Brussels, 25 May 2021

COST 079/21

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action “Holistic design of taller timber buildings” (HELEN) CA20139

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Holistic design of taller timber buildings approved by the Committee of Senior Officials through written procedure on 25 May 2021.

Funded by the Horizon 2020 Framework Programme of the European Union

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA20139
HOLISTIC DESIGN OF TALLER TIMBER BUILDINGS (HELEN)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to address taller multi-storey timber buildings from a collaborative and interdisciplinary perspective, considering static, dynamic, fire, acoustic, human health and other aspects in parallel and not in isolation. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

TECHNICAL ANNEX

OVERVIEW

Summary

With the worldwide construction sector being responsible for one third of carbon dioxide emissions, as well as forty percent of the world's energy use and waste production, a shift to sustainable and renewable construction techniques is crucial. Engineered timber, champion of the sustainable construction materials, has evolved to a stage that enables the construction of not only family housing but also taller buildings commonly built from concrete or steel. Unfortunately, designing taller buildings made from timber is more demanding than their concrete and steel counterparts. Whereas different designers (architects, structural, fire, acoustic engineers etc.) of concrete buildings can work almost independently, the design of taller timber buildings should be performed with intensive collaboration among the design team members. I.e. the acoustic insulation principles currently used in timber buildings are completely contrary to the design demands originating from wind or earthquake loading. This is just one case, unfortunately the list of design collisions is very long. It is therefore crucial to address taller multi-storey timber buildings from a collaborative and interdisciplinary perspective, considering static, dynamic, fire, acoustic, human health and other aspects in parallel and not in isolation. Only through interdisciplinary analysis and interaction can a set of holistic design guidelines be developed that will enable safe construction of taller timber buildings, as well as respect human wellbeing demands. This Action aims to achieve that through intense interdisciplinary work and interaction between different design backgrounds, as well as between academic and design professionals.

Areas of Expertise Relevant for the Action	Keywords
● Civil engineering: Civil engineering ● Civil engineering: Architecture engineering ● Civil engineering: Construction engineering ● Civil engineering: Sustainable engineering, adaptation to long-term environmental changes ● Materials engineering: Wood Technology	● Tall buildings ● Mid-rise buildings ● Timber ● Building design ● Human wellbeing

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

<u>Research Coordination</u>

● Produce and update state-of-the-art in taller multi-storey timber building design fields: 1) Design for adoption, reuse and repair; 2) Deformations and vibrations; 3) Accidental load situations and 4) Sustainability and durability.

● Coordinate, compare and bring together results of related research with the aim of defining optimized holistic approaches to improve the performance of taller timber buildings and widen their use across the EU and rest of the world.

● Collect case studies that show flagship examples describing taller timber building design.

● Identify and address regulatory, governance, financial and legal drivers and barriers for a wider implementation and use of taller timber buildings.

● Suggest new design approaches, processes and technologies that can build and improve upon existing best practices and ensure optimal holistic design of taller timber buildings.

● Identify and contact the most relevant experimental groups, international partners and industrial partners whose participation would strengthen the network.

● Establish an open-access website that will allow the general public to browse through the Action's activities and access the articles and data produced by the research groups.
● Establish a dissemination plan (organization of thematic workshops, participation at international conferences, scientific publications and other publications in electronic and printed media) and a dissemination board that will coordinate outreach activities (combine different dissemination strategies such as scientific publications, presentation to stakeholders and policymakers).
● Establish and reinforce a worldwide multidisciplinary network of skilled professionals able to face the complexity of taller timber building design, combine knowledge among different actors, and identify common issues and problems in order to find suitable applications in various multidisciplinary fields and develop new holistic taller timber building design guidelines.
● Promote the development of a joint research roadmap in order to increase the efficiency and efficacy of the innovation process and, therefore, have a direct impact on the development and implementation of new technologies, processes, methodologies and products for taller timber buildings.

Capacity Building
● Connect with international bodies and associations, such as the Wood Rise Alliance and WCTE (World Conference of timber Engineering) conference participants dealing with the topic of taller timber buildings, hence ensuring the visibility of the HELEN COST Action at meetings and conferences.
● Contribute to human resources training in new technologies on taller timber buildings within the international framework to create an open network of knowledge and professionals with differentiated skills, with particular attention to Inclusiveness Target Countries (ITCs) and Early Career Investigators (ECIs) and with an emphasis on gender equality.
● Organise meetings for Early Career Investigators (ECIs) and PhD students to acquire transferable skills such as grant writing, communication, and time-management as well as encouragement of direct collaboration among ECIs.
● Foster frequent exchanges and short-term scientific stays of research group members from ECIs in top European research centres to help increase their visibility and capacity.
● Give visibility and responsibility to PhD students and postdocs, particularly women, by funding their attendance at conferences through which they promote their Action-related work.
● Accelerate knowledge transfer from fundamental research to industrial application and increase the success rate in future proposals by addressing taller timber building market barriers, identifying suitable pilots, and connecting with existing R&D projects dealing with the topic of multi-storey timber design at both national and international levels.
● Promote interdisciplinary work streams using the synergies between the participating groups for an efficient exchange of knowledge by taking advantage of different COST tools.
● Act as a stakeholder platform to identify the needs and requirements from different fields and points of view through a bottom-up approach (from society, through industry, businesses, clusters, researchers and academia, to policy makers).
● Develop novel approaches by combining different technologies through interdisciplinary and transdisciplinary collaboration of different fields and widen the field of knowledge within each working group by incorporating a joint research approach.
● Increase the soundness and visibility of the Action’s outputs by publishing joint scientific and technical articles, inviting industry to the Action’s workshops, updating the website and organizing a showroom at one of the major events in the sustainable environment field as a final activity of the Action.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1 Soundness of the Challenge

1.1.1 DESCRIPTION OF THE STATE-OF-THE-ART

With the worldwide construction sector being responsible for one third of carbon dioxide emissions, as well as forty percent of the world's energy use and waste production, a shift to sustainable and renewable construction techniques is crucial. Engineered timber, champion of the sustainable construction materials, has evolved to a stage that enables the construction of not only family housing but also taller buildings commonly built from concrete or steel. The number and height of multi-storey timber buildings substantially increased over the past decade [1, 2]. The envelope is being pushed every year, and the current record (as of 2020) for a purely timber multi-storey apartment building stands at 18 storeys (85 m), while for a timber-concrete hybrid it stands at 24 storeys (84 m). Hence, timber buildings up to 10 storeys are now considered as midrise. Due to a healthier environment and the better living quality they offer, contemporary multi-storey timber buildings are being recognised as a long-term sustainable construction solution, especially in urban areas where they present an environmentally friendly alternative to concrete and steel buildings [3]. In the figure (Figure 1) below is shown a set of four midrise timber buildings built in the last decades, the current tallest purely timber building and the tallest concept for a timber building expected to be built by 2041.

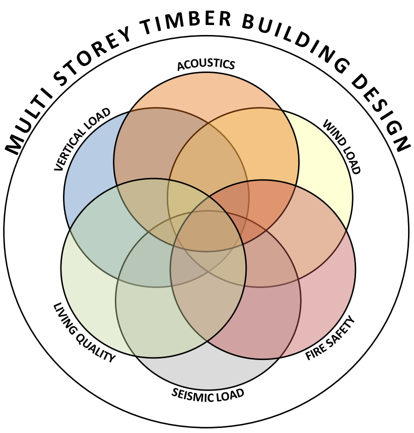
Figure 1: From left to right, Murray Grove London (eight storeys, 2008); Via Cenni Milan (eight storeys, 2013); Forte building Melbourne (nine storeys, 2013); Carbon 12 Portland (eight storeys, 2018); Mjøstårnet Brumunddal (18 storeys, 2018); W350 Project Tokyo (70 storeys, 2041 expected).

In essence, the process of designing taller timber buildings currently does not differ from designing any other buildings. Architects come up with the concept, followed by different engineering fields designing their part of the project. The structural engineers take care of the dimensioning of building elements and connections, mechanical engineers design the heating, ventilation and plumbing installations, fire engineers prescribe the fire protection measures and acousticians help architects choose the correct building component setups to reduce sound transmission. However, the design so far has always been made by highly specialised engineering teams that were well aware of the unique demands and challenges that multi-storey timber buildings bring to the table. For example, the eight-storey Carbon 12 building Portland, Oregon, USA, was planned, designed and built for four years, which is basically double compared to the time a concrete building would demand. And that was 10 years after a similarly tall building was erected in London, with certain knowledge on such timber buildings already available. Despite the several midrise and a few much taller timber buildings already built, the knowledge level on taller timber buildings is still far from its concrete and steel counterparts. Additionally, there are also a lot more challenges to be tackled with taller timber buildings [4]. Research in the field of timber engineering in the last fifteen years was quite intense. This knowledge is now slowly being transferred into design codes and handbooks. The North American codes are being updated faster compared to

Europe. The US 2021 International Building Code will allow buildings up to 18 storeys tall. The European building directives differ between countries, and the modified general structural design code (Eurocode) will not be in use until about 2025. However, despite efforts, practically all the worldwide research performed in the field of multi-storey timber buildings was performed partially with intense focus on individual fields (connections, vibrations, acoustics, fire, durability [5-9]) and not considered from a wider perspective, namely in a holistic manner. Unfortunately, a well-integrated design is absolutely crucial for designing taller timber buildings. This brings us to the main challenge of this Action.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The HELEN COST Action will change the paradigm of building construction research, shifting R&D from isolated topics to an integrated interdisciplinary approach, which is critically necessary to safely design and build as well as correctly maintain and recycle taller timber buildings. Namely, designing taller buildings made from timber is much more demanding than their concrete and steel counterparts. There are several reasons why: less general experience with them; codes for timber buildings are not as developed as they are for concrete or steel [10, 11]; and less suitable literature is available for practicing designers. However, a key difference is the design complexity of timber buildings due to basic material properties. Whereas different designers (architects and structural, fire and acoustic engineers) of concrete buildings can work almost independently, the design of taller timber buildings should be performed with intensive collaboration among the design team members [12]. Otherwise, serious conflicts can arise (Figure 2) that effect both the load resisting and serviceability criteria of a building. To mention just one of many examples, the acoustic insulation principles currently used in timber buildings are completely contrary to the design demands originating from wind or earthquake loads. The acoustic demands decouple elements in order to limit the transfer of noise, however earthquake & wind demands tie them stiffly together to resist lateral loading. Since generally proven solutions for such conflicts in design are not available in code, it is usually up to the design teams – given they have appropriate knowledge and experience – to figure out solutions that can at least partially satisfy all parties. Another example is the wind serviceability design where a higher mass is needed to reduce building vibrations [13]. In some cases, additional mass is consequently being intentionally added to the structure. However, that mass is also potentially increasing the seismic forces. Collisions also arise between the desire to keep timber visible for human well-being and fulfil fire protection as well as acoustic demands [4]. The list goes on, and it gets even more challenging considering all phases a building goes through: design, construction, usage and, finally, demolition and recycling, which is an important part of the way sustainable buildings need to be designed for the future [14].



INTERACTIONS + positive - negative N neutral	VERTICAL LOAD	WIND LOAD	SEISMIC LOAD	FIRE SAFETY	ACOUSTICS	LIVING QUALITY
VERTICAL LOAD		+	-	-	+	N
WIND LOAD	+		+	N	-	N
SEISMIC LOAD	-	+		N	-	N
FIRE SAFETY	-	N	N		+	-
ACOUSTICS	+	-	-	+		-
LIVING QUALITY	N	N	N	-	-	

Figure 2: Interaction of a few different building design fields and their inherent collisions, either positive or negative, that need to be resolved for multi-storey taller timber buildings.

With midrise timber buildings now becoming more common, there is an honest concern that inexperienced designers, not aware of the specifics of timber buildings, may start to design projects beyond their abilities [15, 16]. Counting purely on design codes (i.e. Eurocodes) is not sufficient as the code information and offered solutions only partly address the full range of concerns for timber buildings. Therefore, it is crucial to address taller multi-storey timber buildings from a collaborative and interdisciplinary perspective, considering static, dynamic, fire, acoustic, human health and other aspects in parallel and not in isolation. Only through interdisciplinary analysis and interaction can a set of holistic design guidelines be developed that will enable safe construction of taller timber buildings that respect human well-being demands. However, to further optimise design and increase the use of timber in the construction sector, we should think even broader and assess building creation from conceptual design, to construction factory and construction site organisational logistics, to building decomposition and recycling. Hence, we can also extend a building's lifetime, optimise its production and enable efficient circular economy chains in the building sector. The HELEN COST Action aims to achieve these goals through intense interdisciplinary work and interaction between different engineering design specialties as well as academic and design professionals. Social and economic aspects of the building sector will also be taken into consideration though social life cycle assessment. In the scope of the European Green Deal and the new emission targets set by the European Commission (55 percent reduction by 2030 and carbon neutrality by 2050 [17]), it is imperative that the building sector changes dramatically. Increased use of timber in construction forms a cornerstone of that transition. To achieve a sufficient share of timber buildings, it is necessary to use timber not only for family houses but also for taller multi-storey buildings that make up a major part of the global construction sector. Timber building design codes are still in development, and a substantial part of building design legislation is subject to national regulation that is uncorrelated to timber building demands. Therefore, there is a great need for pan-national design guidelines, founded on holistic assessment of timber buildings, that provide integrated design principles. Documents available today give only partial information and do not consider the number of possible issues and design collisions originating from different building design fields. To increase the taller multi-storey timber building share, more architects and engineers designing them are needed. However, to prevent unnecessary drawbacks originating from poor design, it is needed to provide design teams with safe and proven principles assessed by an interdisciplinary and international team of experts. The HELEN COST Action strives for such principles with its interdisciplinary consortium of architects, engineers, academics and experienced practitioners. This consortium will combine their efforts and knowledge under the COST umbrella to assess, review, redevelop and disseminate the correct principles for taller timber building construction, which will enable the EU to achieve its vision of a sustainable, carbon-neutral continent.

1.2 Progress beyond the state-of-the-art

1.2.1 APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE-OF-THE-ART

The very essence and key to a successful HELEN COST Action will be intense interdisciplinary work with in-depth discussions and debate over a series of hypothetical and real case studies, followed by focused research work. Contrary to common building research work done in the past, where individual topics were assessed in depth by specialised teams working on isolated topics (i.e. just timber connections or just vibration of floor plates), research within the Action will be intensely collaborative and integrated. Good communication will be the starting point of all new development as numerous design collisions will first have to be systematically identified and discussed amongst wider groups of individuals from different backgrounds. These professionals will assess the existing practice over moderated discussions and establish a series of specific research aims. Some issues may be tackled and resolved merely over a debate. However, many will demand more in-depth work involving broader and intense collaboration. In the end, the HELEN COST Action will enable creation of holistic design principles for taller timber buildings that will improve the way such buildings will be designed in the future. The HELEN COST Action will ensure proper knowledge transfer to building designers, provide correct design principles and revised details and, in term, establish a safer transition of the building sector towards sustainable taller timber buildings. In order to fulfil HELEN COST Action goals, the Action will organise target groups consisting of academic and professional experts. The Action will set up a forum-like live and virtual environment to enable fruitful yet organised discussion on critical topics facing taller timber buildings. The Action will provide solutions to these challenges through the reassessed use of existing solutions and development of new ones.

1.2.2 OBJECTIVES

1.2.2.1 Research Coordination Objectives

The main objective of the HELEN COST Action is to foster international interest and effort in developing a shared understanding and deriving common guidelines for the **H**olistic d**E**sign of tal**L**er timb**E**r buildi**N**gs. The synergistic HELEN network will be formed by a large group of experts from a wide field of the built environment sector, where researchers and industrial partners will exchange knowledge and skills that have historically been isolated to individual research fields. This will be carried out through the sharing of technical and scientific skills from the different and diverse research profiles within the network as well as their research facilities. The possibility to organise workshops and think-tank meetings will aid connection and communication not just between academic and industrial partners but also, importantly, national legislation authorities and the general public, thereby bridging the gap between fundamental discoveries, application to real world problems, national regulations and local community uptake. Cooperation within this network will allow for coordinated research efforts and achievement of the following Research Coordination Objectives:

- Produce and update state-of-the-art in taller multi-storey timber building design fields: 1) Design for adoption, reuse and repair; 2) Deformations and vibrations; 3) Accidental load situations and 4) Sustainability and durability. This will include the applicability and state of development for each approach, settling the basis for further improvements and their introduction in real constructions.
- Coordinate, compare and bring together results of related research with the aim of defining optimized holistic approaches to improve the performance of taller timber buildings and widen their use across the EU and rest of the world.
- Collect case studies that show flagship examples describing taller timber building design.
- Identify and address regulatory, governance, financial and legal drivers and barriers for a wider implementation and use of taller timber buildings.
- Suggest new design approaches, processes and technologies that can build and improve upon existing best practices and finally presented in the design guidelines suggesting the optimal holistic design of taller timber buildings.
- Foster the transfer of knowledge among different actors in order to find suitable applications in various multidisciplinary fields (e.g. vibrations of buildings, material response and influence).
- Establish and implement a dissemination plan including the organization of thematic workshops, participation at international conferences, scientific publications and other publications in electronic and printed media.
- Establish an exploitation board to identify and contact the most relevant experimental groups, international partners and industrial partners whose participation would strengthen the network. Sandpit meetings will be organized to identify common areas and goals of interest and establish the pathways through which these goals can be reached.

- Establish an open-access website that will allow the general public to browse through the Action's activities and access the articles and data produced by the research groups.
- Establish a dissemination board that will coordinate outreach activities, combine different dissemination strategies such as scientific publications, presentation to stakeholders and policymakers.
- Establish and reinforce a worldwide network of skilled professionals (architects, engineers, constructors, urban planners, academics, sustainability practitioners) able to face the complexity of taller timber building design.
- Serve as a hub to combine existing knowledge and identify common issues and problems in order to develop new holistic taller timber building design guidelines.
- Promote the development of a joint research roadmap in order to increase the efficiency and efficacy of the innovation process and, therefore, have a direct impact on the development and implementation of new technologies, processes, methodologies and products for taller timber buildings.

1.2.2.2 Capacity-building Objectives

The HELEN COST Action brings together stakeholders from multidisciplinary backgrounds: industry, SMEs, academia, research institutes, governmental organisations and NGOs from Europe and other continents. Links with representatives from outside Europe, namely the United States, Canada, Australia and China, by means of knowledge transfer, will be used to further increase the strength and international competitiveness of European stakeholders in the international markets concerned. Fostering different areas of expertise will lead to a strong synergistic and complementary network that builds on national, international and trans-continental collaboration. The Action's challenge requires combining knowledge from several fields. Only with collaborative interdisciplinary work will the sufficient know-how and experience reach the critical mass necessary to properly address the design, technical, environmental and socio-economic issues of multi-storey taller timber buildings. The HELEN COST Action will build and coordinate efforts to address the challenge by the following capacity building objectives:

- Connect with international bodies and associations, such as the Wood Rise Alliance and WCTE (World Conference of timber Engineering) conference participants dealing with the topic of taller timber buildings, hence ensuring the visibility of the HELEN COST Action at meetings and conferences.
- Contribute to human resources training in new technologies on taller timber buildings within the international framework, favouring the organization of Training Schools, Summer schools, Workshops and STSMs to create an open network of knowledge and professionals with differentiated skills, with particular attention to Inclusiveness Target Countries (ITCs) and Early Career Investigators (ECIs) and with an emphasis on gender equality.
- Organise meetings for Early Career Investigators (ECIs) and PhD students to acquire transferable skills such as grant writing, communication, and time-management as well as encouragement of direct collaboration among ECIs.
- Foster frequent exchanges and short-term scientific stays of research group members from ECIs in top European research centres to help increase their visibility and capacity.
- Give visibility and responsibility to PhD students and postdocs, particularly women, by funding their attendance at conferences through which they promote their Action-related work.
- Accelerate knowledge transfer from fundamental research to industrial application and increase the success rate in future proposals within the Horizon Europe framework by addressing taller timber building market barriers, identifying suitable pilots and connecting with existing R&D projects dealing with the topic of multi-storey timber design at both national and international levels.

- Promote interdisciplinary work streams using the synergies between the participating groups for an efficient exchange of knowledge by taking advantage of different COST tools.
- Act as a stakeholder platform to identify the needs and requirements from different fields and points of view through a bottom-up approach (from society, through industry, businesses, clusters, researchers and academia, to policy makers).
- Develop novel approaches by combining different technologies through interdisciplinary and transdisciplinary collaboration of different fields and widen the field of knowledge within each working group by incorporating a joint research approach.
- Increase the soundness and visibility of the Action's outputs by publishing joint scientific and technical articles, inviting industry to the Action's workshops, assisting at research conferences, updating the website and organizing a showroom at one of the major events in the sustainable environment field as a final activity of the Action.

2. NETWORKING EXCELLENCE

2.1. Added value of networking in S&T Excellence

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

Previous COST actions have dealt with many aspects related to the performance of timber structures such as: E8 (mechanical performance), E24 (reliability), E29 (timber elements), E34 (bonding), E37 (durability), E40 (large dimensional lumber), E53 (quality control) and E55 (performance modelling). All Actions mentioned provide valuable results that widened the scientific basis with respect to timber in construction but nevertheless form only background information. The COST Action FP1004 has given new impulses in the characterisation on wood and the development of enhanced wood products. FP1101 was focused on the assessment, reinforcement and monitoring of timber structures. FP1303 dealt with the performance of biobased building materials and focused on their performance with respect to durability, degradation and LCA and COST Action FP 1407 was focused on technological advances of wood and wood products used as structural materials with respect to the essential requirements The HELEN COST Action, however, builds upon all previous listed Actions and targets all of the seven essential requirements in the CPR with a direct focus on taller timber buildings. Timber buildings act as an integrator but therefore exhibit a high demand for interdisciplinary work, something not present in previously listed COST Actions. This Action can provide complementarity to a wide range of on-going and future projects that have been funded either through national grants or pan-European programmes. Given its multi-disciplinary approach, this Action has the potential to function as medium for networks to be established that develop successful proposals for calls from e.g. the funding programmes "Horizon Europe", ERA Net calls as well as national funding schemes. It is seen as a necessity for the future success of the timber construction industry that the best current scientific and technological knowledge is made available to the corresponding committee responsible for the future revision of the design and product standards. Herewith, the main challenges are:

- The basis of scientific knowledge in timber engineering has increased drastically lately, also due to previous COST Actions and many projects within the Horizon 2020, ERA Net WoodWisdom and ForestValue calls. The documented results, however, are inhomogeneous and fragmented and do not provide the building design teams with the relevant information for their decision making.
- The developments in the timber engineering industry are fast and manifold. Currently this leads to a situation where standards are continuously becoming outdated. Their adoption process is slow and they are by default only focused on individual topics (timber design for strength and

serviceability, acoustic demands, energy demands) and never for complex mechanism like taller timber buildings.

The Action aims at establishing a framework and at developing methods that enable a faster and more reliable transfer of new developments into the taller timber construction market. This development will then be applied to the Holistic design guidelines that will cover what is currently not within the existing timber building literature.

2.2. Added value of networking in impact

2.2.1. SECURING THE CRITICAL MASS AND EXPERTISE

One of the main motivations for establishment of the HELEN COST Action consortium is the current lack of an interdisciplinary international expert network that is able to merge and push forward the recent advancements in the various areas related to multi-storey timber design and construction, which have been treated individually due to their diverse specific scientific areas. The advantage of the COST Action is that it provides a platform where the objectives will be dealt with in a holistic approach. It will allow for a concerted effort with respect to an introduction of recent fundamental and pre-normative research into clear, consistent, and up-to-date set of design rules for timber structures. This joint research network in different fields related to taller timber buildings will therefore enable a strong platform for implementation of holistic design process of taller timber buildings and implementation of design concept in the new generation of European building codes – Eurocodes, which necessitates consensus and acceptance on European level. This necessitates a close coordination between research and practice and strong links to standardization committees. Several scientists and practitioners which have already expressed interest in joining this Action are also members of standardisation committees, assuring the dissemination and explanation of the results of this Action to the relevant standardisation bodies. COST is therefore considered as an excellent framework for doing this since it will provide a common platform for researchers and developers of technologies all over Europe. The lack of such a network could cause a continuation of abovementioned challenges, resulting in a weakened position of the timber industry on European level and on the international market. The COST Action thereby addresses technological and economic needs. The participation of interdisciplinary profile of experts in HELEN COST Action will facilitate the scientific exchange and joint activities. The experts which have already expressed interest in joining this Action represent 28 European countries, whereby countries with a long and profound tradition in timber construction are represented as well as countries in which this sector is momentarily experiencing a strong development. Many of these experts are involved in other European research programmes and will facilitate collaboration between them and the COST Action. The HELEN COST Action will focus on establishing contacts and interaction with many international bodies and committees to create efficient synergies and to enable mutual exchange of knowledge and results, facilitated by STSM exchange and organisation of attractive Conferences, Workshops and Training Schools. Examples of these consortia include, but are not limited to, the following:

- International committees: CEN (TC250/SC5, TC250/SC8, TC124), ISO (TC165), INTER, RILEM
- Connection with existing associations and networks such as Wood Rise Alliance
- Research Projects within "Horizon Europe" and ERA Net Forest Value
- collaboration with other active COST Actions (if applicable)

The expected synergies will advance knowledge at a much faster rate than previously and allow fulfilling the request of the European Commission to develop the scientific foundation that enables the development of a revised set of design standards that really represents the state-of-the art in multi-storey timber construction.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The HELEN COST Action has generated interest from a broad range of stakeholders and is recognized as having the potential of significant impact in generating and consolidating research and technological/economic terms by improving the confidence in and the competitiveness of timber structures. Whilst the emphasis within COST is increasing the European dimension, the success of this Action can be increased through the involvement of experts from over the world. The potential international significance is mirrored by the non-European experts that have expressed their interest during the development of this Action. The Action will enable useful synergies and provide the most effective way of disseminating the results from a large number of projects in the fields covered by this Action to the following target groups and end users of the Action. A range of potential stakeholders have been involved in the development of this Action. From each target group, at least one stakeholder has already expressed interest in joining this Action:

- representatives of the timber construction industry
- architects, structural engineers, consultants, and builders
- product developers in the sector of timber structures
- authorities and policy makers at regional and European levels
- research community, relevant standardization bodies and code writers
- teachers, lecturers and students of structural design, engineering, and architectural schools.

The coordination, discussion, and harmonization of recent efforts in research and development will be realized through workshops, seminars and short term scientific missions (STSMs). The consolidation and dissemination will be realized by conferences, training schools and the joint elaboration of state-of-the-art papers, best practice examples and the final Design guidelines for a holistic design and construction of multi-storey timber buildings. The activities will focus on increasing and consolidating common knowledge and on understanding of the identified technical issues. Experts participating in this Action will come from different backgrounds and Domains. Therefore workshops, conferences, and training schools to be carried out within this Action will promote interdisciplinary research in the fields of wood science and technology, timber engineering and structural reliability. Increasing the involvement of women within the scientific community is a key policy within the European Community. This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve Early Career Investigators (ECIs). This item will also be placed as a standard item on all MC agendas. The role of women and Early Career Investigators will be encouraged by recommending them to the COST National Coordinators as national MC delegates and attention will be paid to fill positions in the lead of WGs with women and early-stage researchers. During Workshops, it is envisaged to dedicate at least one session to presentations from Early-Career Investigators, providing them with valuable experience in participating and presenting to their scientific peers. The involvement of EarlyCarreer Investigators in STSMs, active participation in state-of-the-art reviews and in Training Schools will be promoted.

2.2.3. MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

The HELEN COST Action will provide a network for collaboration within ongoing projects financed by various national and international bodies, to allow for synergies to develop. The HELEN COST Action aims to advance activities and collaboration in both a European and global dimension in areas related to the use of timber and timber products as structural material in holistic approach to multi-storey timber construction. Since the COST Action has already generated interest from experts outside Europe, cooperation with leading non-COST countries in this field such as United Stated, Canada, China and Australia will be initiated in this field. In each relevant scientific area, activities will focus on increasing and consolidating the current knowledge by performing the following general tasks:

- survey amongst stakeholders with respect to existing expertise and results from recent or current research projects including a query on necessities and challenges with respect to programme and work plan of this Action
- compare policies and legislation across continents
- share and analyse the current state of the art in practice (methods and techniques), evaluating these in terms of validity and applicability and learn from previous experience
- analyse and compare these to results from recent fundamental research and pre-normative research
- identify crucial areas of further needed developments and based on this combine time and funds to tackle these issues
- derive scientifically based but practical performance requirements and design approaches with respect to the evaluated technique or design task
- disseminate knowledge of harmonized approaches, methods, and technologies to all stakeholders through background documents, state-of-the-art papers and best practice cases and Design guidelines. Their structure and content shall enable a direct application in practice and give code writing committees the relevant information for their decision making.

3. IMPACT

3.1. Impact to science, society and competitiveness, and potential for innovation/breakthroughs

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

This Action will create scientific, technological, economic, environmental, and social benefits. Research activities with the aim to improve the design and construction of taller timber structures constitute a large share within the domain Forests, their Products and Services, requiring the exchange of information and identification of new research ideas (scientific benefits). Enabling the authorized (i.e. standardized) utilization of recent advances and developments in taller timber construction will widen the range of application of timber for structural applications. A clear description of the scientific background that forms the basis for the design of taller timber structures will lead to increased knowledge and extended possibilities for the use of timber as a structural material, giving architects, engineers, builders and authorities (including their next generations, now in training) a stronger confidence as well as more options for applying timber in the built environment (technological benefits). The development of a framework and methods to achieve a faster and more reliable transfer of new developments into the building market is a clear opportunity for timber industry and will strengthen its position in the international market. Improving the competitiveness of timber and timber products will increase the use of timber in modern and high-performance multistorey structures. An increased use of the genuinely renewable material wood in buildings and the potential replacement of non-renewable materials will generate greater revenue for the forestry sector (economic benefits). This will support the development of an efficient low-carbon economy and a more efficient and sustainable use of forest resources (environmental benefits). Society benefits from safer structures and a more diverse and appealing built environment (social benefits).

3.2 Measures to maximise impact

3.2.1 KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

Apart from the establishment of an expert network that will serve timber construction industry beyond the duration of the HELEN COST Action, the Action will produce written outcomes in form of peer-reviewed articles, state-of-the art reports and the final Design guidelines. The first is a suitable method to prove the importance and accuracy of results and to make these broadly available, also for future generations. All new or adapted methods and technologies which will be developed or defragmented in the Action, will be compiled in state-of-the-art reports and final Holistic tall timber building design guidelines. These shall give essential background information and results that will serve as medium to bring solutions and innovations in the interdisciplinary field of holistic approach of multi-storey timber building design and construction. In addition, suggestions for revision of timber product standards and timber design standards will be provided. More precisely, they shall clearly display the method or innovation, including an explicit proposal with respect to its incorporation into standards which is backed by all necessary background information and scientific evidence. This will provide the knowledge and methods necessary to bring new developments in multi-storey timber construction into building practice. This will be achieved by the coordination, consolidation, harmonization, and dissemination of recent efforts in research and development that aim at enhancing existing or deriving new rules for the design of timber structures. Moreover, the interdisciplinary framework and network established within the HELEN COST Action will develop methods that enable a reliable transfer of new scientific results as well as new technological developments into the building market. Further dissemination activities such as workshops, training schools (TS), seminars, short term scientific missions (STSMs) will foster the knowledge transfer and enhance career development opportunities to wider targeted audience, with a special focus on younger perspective audience from a broad range of relevant fields, and industries which will provide career opportunities to young professionals.

3.2.2 PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

The MC will set up effective dissemination mechanisms to publish the progress and results of the HELEN COST Action, both to the participants and to the extended group of stakeholders, i.e. timber industry, construction industry, architects, structural engineers and builders, authorities and policy makers, scientific community and educational institutions. The Action’s means to disseminate knowledge will be:

i) Website and Social media; The most important dissemination tool is the internet, since it offers the highest flexibility and by far the largest reach of all dissemination tools. The website and social media accounts will be geared towards all stakeholders. The Action’s website will have information about the agenda of all planned activities, e.g. meetings, past and upcoming events. All reports and publications will be possible to download from website as well as technical presentations given at meetings/workshops. The central role of the website in the dissemination process requires particular care of its up-to-date status and correctness, which will be assured during the Action’s lifetime by a designated Web Manager. The website and social media accounts will be open for at least five year after the completion of the Action.

ii) Workshops, Training Schools (TS) and Seminars; Workshops, Training Schools Seminars are a very good scheme to reach the audience working in research, education, and practice. A particular attention will be given to Inclusiveness Target Countries (ITCs) and Early Career Investigators (ECIs), with an emphasis on gender equality. Synergies between institutions and between HELEN and other COST Actions will be used to reach a larger audience. Online and in-person workshops will be arranged in parallel to visiting sites with recognised expertise. Sites of recognised expertise will also be selected as venues for Training Schools for which students, lecturers, and practitioners from woodworking and construction industry will be invited. To support the setup and participation in Training Schools, they will be given a distinct and visible area on the Actions Website, including course material of past Training Schools. Many Action members have teaching obligations that will be used to pass on knowledge to current and future stakeholders secured through courses and seminars at home institutions with the emphasis on holistic design of multi-storey timber structures and representing timber a renewable structural material for a sustainable built environment.

iii) Short term scientific missions (STSMs); STSMs are an ideal tool for HELEN COST Action and will be encouraged especially for Early Career Investigators (ECIs). They encourage greater synergy between institutes, accelerate the learning of students and provide academia and industry with new, highly trained and innovative thinking staff. The objective of a minimum number of 6 missions will be possibly supported each year. To support this objective, STSMs will be given a distinct and visible area on the Actions Website, including all STSMs currently offered and the documentation of past STSMs. Continuous submission, evaluation, and approval of proposals will guarantee maximum flexibility of this tool. An STSM manager will be chosen preferably amongst the participating Early Career Investigators (ECIs). The results of the STSMs will be presented and discussed in the plenary sessions of workshops by the ECIs involved.

iv) Conferences, Association events, Peer-reviewed articles, State-of-the-art reports, Design guidelines; International conferences and associations such as WCTE (World Conference on Timber Engineering) and Wood Rise Alliance are an important tool to bring together researchers, academia and industry in one forum to discuss the progress achieved to date. It is planned to hold at least one mid-term and one final conference. Peer-reviewed articles are a good method to prove the importance and accuracy of results and to make these broadly available, also for future generations. Relevant scientific journals will be contacted to publish special issues dealing with the topic of the Action. Peer-reviewed State of the Art papers shall serve as background documents for standardization committees. Joint publications and papers co-authored by various research groups will be encouraged and fostered by Short term Scientific Missions. All new or adapted methods and technologies, developed within this Action, will be compiled in state-of-the-art reports (STARs) and Design guidelines. The STARs and final Design guidelines will contain recommendations to support the design engineering community with proper holistic design methods. All publications carried out during the time period of HELEN COST Action will acknowledge the support of COST and Open access publications will be strongly encouraged.

v) Link to standardisation and other European bodies; Many experts who will participate in the HELEN COST Action are also members of standardisation committees, assuring the dissemination and explanation of the results of this Action to the relevant standardisation bodies such as CEN TC250/SC5 “Eurocode 5 – Design of Timber Structures” and CEN TC250/SC8/WG3 “Eurocode 8 – Earthquake resistance design of structures – Timber structures” which are mandated to revise the Eurocode standard for the design of timber structures. Several experts that will be invited to participate in the Action are also member of CEN TC124 “Timber Structures” which is mandated to further develop the relevant testing and product standards. Since several of these participants are also member of ISO TC165 “Timber Structures”, the dissemination and explanation of the results of this Action to the relevant standardisation bodies, not only in Europe but also worldwide, is assured. European Platforms like FTP or ECTP will be supported with information to promote the use of timber in structures.

4. IMPLEMENTATION

4.1. Coherence and effectiveness of the work plan

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

The foreseen work is divided among four main working groups (WGs) that have been conceived to coherently cover the most crucial topics contemporary taller timber structures need to address and share common ground in the building planning phase. Each of the working groups will be assessed through the prism of three conceptual stages a building goes through: design, construction, and exploitation. The key part, however, will be the assessment of the main topics by the interdisciplinary teams consisting of different expertise group members. Eight main expertise groups (EG) are planned. Together the expert groups cover all key aspects of the built environment. In order to develop original, balanced and cross-code fitting solutions for taller timber buildings, a holistic assessment performed by a diverse interdisciplinary team is crucial. Opposed to work performed in the past, the expertise groups will be combined of not only structural engineers, but also architects, acousticians, builders, material scientists, sustainability experts, processing specialists etc. Not only academics but also practicing designers will form the teams, as well as legislation and building policy creators.

The priority of topics effecting each of the working groups will be identified and ranked at the kick-off workshop by all participants throughout discussion and with the help of e-tools. The individual topic assessment intensity will also be determined at the kick-off. However, it is only through diversified discussion of the multidisciplinary Expertise Groups that they will be finalised and prioritised. As such, the HELEN Action will organically identify the critical areas, urgent design collisions and socio-economical drawbacks in order to derive the full set of priorities that need to be tackled before taller timber buildings can be adopted by wider crowds of architects and designers.

WG 1: Robust Design for Adoption, Reuse and Repair

This WG will revolve around the planning and design of buildings to be more sustainable and reliable from the very beginning of the process. A holistic approach is chosen in order to consider the demands and benefits of all stakeholders in the building design process. We want tall timber buildings of the future to fulfil not only the basic design code requirements, regardless if national or international, but also be prepared for potential future changing demands and requirements. Hence, they would serve as lighthouses of future construction in general. This shall be achieved by considering robustness and approaching the adoption, repair and reuse of the building and its components in a cross-sectional strategy considering the various stakeholder interests. If structures are not design keeping **Robustness** in mind, the collapse of a single element can trigger further disproportional consequences, possibly even leading to full collapse of a structure. In taller timber buildings the concept is still not well understood, yet it is recognized as crucial due to complex timber properties and assembly procedures. As such it needs to be analysed more in depth and become a part of standard taller timber building design of course in a holistic manner, considering several other boundary conditions and consequences. **Adoption** is the process of considering the demands and needs of the prospective users in the actual usage of a product. This concept is already valid for other products, such as smartphones, cars, clothes etc. The users of the building can adopt the building to their demands, both in a short-term perspective or for long term use, including the adaptation of both load-bearing and non-load-bearing elements. This also includes extensions of the structure (topping up, etc.) and provides higher benefits for the owner. **Repair** will implement the possibility that damaged load-bearing components meaning that parts of the structure can be easily restored or exchanged, which allows to react to unforeseen and accidental cases of e.g. water leakage, compartment fire, etc. Timber buildings are often seen to be potentially more prone to damage compared to other building materials. Concerns are related to wood degradation due to water damage or insect attack but also to fire damage or damages after earthquakes. Replacing load-bearing elements is already a challenge in smaller buildings and is even a greater for taller ones. Redundancy is only a part of the answer, solutions need to be sought through a wider audience. The possibility to repair will increase the trust in timber as a reliable and high-quality building material and increase and maintain value of the building. **Reuse** is obligatory in the light of long-term sustainability, carbon storage, recycling, and circular economy. After reaching the end of the service life, which is often planned to be after at least 50 years, the building can be deconstructed and parts can be reused, recycled or rearranged and can be fed back to the value chain. The approach to design for adoption, reuse and repair introduces the concept of circularity not only to the material and material flow but is a more holistic approach on the structural, building, user, and societal level. By making buildings adaptable to new demands, circumstances or needs to repair, the life cycle of the building can be extended into further cycles. Introducing timber in multi storey buildings is still rare on the market and not necessarily applicable to larger quantities. The challenges described needs to be explicitly considered when scaling up the market and not taken for granted.

Tasks: 1.1) Analyse the state-of-the-art; 1.2) Identify existing and former WG network efforts; 1.3) Identify design field collisions in the design, construction and usage phases; 1.4) Narrow down research focus on previously identified hot-spots and schedule target Training schools, STSMs and Research calls (Horizon Europe + others), 1.5) Write Taller timber building design guidelines chapter on their Design for Adoption, Reuse and Repair.

Activities: WG meetings, Workshops including stakeholders, Training schools for ECI and PhDs, STSMs, Dissemination activities, Cross-cutting activities with other WGs.

<u>WG 2: Deformations and Vibration</u>

WG 2 will focus on the wide topic of deformations and vibrations in taller timber buildings. Timber has inherently low mass and elastic modulus compared to other building materials. For spruce, the respective values are 5- and 3-times lower compared to reinforced concrete. The low mass is generally beneficial as it results in lower forces. Either on foundation that can in term be smaller (less material used, beneficial for the environment) or simpler (foundation plate instead of piles). Or for seismic design where, due to second Newton's law, the lower accelerated mass generates lower seismic forces, which result in lower damage or possibly even no structural damage at all. However, these same inherent properties of wood present design challenges for taller timber buildings. Firstly, because the more standard spans in certain building typologies, i.e. offices, are optimised to other materials, namely steel and concrete. Merely adopting the same building boundary conditions for timber structures can lead to non-rational design as the load bearing elements need to be thicker due to serviceability demands, namely, keeping the **deformation** as well as **vibration** in check. And secondly because mid-rise timber buildings are already tall enough to be affected by wind vibration. In addition to their low mass and stiffness also due to the uncertainties in viscous damping they offer. These properties are also responsible for the low sound isolation timber constructions offer in the lower part of the acoustic spectrum. Consequently, the acoustic demands lead to decoupling of structural elements in order to break the sound vibration transfer. That unfortunately causes problems with both wind as well as seismic design demands where a tightly bonded system is essential.

Tasks: 2.1) Analyse the state-of-the-art; 2.2) Identify existing and former WG network efforts; 2.3) Identify design field collisions in the design, construction and usage phases; 2.4) Narrow down research focus on previously identified hot-spots and schedule target Training schools, STSMs and Research calls (Horizon Europe + others), 2.5) Write Taller timber building design guidelines on Deformation and Vibration related issues.

Activities: WG meetings, Workshops including stakeholders, Training schools for ECI and PhDs, STSMs, Dissemination activities, Cross-cutting activities with other WGs.

WG 3: Accidental Load Situations

Work in this Work Group would in essence revolve around the main accidental load situations taller (timber) buildings face, namely earthquake and fire. In unfavourable, but not uncommon situations, these events are not independent, but fires follow earthquakes due to ruptured electrical and gas installations. This issue has been given little attention in Europe, however more in the United States but not yet well on taller structures. The issues of earthquake and fire are demanding by themselves. Earthquake design of multi storey timber buildings has only been a topic of (isolated) research for less than 15 years, with the current state of knowledge still low compared to concrete and steel counterparts. Fire design of timber on the other hand can be handled with existing design methods and principles, however the protection demands (protection times) have been raised as taller buildings need to withstand fire longer in order to enable safe evacuation of people. This in term also raises the bar for fire protecting solutions as well as performance of existing products. Namely, CLT made with polyurethane adhesive has displayed delamination problems, unacceptable in taller timber buildings. Combining merely seismic and fire demands is a challenge by itself. However, the fire cladding demands can run into collision with acoustic cladding and these run into conflict with seismic and wind demands. The cladding demands overall are in conflict with the human wellbeing aspects which prefer to have timber exposed.

Tasks: 3.1) Analyse the state-of-the-art; 3.2) Identify existing and former WG network efforts; 3.3) Identify design field collisions in the design, construction and usage phases; 3.4) Narrow down research focus on previously identified hot-spots and schedule target Training schools, STSMs and Research calls (Horizon Europe + others), 3.5) Write Taller timber building design guidelines concerning Accidental Load Situations.

Activities: WG meetings, Workshops including stakeholders, Training schools for ECI and PhDs, STSMs, Dissemination activities, Cross-cutting activities with other WGs.

WG 4: Sustainability and Durability

Timber constructions have gained the (rightful) reputation of being a sustainable building option. On the other hand, they also raise questions regarding their durability. They are more susceptible to damage, either induced by moisture or insects as well as design mistakes due to their complexity. They are also less forgiving when it comes to construction mistakes, possibly leading to premature failure of their building components. This Work Group will look into the issues dealing with taller timber building environmental footprint and their longevity based on the design details, all assessed through the interdisciplinary prism of the consortium’s experts. The results of this Work Group’s work will be in close correlation to WG 1, where the initial design assumptions will be considered. As in other WGs, work in this group will also be country dependant as, apart from local legislation, local climate properties are also of great importance. The possibility to build safely and effectively in areas with heavy rain and snow differs greatly from dryer places. This in term influences the construction technologies, which in term affect the building erection price, which makes the timber alternatives to concrete or steel more or less viable. For Europe that strives for an increase in sustainable timber construction, this opens a discussion on state subsidies for timber construction in order to make them more attractive to investors. The interdisciplinary consortium, also including LCC and S-LCA experts, will also be able to provide answers to such questions.

Tasks: 4.1) Analyse the state-of-the-art; 4.2) Identify existing and former WG network efforts; 4.3) Identify design field collisions in the design, construction and usage phases; 4.4) Narrow down research focus on previously identified hot-spots and schedule target Training schools, STSMs and Research calls (Horizon Europe + others), 4.5) Write Taller timber building design guidelines on their Sustainability and Durability.

Activities: WG meetings, Workshops including stakeholders, Training schools for ECI and PhDs, STSMs, Dissemination activities, Cross-cutting activities with other WGs.

Each Work Group will have members consisting of different Expert groups. As such, the Action's structure will ensure the multi-disciplinary forum necessary to effectively assess the WG topics and provide holistic problem solutions. Each Expert Group (EG) will have an EG president and substitute, at least one will be preferably an Early Career Investigator. The importance of individual expert group subtopics described herein, for individual phases (design, build, use) of the four main WG can be hypothetically shown through a heat map (Figure 3). This will be determined at the kick-off meeting and will be further modified as work within individual WGs evolves.

EG 1: Timber Engineering. This expert group will consist of members mastering fields of 1 timber structures, 2 timber connections, 3 fire behaviour, 4 seismic response, 5 wind response, 6 structural reliability, 7 robustness, 8 floor vibration, 9 maintenance, 10 disassembly, and 11 duration of load.

EG 2: Computational Modelling. This expert group will consist of members mastering fields of 1 fire spread modelling and 2 seismic modelling as well as 3 general finite element modelling.

EG 3: Building Physics. This expert group will consist of members mastering fields of 1 acoustics, 2 volatile organic compounds, 3 indoor air quality and 4 thermal behaviour.

EG 4: Architecture. This expert group will consist of members mastering fields of 1 architectural design, 2 room design, 3 facades and 4 urban planning.

EG 5: Construction Management. This expert group will consist of members mastering fields of 1 factory management, 2 construction site management, 3 logistics, 4 industrialization, 5 prefabrication and 6 waste management.

EG 6: Material Science. This expert group will consist of members mastering fields of 1 material production (engineered wood products), 2 adhesives, 3 coatings and 4 wood modification.

EG 7: Human Health. This expert group will consist of members mastering fields of 1 restorative design and 2 ergonomics.

EG 8: Life Cycle Analysis. This expert group will consist of members mastering fields of 1 life cycle analysis, 2 life cycle cost and 3 social life cycle analysis.

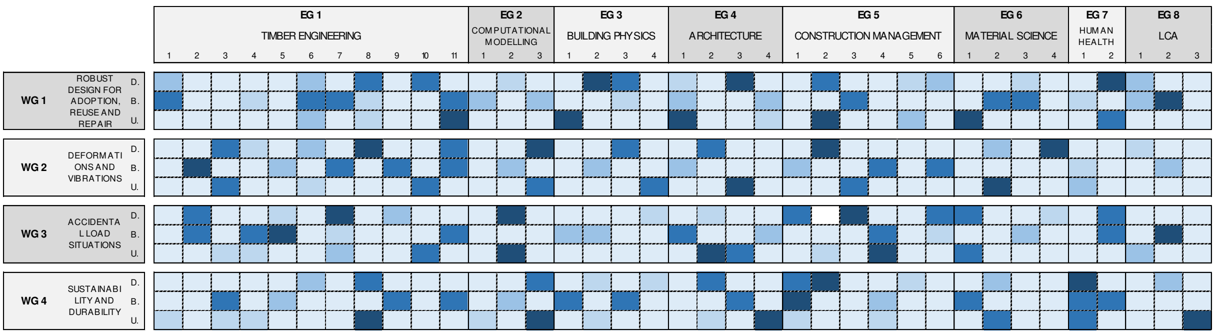


Figure 3: A hypothetical heat map (to be determined at the kick-off meeting) on how importance of different EG fields would be assigned to different substages (design, build, use) of the main four WGs.

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

D1) State of the art report: All the WGs will produce up to date and in-depth the reports based on the state of code design, running research project results and available literature. The compiled report is expected to be finished in Q3 of Year 1.

D2) Short Term Scientific Mission (STSM) reports: All planned STSMs, namely targeted 6 per year, 24 over the course of the project will also result in mission reports. The STSMs will be targeted to work on the issues identified within the consortium. The results will be used for formation of the final Design Guidelines..

D3) Training schools: Training schools are planned to be organised in the second, third and fourth year of the project. Explicit training school topics will be identified in the first year of the project after the state of the art is analysed and research focus is finalised. Q2 of Year 2, Q2 of Year 3, and Q2 of Year 4.

D4) Conferences / Webinars: Two events are planned, if possible preferably held right before or after one of the bigger international conference events (WCTE, Woodrise, SWST or similar), which are commonly held in the summer / autumn period of the year, to increase the possibility of dissemination to a wider crowd. Q3 of Year 2 and Q3 of Year 4.

D5) Annual reports: Annual reports are planned to the Management Committee on project updating. Q4 of Year 1, Q4 of Year 2, Q4 of Year 3, Q4 of Year 4.

D6) Research papers: Several publications in peer reviewed journals are planned. Since most research results are expected towards the end of the action the publications drafts and excepted papers are planned in the last 18 months of the Action. However publications are possible in earlier years as well. At least 12 peer-reviewed papers are expected from the Action. Q3 of Year 4.

D7) Taller Timber Building Design Guidelines: The final publication that will recap all the work performed over the 4 years and present architects, building designers, policy makers, investors etc. with harmonised design approaches is planned at the end of the Action. A draft is planned at the beginning of Year 4, the final version at the end. Q4, Year 4.

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

Risk management and ongoing risk assessment of the HELEN COST Action will be a duty of the Action Chair who will be responsible for periodic reviewing of existing and new risks and for methods to mitigate them.

Decisions and information flow is delayed or inhibited within the Network; A wide and diverse team of experts can get out of hand because of the broadness of topic. Hence a clearly defined management structure and timeline has been established to ensure smooth and timely operations. The experts are divided not only into Working Groups but also Expert Groups that ensure a clear communication flow within the various profiles of the HELEN Action Network.

Network is inharmonious; Having a multidisciplinary team and environment can potentially disrupt the balance. Team building and social events will take place in addition to and alongside project meetings to develop mutual respect and understanding between project partners. The Action Chair will remain in frequent contact with WG and EG leaders to identify and resolve any issues that may arise between partners.

Loss of a partner(s); The consortium is large and diverse. The Action aim to have several experts for different fields and entities to prevent the potential loss of partners and find potential replacements as necessary.

Inadequate expertise within the Network; The nature of this project demands a wide variety of experts that cover an immense field of the built environment. Should it turn out along the Action work that a field is missing, organizations taking part can search for internal sources (usually within universities) and come up with the missing experts.

Infrastructure requirements differ from expectations; A wide array of topics calls for a wide array of research equipment. The HELEN Action network possesses practically all the laboratory equipment necessary within the field of built environment. Several institutions have a substantial part of the equipment individually. Hence the quantity of equipment within the Network is at least doubled.

Financial needs are higher than expected to meet operational needs; Should there be a desire for more STSMs or more networking events that allowed for within the COST Action budget, additional funding beyond expected budgetary needs will be sought through additional research projects (Horizon Europe, Forest Value and other national research calls).

Expected operational needs are insufficient (technological or administrative); The experience of the Network partners a high level of confidence that predicted needs are sufficiently met with operational capacity. As new needs are discovered, additional workload can be shared among partners.

Action's research topic does not meet industry's needs; Although the research topic was developed together with the industry, new challenges may arise, or national legislation may change (i.e. the fire legislation in the UK after the Grenfell fire) that would reduce the Action's relevance. In the scope of the current European green agenda, it is highly unlikely that the overall topic of taller timber buildings would become obsolete.

Action's research topics become resolved by other institutions; The complexity of the work necessary to derive holistic design guidelines for Taller timber buildings is so complex that the possibility of another institution(s) performing the work is slim. Additionally, most of the relevant European and world institutions working on the topic of taller timber buildings are members of the HELEN Action network.

4.1.4. GANTT DIAGRAM

The Gantt diagram is formed in a manner showing the times of individual deliverables as well as other activities, i.e. Management Committee meetings etc. Specific WG activities that would last for a determined period of time, i.e. target analyses of specific scientific problems will be decided on WG levels. There are also 4 key milestones in the HELEN Action:

- M1: State of the art report.
- M2: Action half-time and project review.
- M3: Draft of design guidelines.
- M4: Finalised design guidelines and project end.

ACTIVITIES	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Management																
MC meetings	x		x		x		x		x		x		x		x	
SG meetings			x		x		x		x		x		x		x	

Research																
WG meetings			x		x		x		x		x		x		x	
EG meetings			x		x		x		x		x		x		x	
Workshops			x				x				x				x	
STSMs	min. 6				min. 6				min. 6				min.6			
Dissemination and Education																
Training Schools						x				x				x		
Conferences / Webinars							x								x	
Social media and webpage	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Report and Review																
Annual Reports				x				x				x				x
Reviews								x								x
Publications																
State of the art reports			x													
Drafts of TTB Guidelines													x			
TTB Guidelines																x
Drafts in P.R. Journal Papers												x				
Accepted papers															x	
Milestones			1					2				3				4