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HYBRIDTIM, DESIGN AND CONSTRUCTION OF ENVIRONMENTAL HIGH PERFORMANCE HYBRID ENGINEERED TIMBER BUILDINGS

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ABSTRACT: Immediate actions need to be taken to reach the sustainability target for 2050 of the European Commission for reduction of greenhouse gas emissions and net zero carbon (CO_2) emissions. Architects and engineering companies have already started designing hybrid timber buildings. In order to satisfy the needs of the labor market, it is necessary to prepare students with innovative applied skills in the area of design, construction and onsite construction management of hybrid timber buildings. The HybridTim project promotes sustainable, environmentally friendly design and construction of hybrid timber buildings.

KEYWORDS: Multi-story buildings, hybrid structures, study module, Erasmus+ program

1 INTRODUCTION

To educate a new generation of students, it is necessary to develop and integrate an innovative multi-disciplinary BSc/BA study module. Main target groups are higher education institutions (HEIs), in particular teachers/trainers and BSc/BA students.
Project HybridTim [1] aims to fulfil the future demands in higher education of students in design and construction of high environmental performance hybrid engineered timber buildings by trans-disciplinary innovative student-centered learning approaches. The objectives are:
1) To develop and deliver new trans-disciplinary module on design and construction of engineered hybrid timber buildings, which meets the needs of the HEIs and labor market representatives.
2) To improve competencies of students and teachers in problem solving and teamwork, innovative thinking, motivation, awareness of cross-professional project input and project management by using project-based learning, learning by doing and blended learning approaches.
3) To educate all participants (students, teachers, entrepreneurs) in the field of the engineered hybrid timber construction.
4) To ensure open awareness of the project results to local, national, European Union (EU) level and international target groups. The project is implemented by five higher education institutions from Denmark (Via University College, VIA UC), Lithuania (Vilniaus Gedimino Technikos Universitetas, VGTU), Spain (Universitat Politècnica de Catalunya, UPC), Latvia (Rigas Tehniska Universitate, RTU) and Austria (Technische Universitaet Wien, TU WIEN), assisted by Study and Consulting Center in Lithuania and Spanish association Gremi Fusta i Moble.

The aim is the development of a module of 9 ECTS (**E**uropean **C**redit **T**ransfer and Accumulation **S**ystem) for bachelor. The module will be dedicated to architectural design, architectural technology, construction technology, civil engineering, real estate management and related BSc/BA specializations. Working on one project in an intensive course seems to be the most effective way to transfer the knowledge to students. A module of 9 ECTS in one semester is recommended. Each HEI will adapt this module to local requirements. It means that also 3 times 3 ECTS courses in 3 following semesters are possible and optional. In this case it would be necessary to get sure, that the students are going through all courses.

2 MODULE PHASES

The new module will be tested during the project in three intensive learning/teaching courses. The first part of the module was held in Vienna, Austria in September 2021. The second part took place in Spain (September 2022) and the third one will take place in Latvia (April 2023). International building and construction project phases, which are used in most EU countries, have been adapted in the HybridTim project as a main template, namely brief phase, outline proposal, scheme design, detail 1 and detail 2 phases.

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In total, 75 BSc/BA students will be educated. Students will gain innovative trans-disciplinary knowledge in hybrid timber construction; using innovative learning approaches they will develop their research, teamwork, communication, and cooperation, creative thinking, problem-solving skills required in modern daily work environment. Stakeholders whose activities are related to construction and, in particular, timber construction, e.g. associations and private enterprises, will be involved in development of new module, therefore they will have an opportunity to share their expertise and include the topics that will help to acquire competences, required in labor market. In this way collaboration between academic and business sector will be strengthened.

3 FIRST MODULE IN VIENNA

The first module was held successfully in Vienna in September 2021, 25 students and a dozen lecturers from 5 participating universities took part.
The task was the development of a multi-story hybrid timber building for a given property in the area of "aspern Seestadt" in Vienna's fast-growing 22nd district in the north-east of the city - one of Europe's largest urban development projects. (Figure 1, 2, 3).

Figure 1: *Location of "Seestadt" inside Vienna (@google Earth)*

Figure 2: *Location of building site in "Seestadt" (@google Earth)*

Figure 3: *building site*

The predefined task can be briefly summarized as follows:
"The developer wants to build a 10-story high multi-story house where timber is the dominating material. The plinth level 1-3 (first 3 stories) must be built with concrete as load bearing material. On top of this plinth a terrace must be created/designed, where there is common access for the inhabitants of the building, and also public access for people from the area. From level 1-3 the building must be designed as business-related functions (shops, restaurants, offices etc.) included common access areas is 985m² gross area in 3 floors.
From Level 4-6, there must be designed 8 apartments of different sizes where the apartments included common access areas is 810m² gross area. The rest of the roof for level 3 must be arranged as green area for common use. From Level 7-10, there must be designed 4 apartments where the apartments included common access areas is 545m² gross area. The rest of the roof for level 6 must be arranged as green area for common use. (Figures 4 and 5).
Generally, the project must not contribute to adverse effects on the surrounding environment. The aim should be for the project to contribute to the improvement of the environment in the area, and to create an attractive building that simultaneously affects users for environmentally responsible behavior."

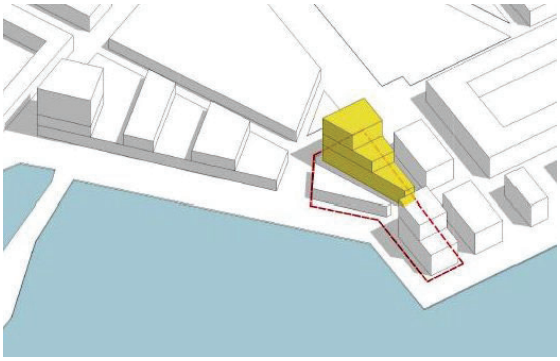

Figure 4: *Predefined building volume*

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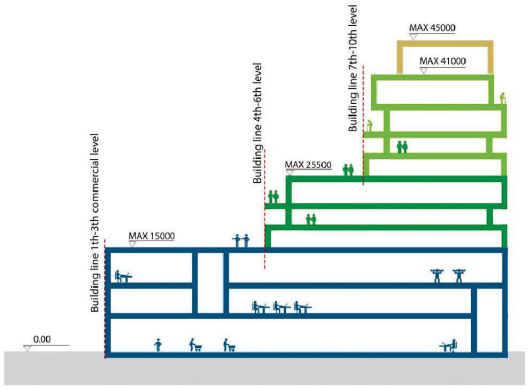

Figure 5: *Predefined section of the building*

Some face-to-face and online lectures have been held in the morning of the first week in the historical building of TU WIEN (Figure 6). The topics were about teaching methodology **p**roblem-**b**ased **l**earning (PBL), Architectural concepts, technical aspects of timber buildings, building management, building systems, statics and dynamics, sustainability, façades and building physics.

Figure 6: *Lectures*

In the afternoon, student groups developed and presented their project ideas (Figure 7).

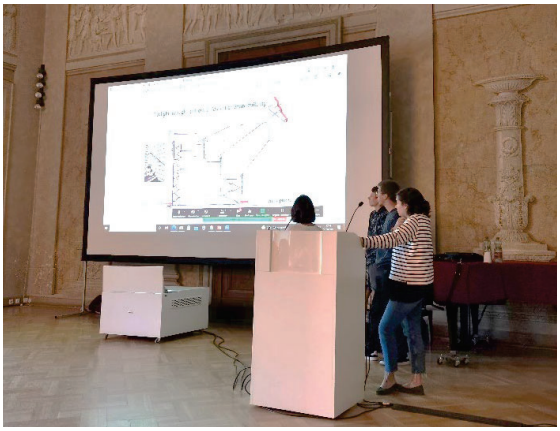

Figure 7: *Student presentation*

In the second week, site visits (Figure 8) and the workshop next to the project property were on the agenda (Figure 9).

Figure 8: *Site visit*

Figure 9: *Workshop*

Five projects were presented at the end.
In the following, one figure per group shall represent the results. The names of the group members are indicated.

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Figure 10: *Image by Javier Arés, Christian Regelmann, Reinis Zars, Kipras Dankevicius, Henrikke Lockert-Hansen*

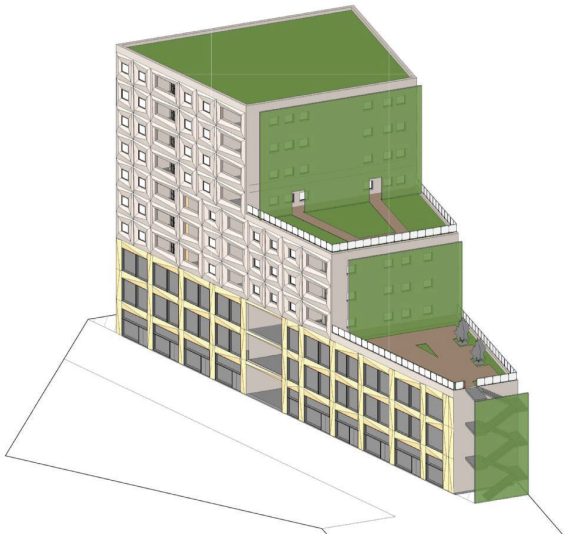

Figure 11: *Image by Asger Overgaard Ottesen, Cesar Pena Ostos, Oksana Generalova, Anna Haijima*

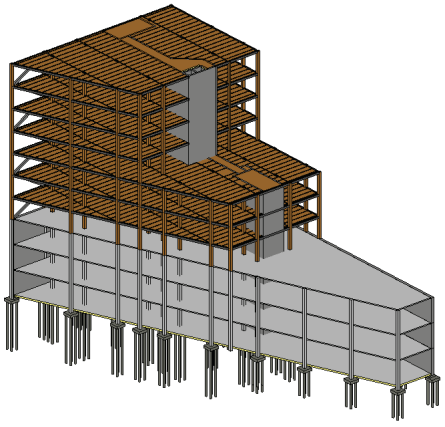

Figure 12: *Image by Aija Pusepa, Theis Trolle, Nada Ahmed, Oscar Galera Lara, Azuolas Skucas*

Figure 13: *Image by María Fernanda Zehl Pardo Valle, Artūrs Dzenis, Karagozaiym Turganbek, Darijus Jankauskas, Thomas Bonde Knudsen*

Figure 14: *Image by Lluc Ruiz Esteve, Peteris Petersons, Søren Gustav Lindstrøm Gleerup, Romualdas Jurgilevicius, Sebastian Eckert*

After the final presentation, the module was finished. (Figure 15)

Figure 15: *Closing day*

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4 SECOND MODULE IN BARCELONA

The second module was held in the Barcelona School of Building Construction of the UPC, during two weeks in September 2022. The number of participants was similar to the Vienna course, 25 students from the 5 participant universities and around a dozen lecturers. This intensive course had the aim to cover the scheme design phase of a multi-story hybrid timber building. In order to have enough information about the outline proposal phase it was selected an existing social housing complex located in Barcelona made with reinforced concrete structure and the students had the task to implement a structural system that maximizes the use of timber. The architects of the original project provided us with information and drawings that the students received as starting working material. Figure 16 shows an image of the existing building.

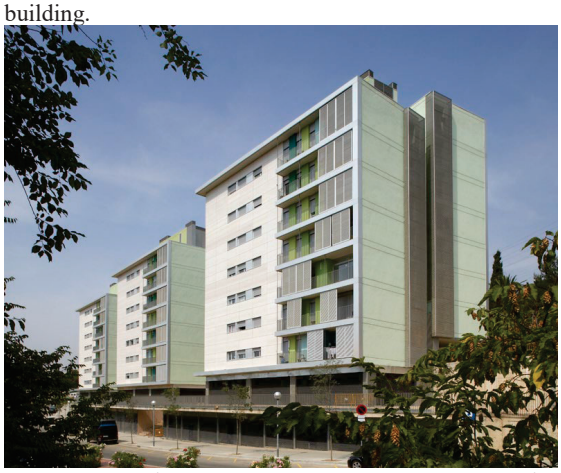

Figure 16: *Social Housing in Trinitat Nova. Source: Ruisánchez Arquitectes*

In the same way as in Vienna, the assignment for the students was contextualized with the area in which they were going to develop the project. In the case of Barcelona, the location was the neighborhood of Trinitat Nova in the district of Nou Barris (figure 17). This district located in the outskirts of Barcelona has one of the lowest household incomes of Barcelona and it is part of a program of urban regeneration from the Barcelona council. Among other actions the council has promoted social housing buildings, recovery of green spaces and increase of public services.

Figure 17: *Map of the districts of Barcelona*

The students were divided in five groups with participants from each university in each group. The task that they had to solve was as follows:

On 2005 the council of Barcelona set a public competition to build 189 units of social housing. The selected project consisted of a main building of ground floor plus 7 floors with a structure of reinforced concrete. The experience has been successful and the residents are happy with the outcome of the project. Now the city council wants to build a new social housing in the neighborhood, but they want to minimize the environmental impact of the building. Therefore, the use of timber structures is highly encouraged. On the other hand, for this project the maximum height restrictions allow to increase the number of floors to ground floor plus 9 floors.

Your studio has decided to modify the project of 2005 and adapt it to the new requirements. Therefore, your work team has to:

- *Implement a timber structural system.*
- *Define a ground plan at 1:50 to define the modularity and the integration of the structural elements in the spatial distribution.*
- *Pre-dimension of the constructive elements. Give one example of the structure and the façade.*
- *Description of the horizontal and vertical efforts and deformations.*
- *Description of the strategies to comply with the fire resistance requirements.*
- *Description of the joint system.*
- *Proposal to guarantee acoustic insulation and to reduce acoustic impact transmittance.*
- *Examples of constructive façade details.*
- *CO_2 footprint of the structural system.*
- *Compliance with the thermal transmittance of the envelope.*

As it can be seen in figure 18, during the course the students received some lectures related with relevant topics to develop the assignment, such as hybrid timber systems, statics and dynamics of timber constructions, acoustics and fire protection strategies. There were also organized technical visits to timber buildings in Barcelona city, including the Nou Barris area (figure 19) and to some timber constructions outside from Barcelona (figure 20).

Figure 18: *One of the lectures of the course*

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Figure 19: *Technical visit to a building site near Nou Barris*

Figure 20: *Visit to a Passive House timber building*

The working groups also had time and space to work in their proposal, which they presented on the last day of the course. Figures 21 to 25 display an example of the outputs obtained by each group.

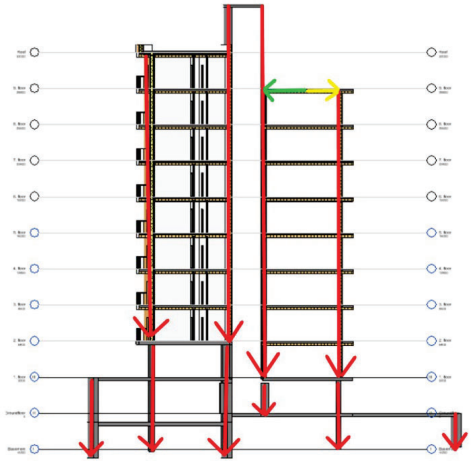

Figure 21: *Description of the effect of vertical and horizontal loads. Image by: Aija Pusepa, Leva Gendvilate, Rasmus Fredskilde, Erika Viviana Beltrat*

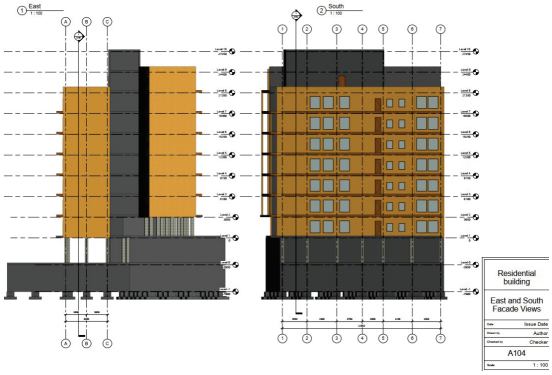

Figure 22: *View of east and south façade. Image by: Hawks Turtles: Emanuel Balaj, Gabriele Remeikaite, Artus Dzenis*

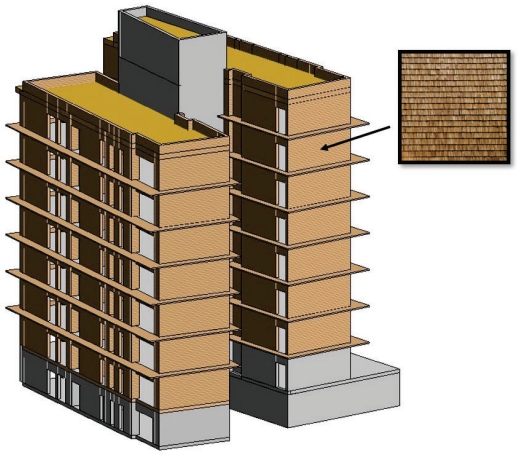

Figure 23: *Proposal of the façade timber cladding. Image by: Christian Regelmann, Lykke Skjerbaek, Ruta Gricenaite, Reinis Zars, Anna Haijima.*

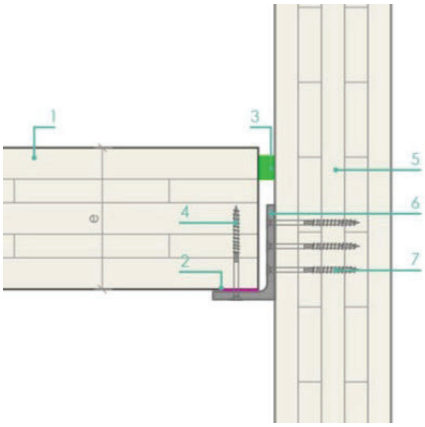

Figure 24: *Detail of a timber-steel joint. Image by Lars Ravn, Mantas Petronis, Usama Malik, Peteris Petersons, Martina Dolic*

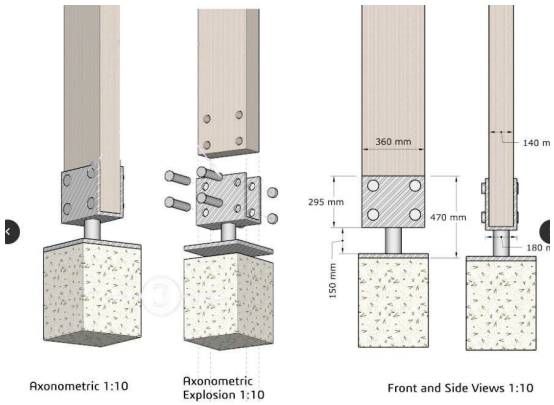

Figure 25: *Detail of the connections of the timber pillars with the concrete floor. Image by Danie HØjlund, Paulius Gadeikis, Andrejs Kavlaks, Karagozaiym Turganbek, MªFernanda Zehl*

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5 CONCLUSION AND OUTLOOK

The third module will take place in Riga in April 2023.
In the near future timber buildings will form a much bigger part of the European and international built environment. The future sustainable hybrid timber buildings will be designed and constructed with sustainable-engineered timber components.
The project aims are to fulfil the future demands in higher education of students in design and construction of high environmental high-performance hybrid engineered timber buildings by trans-disciplinary innovative student - centered learning approaches. Along Europe there is still a significant difference in the level of development of timber construction of different countries. This project has allowed the participant institutions to share experiences that could be later implemented in different bachelor degrees at a local level. Participation of professional associations help to increase the collaboration with stakeholders of the building sector

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REFERENCES

[1] HybridTim, Design and Construction of Environmental High Performance Hybrid Engineered Timber Buildings; https://hybridtim.eu/ (accessed March 5, 2023)

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