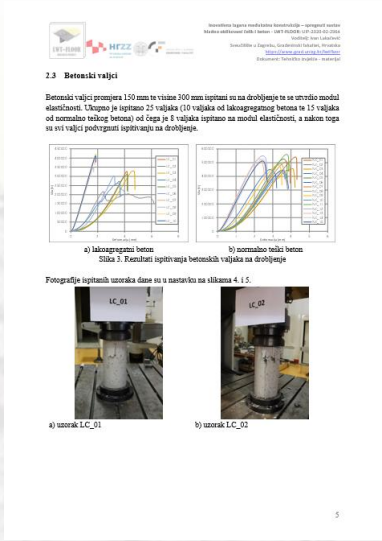
Zagreb, 2022.



2.2 Čelične epruvete

Debljine ispitanih čeličnih epruveta su: 0,8 mm, 1,0 mm, 1,25 mm, 1,5 mm, 2,0 mm, 2,5 mm i 3,0 mm. Ukupno je ispitano 10 čeličnih epruveta debljina 0.8 mm-1,5 mm. Epruveta debljina 2,0 mm ispitano je 36 uzoraka od čega je 26 uzoraka izrađeno iz pojasnica i hrptova C profila kako bi se potvrdile iste karakteristike kao i kod ostalih 10 epruveta. Uzoraka čeličnih epruveta debljine 2.5 mm ispitano je 33 komada od čega su 23 epruvete izrezane iz C profila, dok je kod debljine 3.0 takvih epruveta bilo 8 (još 10 je dodatnih ispitano). Čeličnih epruveta s oznakom GD 350 ispitano je 8. Ukupno je ispitano 135 uzoraka čeličnih epruveta.

a) debljina 0,8 mm
b) debljina 1,0 mm
c) debljina 1,25 mm
d) debljina 1,5 mm
e) debljina 2,0 mm



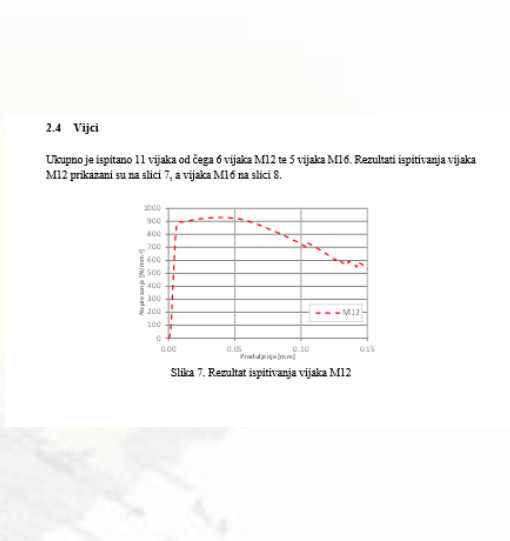
2.3 Betonski valjci

Betonski valjci promjera 150 mm te visine 300 mm ispitani su na drobljenje te se utvrdio modul elastičnosti. Ukupno je ispitano 25 valjaka (10 valjaka od lakoagregatnog betona te 15 valjaka od normalno teškog betona) od čega je 8 valjaka ispitano na modul elastičnosti, a nakon toga su svi valjci podvrgnuti ispitivanju na drobljenje.

a) lakoagregatni beton
b) normalno teški beton
Slika 3. Rezultati ispitivanja betonskih valjaka na drobljenje

Fotografije ispitanih uzoraka dane su u nastavku na slikama 4. i 5.

a) uzorak LC_01
b) uzorak LC_02



2.4 Vijci

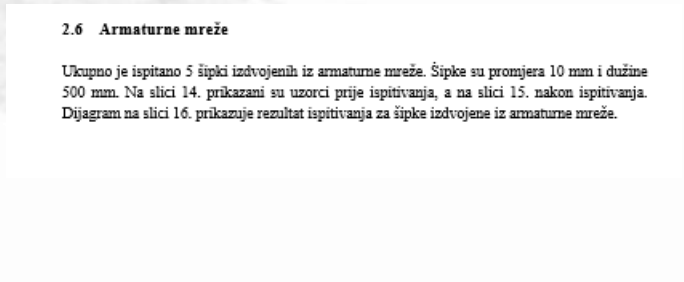
Ukupno je ispitano 11 vijaka od čega 6 vijaka M12 te 5 vijaka M16. Rezultati ispitivanja vijaka M12 prikazani su na slici 7, a vijaka M16 na slici 8.

Slika 7. Rezultat ispitivanja vijaka M12

2.5 Armaturne šipke

Ukupno je ispitano 5 šipki promjera 8 mm te dužine 500 mm. Na slici 11. prikazani su uzorci prije ispitivanja, a na slici 12. nakon ispitivanja. Dijagram na slici 13. prikazuje rezultat ispitivanja za šipke.

Slika 11. Uzorci za armaturnih šipki prije ispitivanja

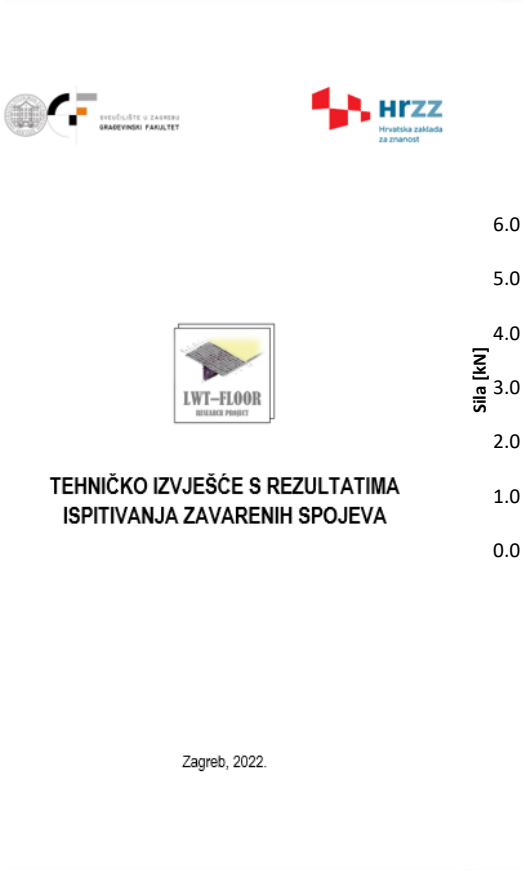


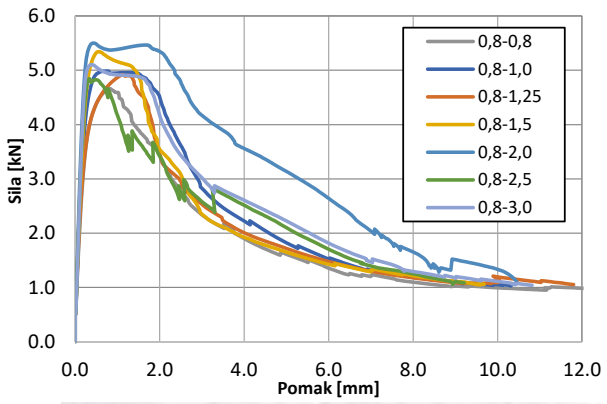
2.6 Armaturne mreže

Ukupno je ispitano 5 šipki izdvojenih iz armaturne mreže. Šipke su promjera 10 mm i dužine 500 mm. Na slici 14. prikazani su uzorci prije ispitivanja, a na slici 15. nakon ispitivanja. Dijagram na slici 16. prikazuje rezultat ispitivanja za šipke izdvojene iz armaturne mreže.

3. Realised activities 2nd year

- D7. Technical report with test results on spot welded connections - 330 (558) tests, see Application form (O2)





3. Realised activities 2nd year

- D8. Technical report with results for tested types of shear connections - 30 tests, see Application form (O2)


SVEUČILIŠTE U ZAGREBU
GRAĐEVINSKI FAKULTET

HRZZ
Hrvatska zaklada za znanost

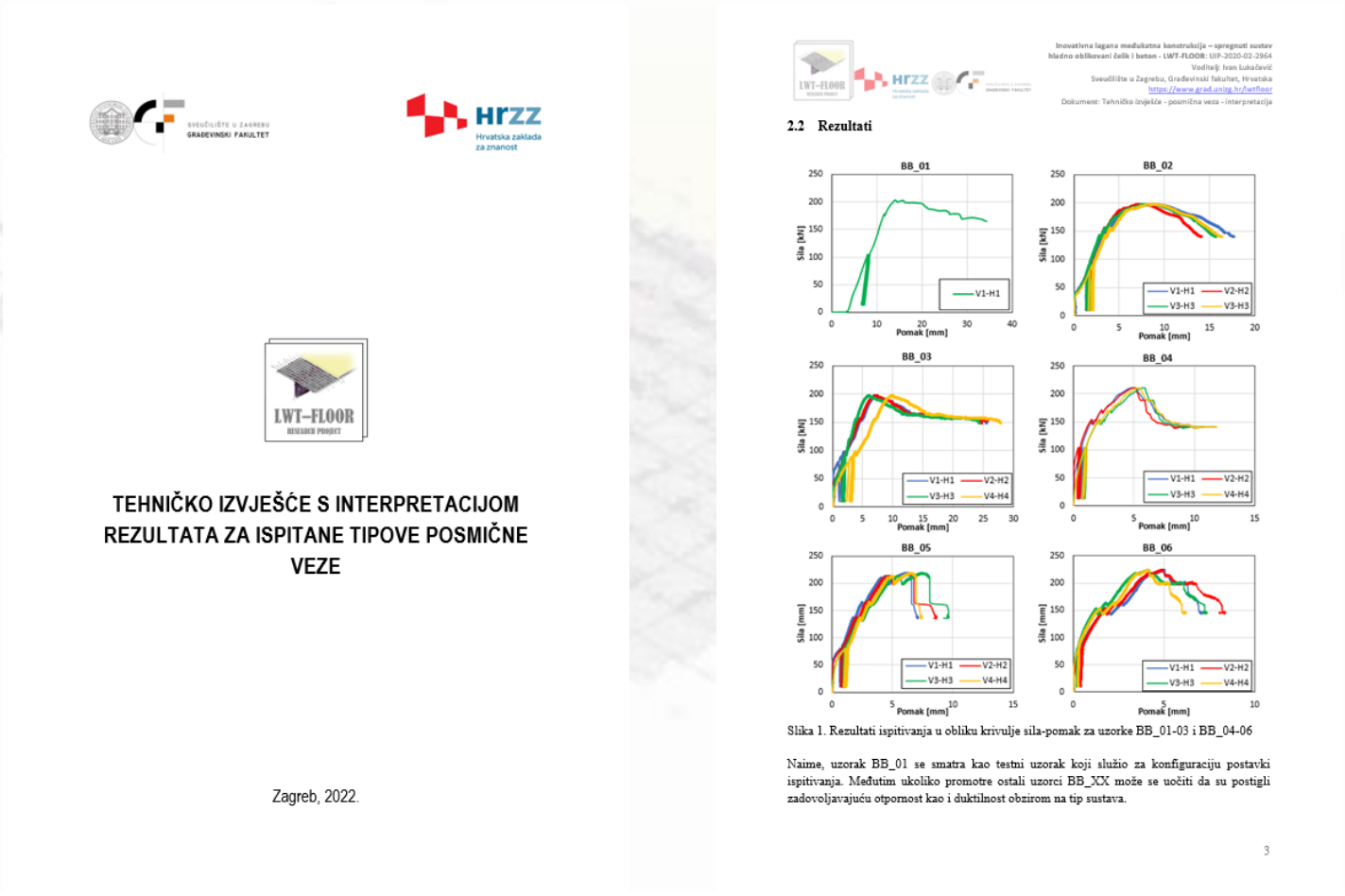
LWT–FLOOR
RESEARCH PROJECT

TEHNIČKO IZVJEŠĆE S REZULTATIMA ZA ISPITANE TIPOVE POSMIČNE VEZE

Zagreb, 2022.

3. Realised activities 2nd year

- D9. Technical report with interpretation of results for tested types of shear connections - 30 tests, see Application form (O2)



SVEUČILIŠTE U ZAGREBU GRAĐEVINSKI FAKULTET

HRZZ Hrvatska zaklada za znanost

LWT–FLOOR RESEARCH PROJECT

TEHNIČKO IZVJEŠĆE S INTERPRETACIJOM REZULTATA ZA ISPITANE TIPOVE POSMIČNE VEZE

Zagreb, 2022.

Inovativna lagana međukatna konstrukcija – spregnuti sustav hladno oblikovani čelik i beton - LWT-FLOOR: UIP-2020-02-2964
Voditelj: Ivan Lukačević
Sveučilište u Zagrebu, Građevinski fakultet, Hrvatska
https://www.grad.unizg.hr/lwtfloor
Dokument: Tehničko izvješće - posmična veza - interpretacija

2.2 Rezultati

Slika 1. Rezultati ispitivanja u obliku krivulje sila-pomak za uzorke BB_01-03 i BB_04-06

Naime, uzorak BB_01 se smatra kao testni uzorak koji služio za konfiguraciju postavki ispitivanja. Međutim ukoliko promotre ostali uzorci BB_XX može se uočiti da su postigli zadovoljavajuću otpornost kao i duktilnost obzirom na tip sustava.

3

3. Realised activities 2nd year

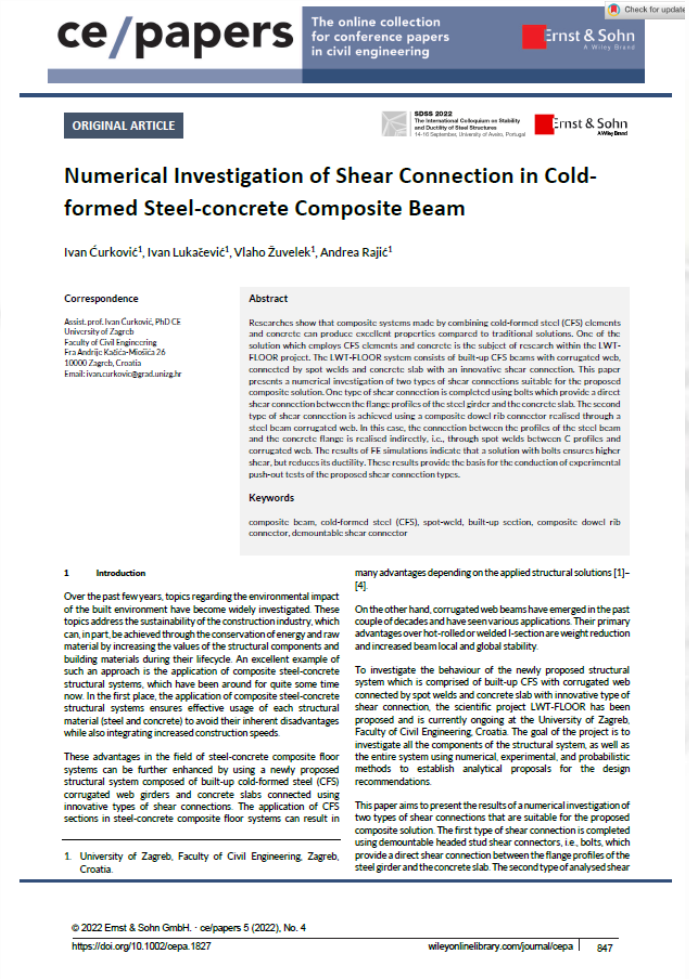
- D10. Fabrication of full-scale steel specimens – 3 specimens, see Application form (O3)

3. Realised activities 2nd year

- D11. Fabrication of full-scale composite specimens – 3 specimens, see Application form (O3)

3. Realised activities 2nd year

- D12. Presentation of one or two papers (SDSS 2022) (O2)



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ORIGINAL ARTICLE

Numerical Investigation of Shear Connection in Cold-formed Steel-concrete Composite Beam

Ivan Ćurković[1], Ivan Lukačević[1], Vlaho Žuvelek[1], Andrea Rajić[1]

Correspondence

Assist. prof. Ivan Ćurković, PhD CE
University of Zagreb
Faculty of Civil Engineering
Fra Andrije Kačića-Miošića 26
10000 Zagreb, Croatia
Email: ivan.curkovic@grad.unizg.hr

Abstract

Researches show that composite systems made by combining cold-formed steel (CFS) elements and concrete can produce excellent properties compared to traditional solutions. One of the solution which employs CFS elements and concrete is the subject of research within the LWT-FLOOR project. The LWT-FLOOR system consists of built-up CFS beams with corrugated web, connected by spot welds and concrete slab with an innovative shear connection. This paper presents a numerical investigation of two types of shear connections suitable for the proposed composite solution. One type of shear connection is completed using bolts which provide a direct shear connection between the flange profiles of the steel girder and the concrete slab. The second type of shear connection is achieved using a composite dowel rib connector realised through a steel beam corrugated web. In this case, the connection between the profiles of the steel beam and the concrete flange is realised indirectly, i.e., through spot welds between C profiles and corrugated web. The results of FE simulations indicate that a solution with bolts ensures higher shear, but reduces its ductility. These results provide the basis for the conduction of experimental push-out tests of the proposed shear connection types.

Keywords

composite beam, cold-formed steel (CFS), spot-weld, built-up section, composite dowel rib connector, demountable shear connector

1 Introduction

Over the past few years, topics regarding the environmental impact of the built environment have become widely investigated. These topics address the sustainability of the construction industry, which can, in part, be achieved through the conservation of energy and raw material by increasing the values of the structural components and building materials during their lifecycle. An excellent example of such an approach is the application of composite steel-concrete structural systems, which have been around for quite some time now. In the first place, the application of composite steel-concrete structural systems ensures effective usage of each structural material (steel and concrete) to avoid their inherent disadvantages while also integrating increased construction speeds.

These advantages in the field of steel-concrete composite floor systems can be further enhanced by using a newly proposed structural system composed of built-up cold-formed steel (CFS) corrugated web girders and concrete slabs connected using innovative types of shear connections. The application of CFS sections in steel-concrete composite floor systems can result in many advantages depending on the applied structural solutions [1]–[4].

On the other hand, corrugated web beams have emerged in the past couple of decades and have seen various applications. Their primary advantages over hot-rolled or welded I-section are weight reduction and increased beam local and global stability.

To investigate the behaviour of the newly proposed structural system which is comprised of built-up CFS with corrugated web connected by spot welds and concrete slab with innovative type of shear connection, the scientific project LWT-FLOOR has been proposed and is currently ongoing at the University of Zagreb, Faculty of Civil Engineering, Croatia. The goal of the project is to investigate all the components of the structural system, as well as the entire system using numerical, experimental, and probabilistic methods to establish analytical proposals for the design recommendations.

This paper aims to present the results of a numerical investigation of two types of shear connections that are suitable for the proposed composite solution. The first type of shear connection is completed using demountable headed stud shear connectors, i.e., bolts, which provide a direct shear connection between the flange profiles of the steel girder and the concrete slab. The second type of analysed shear

1. University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia.

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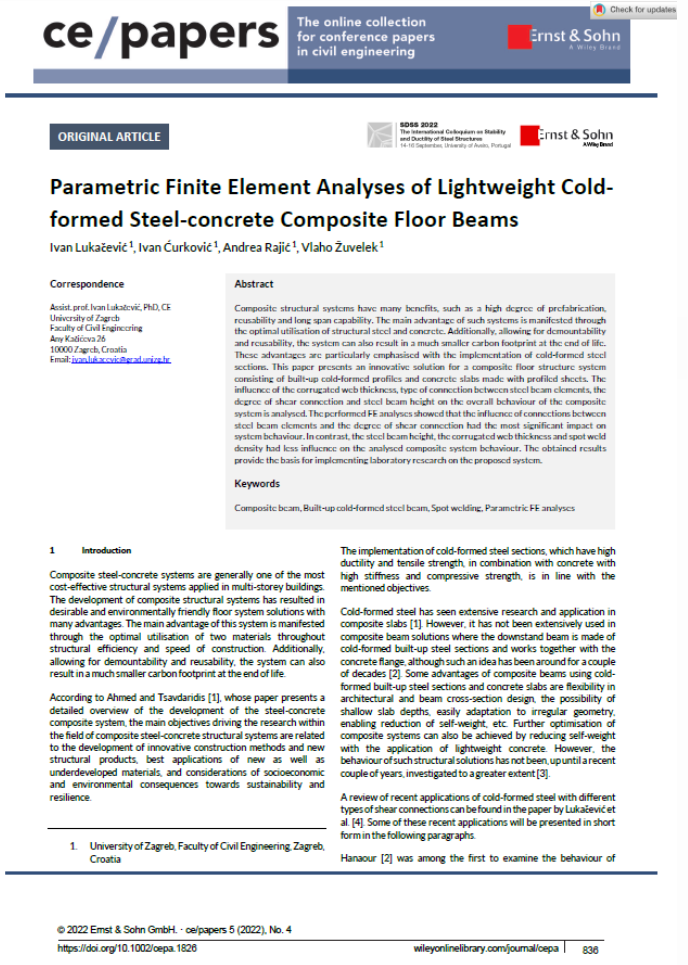
https://doi.org/10.1002/cepa.1827 wileyonlinelibrary.com/journal/cepa 847



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ORIGINAL ARTICLE

Parametric Finite Element Analyses of Lightweight Cold-formed Steel-concrete Composite Floor Beams

Ivan Lukačević[1], Ivan Ćurković[1], Andrea Rajić[1], Vlaho Žuvelek[1]

Correspondence

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Abstract

Composite structural systems have many benefits, such as a high degree of prefabrication, reusability and long span capability. The main advantage of such systems is manifested through the optimal utilisation of structural steel and concrete. Additionally, allowing for demountability and reusability, the system can also result in a much smaller carbon footprint at the end of life. These advantages are particularly emphasised with the implementation of cold-formed steel sections. This paper presents an innovative solution for a composite floor structure system consisting of built-up cold-formed profiles and concrete slabs made with profiled sheets. The influence of the corrugated web thickness, type of connection between steel beam elements, the degree of shear connection and steel beam height on the overall behaviour of the composite system is analysed. The performed FE analyses showed that the influence of connections between steel beam elements and the degree of shear connection had the most significant impact on system behaviour. In contrast, the steel beam height, the corrugated web thickness and spot weld density had less influence on the analysed composite system behaviour. The obtained results provide the basis for implementing laboratory research on the proposed system.

Keywords

Composite beam, Built-up cold-formed steel beam, Spot welding, Parametric FE analyses

1 Introduction

Composite steel-concrete systems are generally one of the most cost-effective structural systems applied in multi-storey buildings. The development of composite structural systems has resulted in desirable and environmentally friendly floor system solutions with many advantages. The main advantage of this system is manifested through the optimal utilisation of two materials throughout structural efficiency and speed of construction. Additionally, allowing for demountability and reusability, the system can also result in a much smaller carbon footprint at the end of life.

According to Ahmed and Tsavdaridis [1], whose paper presents a detailed overview of the development of the steel-concrete composite system, the main objectives driving the research within the field of composite steel-concrete structural systems are related to the development of innovative construction methods and new structural products, best applications of new as well as underdeveloped materials, and considerations of socioeconomic and environmental consequences towards sustainability and resilience.

The implementation of cold-formed steel sections, which have high ductility and tensile strength, in combination with concrete with high stiffness and compressive strength, is in line with the mentioned objectives.

Cold-formed steel has seen extensive research and application in composite slabs [1]. However, it has not been extensively used in composite beam solutions where the downstand beam is made of cold-formed built-up steel sections and works together with the concrete flange, although such an idea has been around for a couple of decades [2]. Some advantages of composite beams using cold-formed built-up steel sections and concrete slabs are flexibility in architectural and beam cross-section design, the possibility of shallow slab depths, easily adaptation to irregular geometry, enabling reduction of self-weight, etc. Further optimisation of composite systems can also be achieved by reducing self-weight with the application of lightweight concrete. However, the behaviour of such structural solutions has not been, up until a recent couple of years, investigated to a greater extent [3].

A review of recent applications of cold-formed steel with different types of shear connections can be found in the paper by Lukačević et al. [4]. Some of these recent applications will be presented in short form in the following paragraphs.

Hanaour [2] was among the first to examine the behaviour of

1. University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia

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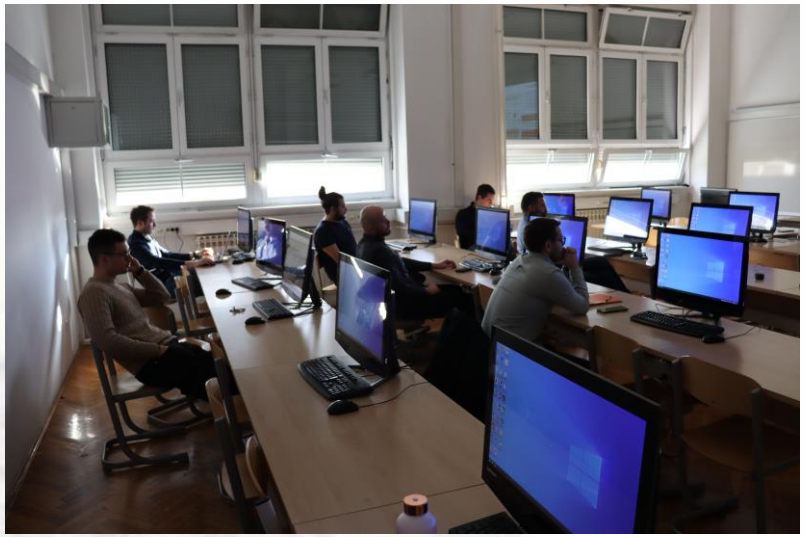
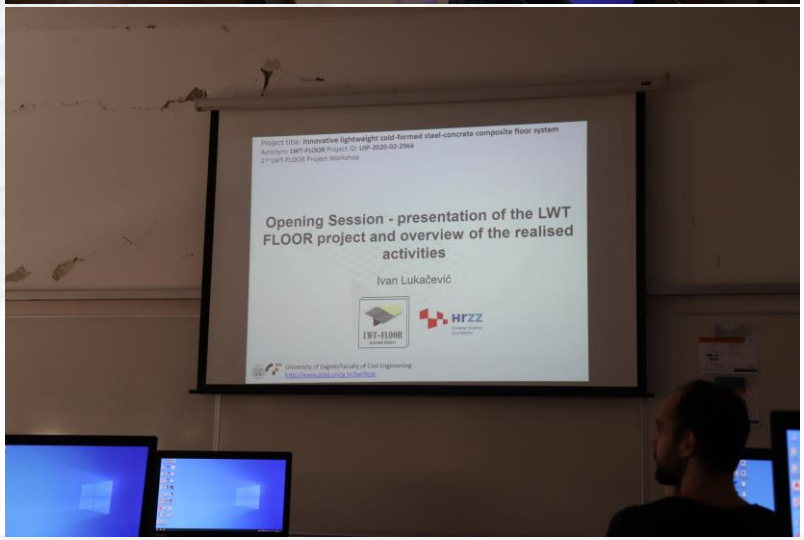
https://doi.org/10.1002/cepa.1826 wileyonlinelibrary.com/journal/cepa 836

3. Realised activities 2nd year

- D13. 2nd Workshop organised (O1 to O2)





4. Realised activities 3rd year

3rd Project Period	
Results to be achieved	RG member
D1. Presentation of project on the web site (O1 to O6) – continuous job…	IL, AR
D2. 4th and 5th Research group coordination meeting (O1 to O6) – 21st of July, 5th today☺	All
D3. Training for one group member - DAQ system (O2, O3) – December 2023, January 2024	MB
D4. Technical report with results for full-scale steel specimens - 3 tests, see Application form (O3)– we are working on it	IL, AR, MB, MP, FLB
D5. Technical report with results for full-scale composite floor system specimens - 3 tests, see Application form (O3) – we are working on it	IL, AR, MB, IĆ, VŽ
D6. Technical report with interpretation of results for full-scale steel and composite floor system specimens (O3)– we are working on it	IL, AR, MB, IĆ, VŽ
D7. Report with validation of FEM models for analysed types of shear connection (O2)– we are working on it	IL, AR, MP, IĆ, VŽ, FLB
D8. Presentation of one or two papers (ICAEM 2023) and one or two papers (EUROSTEEL 2023) (O2, O3)– EUROSTEEL 2023, MBMST2023, IALCCE 2023 and MASE 2023	IL, AR, MB, IĆ, VŽ
D9. Journal Paper SCOPUS WoS Q1, Q2 (O2, O3)– 2 papers already published	IL, AR, MB, IĆ, VŽ
D10. 3rd Workshop organised (O1 to O3) – End of 2023 (21st of December)	All

4. Realised activities 3rd year

- D1. Presentation of project on the web site (O1 to O6)

2023 12 | 12 |
Edited: 2023-12-12 at 19:42
Author: Ivan Lukačević

3rd Workshop LWT-FLOOR Project

3rd LWT-FLOOR Project WORKSHOP will be organised at the University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia on 21th of December 2023, Council chamber, ground floor left, Kranjceviceva 2.

A workshop flyer with the preliminary programme is available HERE.

2023 11 | 20 |
Edited: 2023-11-20 at 08:34
Author: Andrea Rajić

New journal paper related to LWT-FLOOR project has been published!

Rajić, A.; Lukačević, I.; Skejić, D.; Ungureanu, V. Cold-formed Steel-Concrete Composite Beams with Back-to-Back Channel Sections in Bending. Civil engineering journal (Tehran), 9 (2023.), 10; 2345-2369. doi: 10.28991/CEJ-2023-09-10-01

2023 10 | 06 |
Author: Ivan Lukačević

Testing of LWT-FLOOR composite girders

The LWT-FLOOR composite girders were tested.

2023 10 | 06 |
Edited: 2023-10-06 at 10:52
Author: Ivan Lukačević

14th International Conference "Modern Building Materials, Structures and Techniques" (MBMST 2023)

The new research paper "**Laboratory tests of lightweight composite floor system LWT-FLOOR**" coauthored by Ivan Lukačević, Marko Bartolac, Ivan Ćurković, Andrea Rajić and Vlaho Žuvlek is presented by Professor Marko Bartolac at the 14th International Conference "Modern Building Materials, Structures and Techniques" (MBMST 2023). The conference was held in Vilnius, Lithuania on October 5–6, 2023. The Conference is organised by the Faculty of Civil Engineering of VILNIUS TECH.

The conference programme can be found at the following link: MBMST 2023 Conference Programme

2023 10 | 06 |
Edited: 2023-10-06 at 10:51
Author: Ivan Lukačević

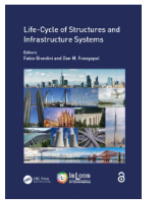
20th International Symposium of MASE - Resilient Structures

Ivan Lukačević and Ivan Ćurković presented the paper "**Bending resistance of composite steel-concrete floor system made of built-up cold-formed steel elements**" at the 920th International Symposium of MASE - Resilient Structures, Skopje, North Macedonia, which has been organised fro 28 to 29 September 2023 in Skopje.

The conference programme can be found at the following link: http://mase.gf.ukim.edu.mk/downloads/MASE20_Final_Programme.pdf.

The presented paper:

Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Žuvelek, Vlaho: Bending resistance of composite steel-concrete floor system made of built-up cold-formed steel elements// PROCEEDINGS OF THE 20th INTERNATIONAL SYMPOSIUM OF MASE/ Skopje, Sveučilište sv. Ćirila i Metoda Skopje. str. 421-430.

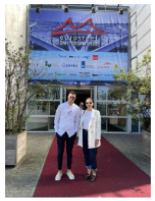


2023 10 | 06 |
Edited: 2023-10-06 at 10:53
Author: Ivan Lukačević

Eighth International Symposium on Life-Cycle Civil Engineering (IALCCE 2023)

The new research paper "**A comparative life-cycle assessment of structural composite steel-concrete floor systems – A case study**" coauthored by Ivan Lukačević, Andrea Rajić, Viorel Ungureanu and Raluca Buzatu is presented by Professor Viorel Ungureanu at the Eighth International Symposium on Life-Cycle Civil Engineering (IALCCE 2023). The conference was held in Milan, Italy, July 2-6, 2023, under the auspices of Politecnico di Milano.

IALCCE 2023 | Open Access Book



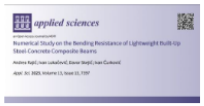
2023 10 | 06 |
Edited: 2023-10-06 at 10:53
Author: Ivan Lukačević

10th European conference on steel and composite structures (EUROSTEEL 2023)

Two new research papers have been presented at the 10th European Conference on Steel and Composite Structures (EUROSTEEL 2023) jointly organized by TU Delft, ETH Zurich and Bouwen met Staal, and supported by ECCS held in Amsterdam, from 12 to 14 September 2023.

The paper "**Performance evaluation of cold-formed steel spot weld connections**" coauthored by Andrea Rajić, Ivan Lukačević, Ivan Ćurković, Vlaho Žuvelek has been presented by Research Assistant Andrea Rajić (https://onlinelibrary.wiley.com/doi/10.1002/cepa.2627).

The paper "**Finite Element Analyses of Demountable Shear Connection in Cold-Formed Steel-Concrete Composite Beam Based on Experimental Data**" coauthored by Vlaho Žuvelek, Ivan Ćurković, Ivan Lukačević, Andrea Rajić has been presented by Research Assistant Vlaho Žuvelek (https://onlinelibrary.wiley.com/doi/10.1002/cepa.2629).



2023 07 | 17 |
Edited: 2023-07-17 at 09:35
Author: Ivan Lukačević

New journal paper related to LWT-FLOOR project has been published!

Rajić, A.; Lukačević, I.; Skejić, D.; Ćurković, I. **Numerical Study on the Bending Resistance of Lightweight Built-Up Steel-Concrete Composite Beams**. *Appl. Sci.* **2023**, *13*, 7397. https://doi.org/10.3390/app13137397

2023 07 | 17 |
Edited: 2023-07-17 at 09:21
Author: Ivan Lukačević

Testing of LWT-FLOOR steel girders

The LWT-FLOOR steel girders were tested.

2022 12 | 23 |
Edited: 2022-12-23 at 08:34
Author: Ivan Lukačević

Merry Christmas and a happy and prosperous new year!

We wish you a Merry Christmas and a happy and prosperous 2023 year!

LWT-FLOOR Project Research Group Members

2022 12 | 23 |
Edited: 2022-12-23 at 08:33
Author: Ivan Lukačević

The second workshop of LWT-FLOOR project

On December 15th, the second LWT-FLOOR project workshop was held. We thank all the presenters and participants of the workshop.

The workshop presentations will be published on the project web page soon.

4. Realised activities 3rd year

- D2. 4th and 5th Research group coordination meeting (O1 to O6)

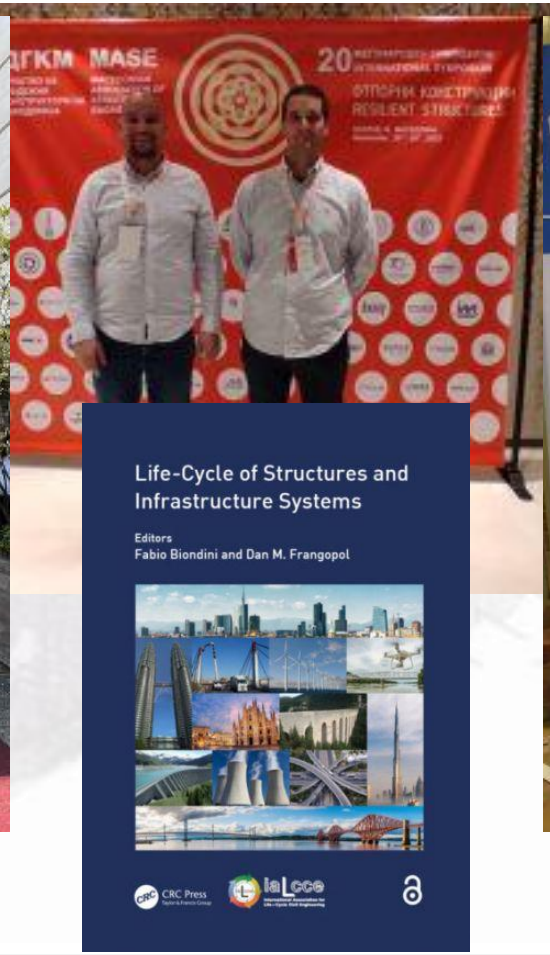
4. Realised activities 3rd year

- D3. Training for one group member - DAQ system (O2, O3) – Training will be realised – January 2024

- D4. Technical report with results for full-scale steel specimens - 3 tests, see Application form (O3)
- D5. Technical report with results for full-scale composite floor system specimens - 3 tests, see Application form (O3)
- D6. Technical report with interpretation of results for full-scale steel and composite floor system specimens (O3)
- D7. Report with validation of FEM models for analysed types of shear connection (O2)
- …we are working on all of these reports…

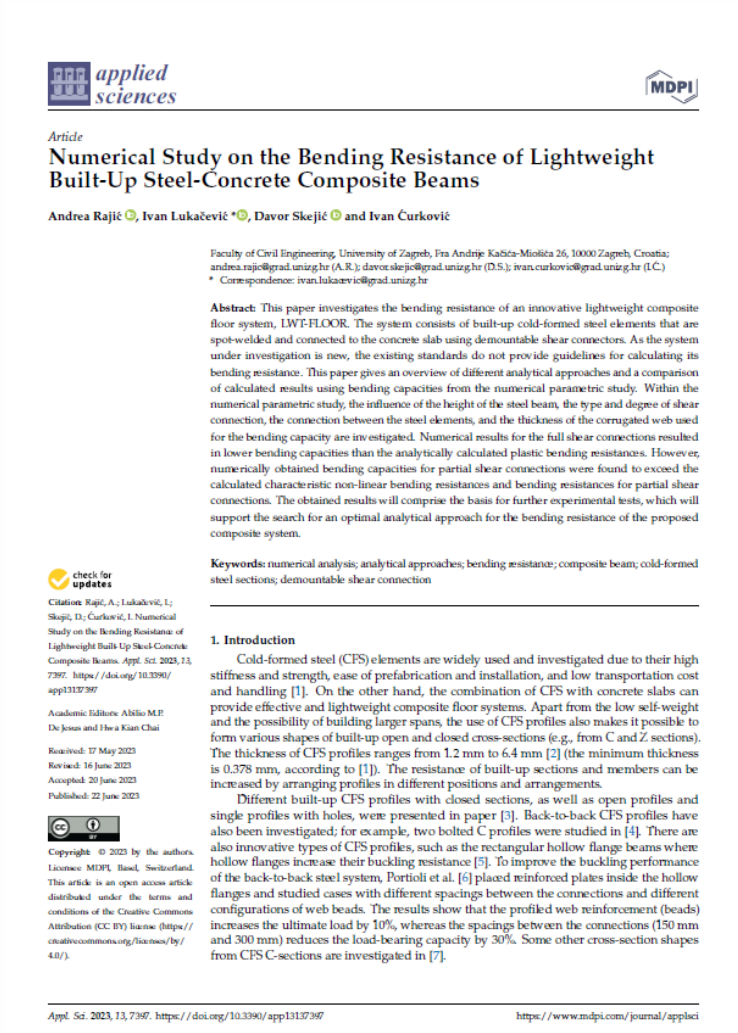
4. Realised activities 3rd year

- D8. Presentation of one or two papers (ICAEM 2023) and one or two papers (EUROSTEEL 2023) (O2, O3)



4. Realised activities 3rd year

- D9. Journal Paper SCOPUS WoS Q1, Q2 (O2, O3)



applied sciences

MDPI

Article

Numerical Study on the Bending Resistance of Lightweight Built-Up Steel-Concrete Composite Beams

Andrea Rajić, Ivan Lukačević *, Davor Skejić and Ivan Ćurković

Faculty of Civil Engineering, University of Zagreb, Fra Andrije Kačića-Miošića 26, 10000 Zagreb, Croatia; andrea.rajic@grad.unizg.hr (A.R.); davor.skejic@grad.unizg.hr (D.S.); ivan.curkovic@grad.unizg.hr (I.Ć.)
* Correspondence: ivan.lukacevic@grad.unizg.hr

Abstract: This paper investigates the bending resistance of an innovative lightweight composite floor system, LWT-FLOOR. The system consists of built-up cold-formed steel elements that are spot-welded and connected to the concrete slab using demountable shear connectors. As the system under investigation is new, the existing standards do not provide guidelines for calculating its bending resistance. This paper gives an overview of different analytical approaches and a comparison of calculated results using bending capacities from the numerical parametric study. Within the numerical parametric study, the influence of the height of the steel beam, the type and degree of shear connection, the connection between the steel elements, and the thickness of the corrugated web used for the bending capacity are investigated. Numerical results for the full shear connections resulted in lower bending capacities than the analytically calculated plastic bending resistances. However, numerically obtained bending capacities for partial shear connections were found to exceed the calculated characteristic non-linear bending resistances and bending resistances for partial shear connections. The obtained results will comprise the basis for further experimental tests, which will support the search for an optimal analytical approach for the bending resistance of the proposed composite system.

Keywords: numerical analysis; analytical approaches; bending resistance; composite beam; cold-formed steel sections; demountable shear connection

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Citation: Rajić, A.; Lukačević, I.; Skejić, D.; Ćurković, I. Numerical Study on the Bending Resistance of Lightweight Built-Up Steel-Concrete Composite Beams. *Appl. Sci.* **2023**, *13*, 7397. https://doi.org/10.3390/app13137397

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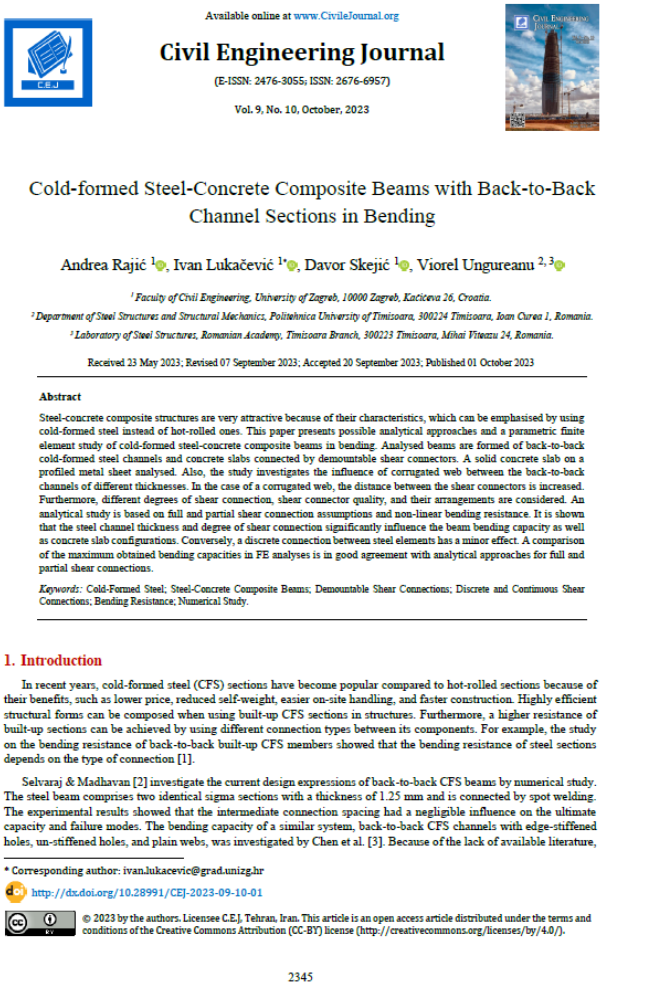
Accepted: 20 June 2023
Published: 22 June 2023

1. Introduction

Cold-formed steel (CFS) elements are widely used and investigated due to their high stiffness and strength, ease of prefabrication and installation, and low transportation cost and handling [1]. On the other hand, the combination of CFS with concrete slabs can provide effective and lightweight composite floor systems. Apart from the low self-weight and the possibility of building larger spans, the use of CFS profiles also makes it possible to form various shapes of built-up open and closed cross-sections (e.g., from C and Z sections). The thickness of CFS profiles ranges from 1.2 mm to 6.4 mm [2] (the minimum thickness is 0.378 mm, according to [1]). The resistance of built-up sections and members can be increased by arranging profiles in different positions and arrangements.

Different built-up CFS profiles with closed sections, as well as open profiles and single profiles with holes, were presented in paper [3]. Back-to-back CFS profiles have also been investigated; for example, two bolted C profiles were studied in [4]. There are also innovative types of CFS profiles, such as the rectangular hollow flange beams where hollow flanges increase their buckling resistance [5]. To improve the buckling performance of the back-to-back steel system, Portioli et al. [6] placed reinforced plates inside the hollow flanges and studied cases with different spacings between the connections and different configurations of web beads. The results show that the profiled web reinforcement (beads) increases the ultimate load by 10%, whereas the spacings between the connections (150 mm and 300 mm) reduces the load-bearing capacity by 30%. Some other cross-section shapes from CFS C-sections are investigated in [7].



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(E-ISSN: 2476-3055; ISSN: 2676-6957)

Vol. 9, No. 10, October, 2023

Cold-formed Steel-Concrete Composite Beams with Back-to-Back Channel Sections in Bending

Andrea Rajić [1], Ivan Lukačević [1]*, Davor Skejić [1], Viorel Ungureanu [2,3]

[1] Faculty of Civil Engineering, University of Zagreb, 10000 Zagreb, Kačićeva 26, Croatia.
[2] Department of Steel Structures and Structural Mechanics, Politehnica University of Timisoara, 300224 Timisoara, Ioan Curea 1, Romania.
[3] Laboratory of Steel Structures, Romanian Academy, Timisoara Branch, 300223 Timisoara, Mihai Viteazu 24, Romania.

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Abstract

Steel-concrete composite structures are very attractive because of their characteristics, which can be emphasised by using cold-formed steel instead of hot-rolled ones. This paper presents possible analytical approaches and a parametric finite element study of cold-formed steel-concrete composite beams in bending. Analysed beams are formed of back-to-back cold-formed steel channels and concrete slabs connected by demountable shear connectors. A solid concrete slab on a profiled metal sheet analysed. Also, the study investigates the influence of corrugated web between the back-to-back channels of different thicknesses. In the case of a corrugated web, the distance between the shear connectors is increased. Furthermore, different degrees of shear connection, shear connector quality, and their arrangements are considered. An analytical study is based on full and partial shear connection assumptions and non-linear bending resistance. It is shown that the steel channel thickness and degree of shear connection significantly influence the beam bending capacity as well as concrete slab configurations. Conversely, a discrete connection between steel elements has a minor effect. A comparison of the maximum obtained bending capacities in FE analyses is in good agreement with analytical approaches for full and partial shear connections.

Keywords: Cold-Formed Steel; Steel-Concrete Composite Beams; Demountable Shear Connections; Discrete and Continuous Shear Connections; Bending Resistance; Numerical Study.

1. Introduction

In recent years, cold-formed steel (CFS) sections have become popular compared to hot-rolled sections because of their benefits, such as lower price, reduced self-weight, easier on-site handling, and faster construction. Highly efficient structural forms can be composed when using built-up CFS sections in structures. Furthermore, a higher resistance of built-up sections can be achieved by using different connection types between its components. For example, the study on the bending resistance of back-to-back built-up CFS members showed that the bending resistance of steel sections depends on the type of connection [1].

Selvaraj & Madhavan [2] investigate the current design expressions of back-to-back CFS beams by numerical study. The steel beam comprises two identical sigma sections with a thickness of 1.25 mm and is connected by spot welding. The experimental results showed that the intermediate connection spacing had a negligible influence on the ultimate capacity and failure modes. The bending capacity of a similar system, back-to-back CFS channels with edge-stiffened holes, un-stiffened holes, and plain webs, was investigated by Chen et al. [3]. Because of the lack of available literature,

* Corresponding author: ivan.lukacevic@grad.unizg.hr

http://dx.doi.org/10.28991/CEJ-2023-09-10-01

5. Publications

Journal papers:

1. Lukačević, Ivan; Ungureanu, Viorel; Valčić, Anđelo; Ćurković, Ivan: **Numerical study on bending resistance of cold- formed steel back-to-back built-up elements** // *ce/papers*, **4** (2021), 2-4; 487-494 doi:10.1002/cepa.1320 (međunarodna recenzija, članak, znanstveni)
2. Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Čudina, Ivan: **Innovative Lightweight Cold-Formed Steel-Concrete Composite Floor System – LWT-FLOOR project** // IOP conference series. Materials science and engineering, 1203 (2021), 1-10 doi:10.1088/1757-899X/1203/3/032078 (međunarodna recenzija, članak, znanstveni)
3. Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Bartolac, Marko: **Lightweight Composite Floor System—Cold-Formed Steel and Concrete—LWT-FLOOR Project** // *Buildings.* **12**, (2022) no. 2: 209; https://doi.org/10.3390/buildings12020209 (međunarodna recenzija, članak, znanstveni)
4. Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Žuvelek, Vlaho: **Parametric Finite Element Analyses of Lightweight Cold-formed Steel-concrete Composite Floor Beams** // *ce/papers,* **5** (2022), 4; 836-846 doi:10.1002/cepa.1826 (međunarodna recenzija, članak, znanstveni)
5. Ćurković, Ivan; Lukačević, Ivan; Žuvelek, Vlaho; Rajić, Andrea: **Numerical Investigation of Shear Connection in Cold- formed Steel-concrete Composite Beam** // *ce/papers,* **5** (2022), 4; 847-856 doi:10.1002/cepa.1827 (međunarodna recenzija, članak, znanstveni)
6. Rajić, A.; Lukačević, I.; Skejić, D.; Ćurković, I. **Numerical Study on the Bending Resistance of Lightweight Built-Up Steel-Concrete Composite Beams** // *Appl. Sci.* **13** (2023), 7397. https://doi.org/10.3390/app13137397 (međunarodna recenzija, članak, znanstveni)
7. Rajić, A.; Lukačević, I.; Ćurković, I.; Žuvelek, V. **Performance evaluation of cold-formed steel spot weld connections** // ce/papers, 6/2023 (2023), 3-4; 1959-1964. doi: 10.1002/cepa.2627
8. Žuvelek, V.; Ćurković, I.; Lukačević, I.; Rajić, A. **Finite Element Analyses of Demountable Shear Connection in Cold-Formed Steel-Concrete Composite Beam Based on Experimental Data** // ce/papers, 6/2023 (2023), 3-4; 213-219. doi: 10.1002/cepa.2629
9. Rajić, A.; Lukačević, I.; Skejić, D.; Ungureanu, V. **Cold-formed Steel-Concrete Composite Beams with Back-to-Back Channel Sections in Bending** // Civil engineering journal (Tehran), 9 (2023), 10; 2345-2369. doi: 10.28991/CEJ-2023-09-10-01

5. Publications

Conference Papers:

1. Rajić, Andrea; Lukačević, Ivan: **Behaviour of lightweight built up cold-formed steel concrete composite beam in bending** // *10th International Conference on Business, Technology and Innovation 2021 - Conference Book of Abstract* / Hajrizi, Edmond (ur.). Pristina: UBT – Higher Education Institution, 2021. str. - (predavanje, međunarodna recenzija, cjeloviti rad (in extenso), znanstveni)
2. Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Čudina, Ivan: **Numerical analysis of lightweight cold-formed steel- concrete composite floor system** // *3rd International Conference on Lightweight Materials & Engineering Structures LIMAS – 2021 Proceedings* / Das, Purnendu (ur.). Glasgow: ASRANet Ltd, 2021. str. 20-28 (predavanje, međunarodna recenzija, cjeloviti rad (in extenso), znanstveni)
3. Žuvelek Vlaho; Ćurković Ivan: **Numeričko modeliranje posmične veze između čelika i betona kod spregnutih nosača izvedenih od hladno oblikovanih profila** // *8. Simpozij doktorskog studija građevinarstva Zbornik radova (Proceedings of the 8th Symposium on Doctoral Studies in Civil Engineering)* / Štirmer, Nina (ur.). Zagreb, 2022. str. 97-110 doi:10.5592/CO/PhDSym.2022.08 (ostalo, domaća recenzija, cjeloviti rad (in extenso), znanstveni)
4. Andrea Rajić, Ivan Lukačević: **Analiza otpornosti na savijanje LWT-FLOOR sustava** // *Osmi simpozij doktorskog studija građevinarstva*, Zagreb, Republika Hrvatska, 2022. str. 57-71 doi:10.5592/CO/PhDSym.2022 (predavanje, domaća recenzija, cjeloviti rad (in extenso), znanstveni)
5. Rajić, Andrea ; Lukačević, Ivan **Numerička analiza spregnutog sustava hladno oblikovani čelik-beton s demontažnim posmičnim spojem** // Zbornik radova devetog skupa istraživača iz područja građevinarstva i srodnih tehničkih znanosti / Krstić, Hrvoje ; Anić, Filip ; Jeleč, Mario (ur.). Osijek: Građevinski i arhitektonski fakultet Sveučilišta Josipa Jurja Strossmayera u Osijeku, 2022. str. 125-130
6. Žuvelek, Vlaho ; Ćurković, Ivan **Numeričko modeliranje ponašanja demontažne posmične veze spregnutih nosača izvedenih od hladno oblikovanog čelika i betona** // Zbornik radova devetog skupa istraživača iz područja građevinarstva i srodnih tehničkih znanosti / Krstić, Hrvoje ; Anić, Filip ; Jeleč, Mario (ur.). Osijek: Građevinski i arhitektonski fakultet Sveučilišta Josipa Jurja Strossmayera u Osijeku, 2022. str. 107-116
7. Žuvelek, Vlaho; Ćurković, Ivan; Lukačević, Ivan; Rajić, Andrea: **Numerical study of the behavior of the bolted shear connection in cold-formed steel-concrete composite beam** // *Cold-Formed Steel Research Consortium Colloquium 2022 (CFSRC Colloquium 2022)*, Baltimore, United States, 2022. ID102, 12 (predavanje, međunarodna recenzija, cjeloviti rad (in extenso), znanstveni)
8. Rajić, Andrea; Lukačević, Ivan; Ćurković, Ivan; Žuvelek, Vlaho: **Numerical study of cold-formed steel-concrete composite floor system with demountable shear connectors** // *Cold-Formed Steel Research Consortium Colloquium 2022 (CFSRC Colloquium 2022)*, Baltimore, United States, 2022. ID103, 10 (predavanje, međunarodna recenzija, cjeloviti rad (in extenso), znanstveni)
9. Lukačević, Ivan; Ungureanu, Viorel **Numerical parametric study on corrugated web built- up beams with pinned end supports** // *Cold-Formed Steel Research Consortium Colloquium 2022 (CFSRC Colloquium 2022)*, Baltimore, United States, 2022. ID59, 10 (predavanje, međunarodna recenzija, cjeloviti rad (in extenso), znanstveni)
10. Lukačević, Ivan; Rajić, Andrea; Ungureanu, Viorel; Buzatu, Raluca **A comparative life-cycle assessment of structural composite steel-concrete floor systems – A case study** // Life-Cycle of Structures and Infrastructure Systems. London: Taylor & Francis, 2023. str. 751-758 doi: https://doi.org/10.1201/9781003323020
11. Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Žuvelek, Vlaho **Bending resistance of composite steel-concrete floor system made of built-up cold-formed steel elements** // PROCEEDINGS OF THE 20th INTERNATIONAL SYMPOSIUM OF MASE. Skopje: Sveučilište sv. Ćirila i Metoda Skopje, 2023. str. 421-430
12. Lukačević, Ivan; Bartolac, Marko; Ćurković, Ivan; Rajić, Andrea; Žuvelek, Vlaho **Laboratory Tests of Lightweight Composite Floor System LWT-FLOOR** // Modern Building Materials, Structures and Techniques. Springer Nature Switzerland, 2023.

5. Publications

Conference Abstracts:

1. Lukačević, Ivan; Ćurković, Ivan; Rajić, Andrea; Čudina, Ivan: **Innovative Lightweight Cold-Formed Steel-Concrete Composite Floor System – LWT-FLOOR project** // *6th WMCAUS 2021 - 6th World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium - ABSTRACT BOOK* / Yilmaz, Işık ; Marschalko, Marian ; Drusa, Marian (ur.). Prag: World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium, 2021. str. 427-427 (predavanje, međunarodna recenzija, sažetak, znanstveni)
2. Rajić, Andrea; Lukačević, Ivan: **Behaviour of lightweight built up cold-formed steel concrete composite beam in bending** // *10th International Conference on Business, Technology and Innovation 2021 - Conference Book of Abstract* / Hajrizi, Edmond (ur.). Pristina: UBT – Higher Education Institution, 2021. str. 247-247 (predavanje, međunarodna recenzija, sažetak, znanstveni)
3. Rajić, Andrea; Lukačević, Ivan; Ćurković, Ivan; Žuvelek, Vlaho: **Innovative lightweight composite floor system – built-up cold formed steel-concrete** // Modern structures of metal and wood - Book of Abstract Odesa: Ministry of Education and Science of Ukraine; Odesa State Academy of Civil Engineering and Architecture Rzeszów; University of Technology (Poland); University of Rijeka (Croatia), 2022. str. 18-20 (predavanje, međunarodna recenzija, sažetak, znanstveni)

5. Publications

1st LWT-FLOOR Project Workshop

1st LWT-FLOOR Project WORKSHOP was organised at the University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia on 17th of December 2021.

Aims of the workshop was the presentation of the LWT-FLOOR project background, presentations and discussions about planned activities and recent results and presentation of other activities of the research group members and project advisors related to the composite and cold-formed steel structural elements. A workshop flyer with the programme is available HERE.

The recorded videos of the workshop presentations are available via the following links:

doc. dr. sc. Ivan Lukačević: Opening Session – presentation of the LWT-FLOOR project

prof. dr. sc. Daniel Viorel Ungureanu, izv. prof. dr. sc. Ioan Both: Corrugated web built-up cold-formed beams

doc. dr. sc. Ivan Lukačević: Investigations on spot welded built-up cold-formed steel beams

Andrea Rajić, mag. ing. aedif., Vlaho Žuvelek, mag. ing. aedif.: Numerical analysis of lightweight cold-formed steel-concrete composite floor system

doc. dr. sc. Marko Bartolac: Scope of activities of Structural testing laboratory at the University of Zagreb - Faculty of Civil Engineering

Andrea Rajić, mag. ing. aedif.: Behaviour of lightweight built up cold-formed steel-concrete composite beam in bending

doc. dr. sc. Ivan Lukačević: Numerical study on bending resistance of cold-formed steel back-to-back built-up elements

doc. dr. sc. Ivan Ćurković: Steel and composite steel-concrete shear panels

Anton Kralj, mag. ing. aedif., prof. dr. sc. Davor Skejić: Loadbearing capacity of LSF walls under fire exposure

doc. dr. sc. Ivan Lukačević: Closing of Workshop

Presentations from Cold-Formed Steel Research Consortium Colloquium 2022 (CFSRC Colloquium 2022)

Andrea Rajić, mag. ing. aedif.: Numerical study of cold-formed steel-concrete composite floor system with demountable shear connectors

Vlaho Žuvelek, mag. ing. aedif.: Numerical study of the behavior of the bolted shear connection in cold-formed steel-concrete composite beam

doc. dr. sc. Ivan Lukačević: Numerical parametric study on corrugated web built-up beams with pinned end supports

2nd LWT-FLOOR Project Workshop

2nd LWT-FLOOR Project WORKSHOP was organised at the University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia on 15th of December 2022.

The workshop presentations are available via the following links:

doc. dr. sc. **Ivan Lukačević**: Opening Session presentation of the LWT FLOOR project and overview of the realised activities

doc. dr. sc. **Ivan Lukačević**, doc. dr. sc. **Ivan Ćurković**, Andrea Rajić, mag. ing. aedif., Vlaho Žuvelek, mag. ing. aedif.: Design and fabrication of material, spot welded and push-out specimens

doc. dr. sc. Ivan Lukačević, doc. dr. sc. Ivan Ćurković, izv. prof. dr. sc. Marko Bartolac, **Andrea Rajić**, mag. ing. aedif., Vlaho Žuvelek, mag. ing. aedif.: Implementation and analyses of laboratory tests-base material & spot welds

doc. dr. sc. Ivan Ćurković, doc. dr. sc. Ivan Lukačević, izv. prof. dr. sc. Marko Bartolac, **Vlaho Žuvelek**, mag. ing. aedif., Andrea Rajić, mag. ing. aedif.: Implementation and analysis of the push-out test on shear connectors in composite beams cold-formed steel profiles-concrete

doc. dr. sc. Ivan Lukačević, doc. dr. sc. Ivan Ćurković, **Andrea Rajić**, mag. ing. aedif., Vlaho Žuvelek, mag. ing. aedif.: Parametric finite element analyses of lightweight cold-formed steel-concrete composite floor beams

doc. dr. sc. **Ivan Ćurković**, doc. dr. sc. Ivan Lukačević, Vlaho Žuvelek, mag. ing. aedif., Andrea Rajić, mag. ing. aedif.: Numerical investigation of shear connection in cold-formed steel-concrete composite beam

Andrea Rajić, mag. ing. aedif., doc. dr. sc. Ivan Lukačević, doc. dr. sc. Ivan Ćurković, Vlaho Žuvelek, mag. ing. aedif.: Numerical study of cold-formed steel-concrete composite floor system with demountable shear connectors

Vlaho Žuvelek, mag. ing. aedif., doc. dr. sc. Ivan Ćurković, Andrea Rajić, mag. ing. aedif., doc. dr. sc. Ivan Lukačević: Numerical study of the behaviour of the bolted shear connection in cold-formed steel-concrete composite beams

doc. dr. sc. **Ivan Lukačević**, prof. dr. sc. Daniel Viorel Ungureanu: Numerical parametric study on corrugated web built-up beams with pinned end supports

6. Equipment

- Inverter Spot-welding machine

6. Equipment

- Data Aquisition System

6. Equipment

- 2 PCs

6. Equipment

- Force measuring sensors

- Linear Variable Differential Transformers

6. Equipment

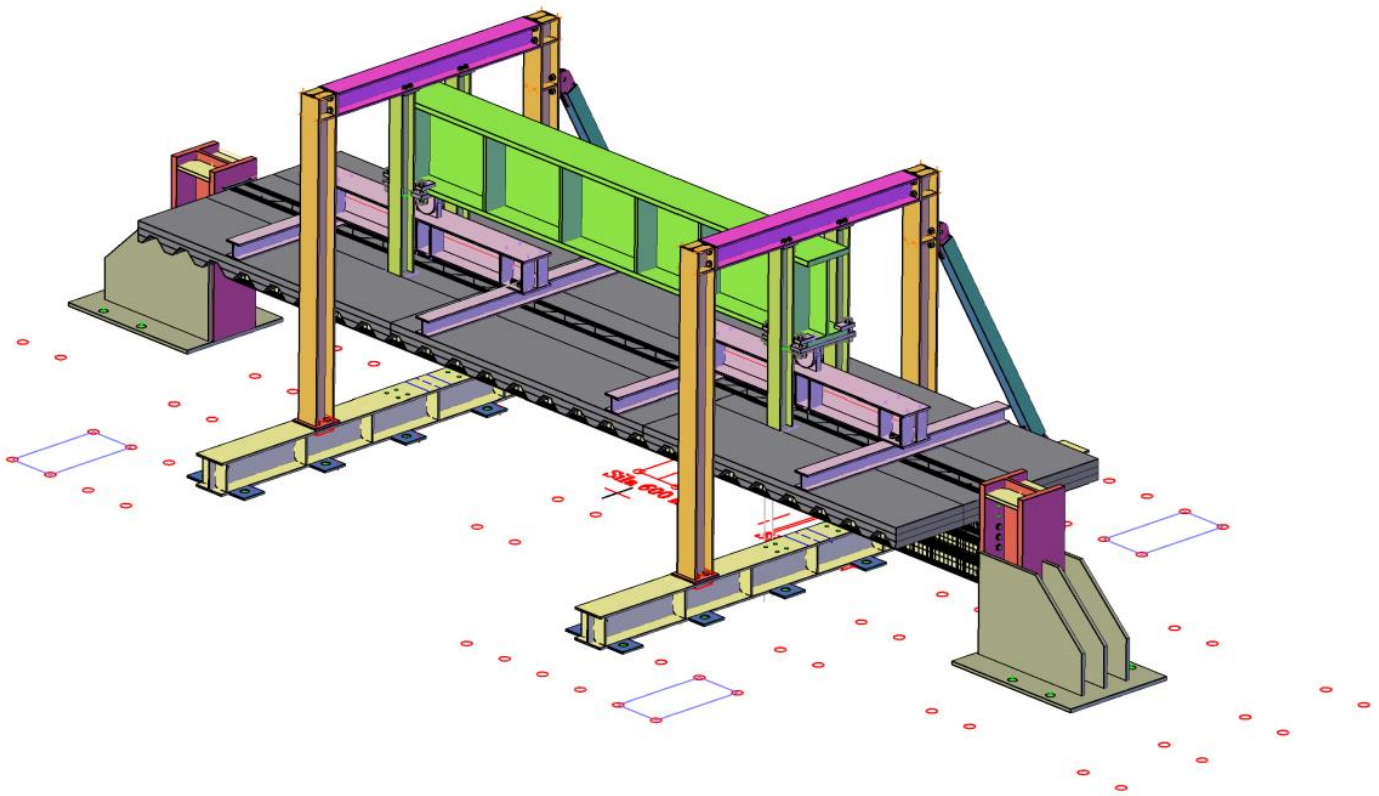
- Camera

6. Equipment

- 3D scanner

6. Equipment

- Test rig for Zwick&Roell servo hidraulic machine

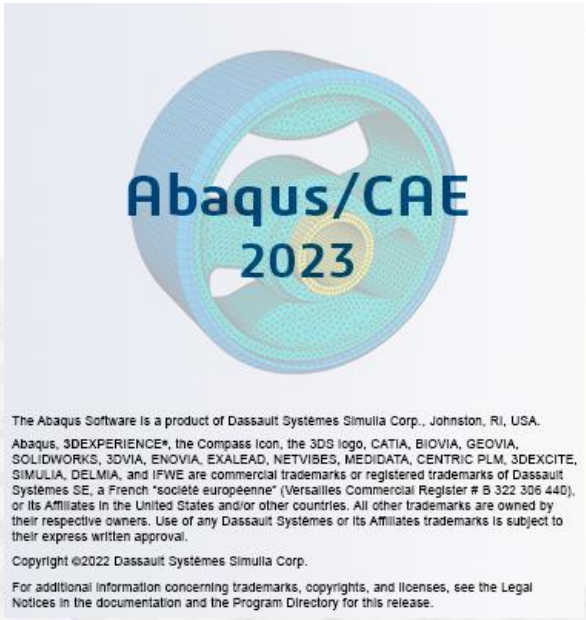


6. Equipment

- Workstation Fujitsu CELSIUS R970B

7. Software

- Abaqus



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Opening Session - presentation of the LWT FLOOR project and overview of the realised activities - 3rd project year

Ivan Lukačević