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# Executive Summary

This report gives an insight into the personal, but reasoned opinion of the research team regarding future regulatory activities by the EU. The author discussed the topics execution of risk analyses, extreme wind loads on buildings, structural performance during earthquakes, structures under fire, plane impacts on buildings, explosion in or close to buildings, biological or chemical hazards, flooding, evacuation and its simulation, multi-criteria analysis, building information modelling (BIM), sensors and their collected data with different experts of the research team. This report summarizes the content and the conclusions of these discussions and recommends the EU to start regulatory activities for risk analyses and further research activities for evacuation and its simulation as well as building information modelling (BIM).

# Contents

# 1 Introduction

The ELASSTIC-project is about the design of a large-scale building and has a special focus on safety and security issues. The objective is to achieve a blueprint of a building design and to demonstrate that great architecture and profitability are no contradictions to a high safety and security level.
During the working time of the research project, many different topics were addressed. The objective of the deliverable 4.6 is to objectively show if a regulatory framework process should be initiated by EU policy makers or not. From the beginning it was clear that this question cannot be answered in general because to many different topics were addressed within the scope of the whole project. Therefore, the research team decided during one of its general assemblies to answer this question for selected topics separately. These selected topics are:

- Execution of risk analyses,
- Extreme wind loads on buildings,
- Structural performance during earthquakes,
- Structures under fire,
- Plane impacts on buildings,
- Explosion in or close to buildings,
- Biological or chemical hazards,
- Flooding,
- Evacuation and its simulation,
- Multi-Criteria analysis,
- Building Information Modelling (BIM),
- Sensors and their collected data.

For any of these 12 topics the author performed one or more interviews with different experts within the research team. During these interviews questions were asked and answered by following the chart in figure 1.1.

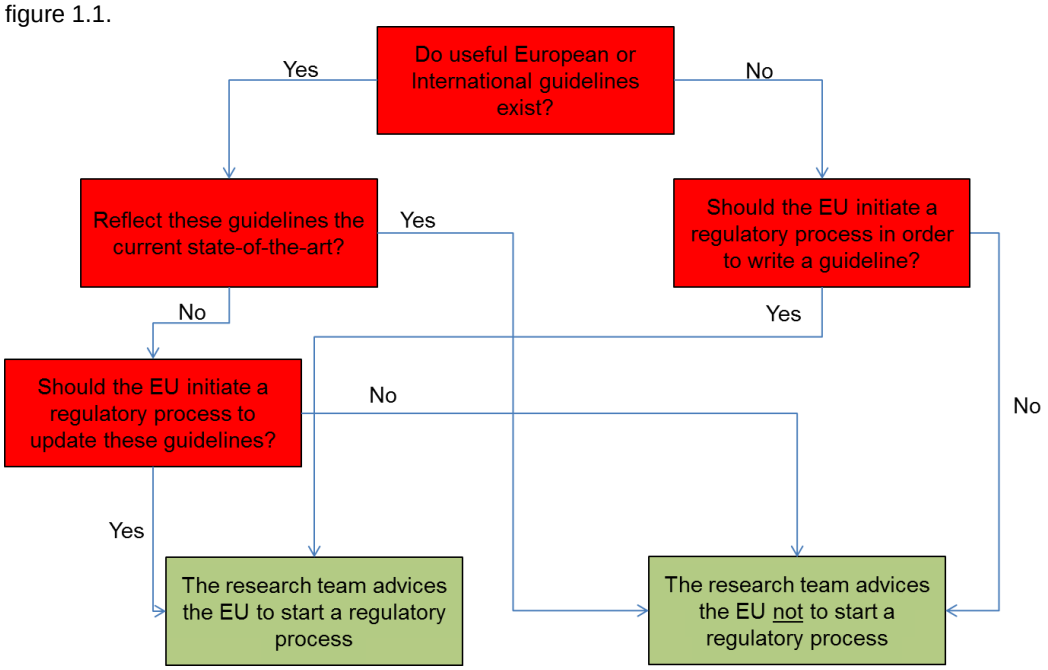


Figure 1.1: Chart for questions during the interviews

In the following chapter the reader will find the summaries of the different interviews and will get an insight into the recommendations for regulatory frameworks by the ELASSTIC research team.

# 2 Interviews and Recommendations

## 2.1 EXECUTION OF RISK ANALYSES

The objectives of risk analyses are to describe and to calculate risks. For building structures the Eurocode EN 1991-1-7 [1] is the only international document which deals with the topic risk analyses. In the appendix B, which is not prescriptive, the reader can find general information about risk analyses. But the information is not detailed enough to enable the reader to execute comparable risk analyses. In this context *comparable* means that the result of a risk analysis is independent of the person who executes it. This will not be the case by applying EN 1991-1-7 [1]. This document contents a quite vague and general description of risk analyses. Therefore, the result will strongly depend on the knowledge and the data base the person who executes the risk analysis has.
The research team recommends to the EU to initiate a regulatory process regarding risk analyses. This guideline should start with definitions of the important terms and should focus on the description of an efficient manner to perform a comparable risk analysis. This risk analysis should be prescriptive for certain buildings, e.g. critical infrastructures, and will therefore improve the safety and security of your built environment.

## 2.2 EXTREME WIND LOADS ON BUILDINGS

Nowadays, actions on buildings due to extreme wind are described in the Eurocode EN 1991-1-4 [2]. This code covers the complete topic *wind loads on buildings* and is a practical and efficient code which enables structural engineers to design their building against wind loads. The described wind loads in this code are based on statistical data and this data is periodically updated by experts.
The abovementioned code reflects the state-of-the-art and satisfies the needs of structural engineers. Therefore, the research team sees no need for new regulatory activities regarding extreme wind loads on buildings and does not recommend to the EU to initiate those.

## 2.3 STRUCTURAL PERFORMANCE DURING EARTHQUAKES

Nowadays, actions on buildings due to earthquakes are described in the Eurocode EN 1998-1 [3]. This code covers the complete topic *seismic actions and rules for buildings* and is a practical and efficient code which enables structural engineers to design their building against earthquakes. The described loads due to earthquakes are not quantified in this code. But this code refers to the national authorities who have to divide their territory into different earthquake zones. These earthquake zones have to be related to certain peak ground acceleration. Except for this number of the earth acceleration during an earthquake any important information can be found in [3]. But in conjunction with a national earthquake map, this code reflects the state-of-the-art and satisfies the needs of structural engineers.
Therefore, the research team sees no need for new regulatory activities regarding the structural performance of buildings during an earthquake and does not recommend to the EU to initiate those.

## 2.4 STRUCTURES UNDER FIRE

Nowadays, actions on buildings due to fire or more precisely *structural fire design* is described in 7 different Eurocodes [4] – [10]. One general code exists for the description of the action due to fire and for every building material (concrete, steel, composite steel and concrete, timer, masonry and aluminium) a

separated code with a description of its specific structural fire design. The reason for this quite complicated procedure is that every building material reacts differently under fire or high temperatures. Nevertheless, these codes cover the complete topic *structural fire design* and they are practical and efficient codes which enables structural engineers to design the building structure against fire.
The abovementioned codes reflect the state-of-the-art and satisfy the needs of structural engineers. Therefore, the research team sees no need for new regulatory activities regarding structures under fire and does not recommend to the EU to initiate those.

## 2.5 PLANE IMPACTS ON BUILDINGS

International codes for plane impact on buildings do not exist. The author knows some national codes in Germany for the design of nuclear power plants against plane impact, but the access to these documents is restricted. In these documents the impact of a fighter plane is a possible hazard scenario.
For regular buildings this scenario would lead to uneconomic and architecturally unsatisfactory constructions. Furthermore, a failing regular building has not the same cascade effects than a failing nuclear power plant and therefore does not need the same level of safety. The conclusion is that this hazard scenario, impact of a fighter plane, should not be considered as a hazard scenario for regular buildings. But even the direct impact of a small airliner, e.g. a Learjet, on a critical structural element, e.g. a column, is a very rare event because only if the airliner hits the column directly, the column will probably fail. If the wings hit the column, it will probably still stand up. In this case a fire which was initiated by the plane impact will be the crucial hazard scenario for the structure.
The research team sees no need for new regulatory activities regarding direct plane impact on buildings, but it recommends to the EU to check if the regular time-temperature-curves for fire design cover fires initiated by plane, car or truck impacts on buildings, too.

## 2.6 EXPLOSION IN OR CLOSE TO BUILDINGS

In the EU only unintended, internal explosions are covered by a code. In Eurocode 1 [1] the questions are answered whether a structure has to be designed against such an explosion and how to do it. Other types of explosions are not covered by codes or guidelines, e.g. intended explosions (terrorism) or unintended external explosions (shockwaves on neighbouring buildings due to an explosion on an industrial plant). Therefore, building owners do not have to design their buildings against these other types of explosions and most often do not do it.
So, the question whether the EU should start regulatory activities regarding explosions scenarios is linked to the questions whether the EU wants to oblige building owners to design their buildings against explosions. The research team answers both questions with *no* mainly for two reasons. Firstly, in the European Union the probability to become a victim due to the failure of a building as a consequence of a terroristic event is comparable low in contrast to be a victim of the fragments from an explosion. Secondly, terrorists are able to change their tactics during months, e.g. rapid-fire weapons instead of bombs, but the society would need centuries to strengthen their entire critical infrastructure.
Therefore, the research team sees no need for new regulatory activities regarding explosions in or close to buildings and does not recommend to the EU to initiate those. Building owners can voluntarily design their buildings against explosions which are not covered by Eurocode 1 [1] and will find several experts in the EU who have the specific knowledge to consult them.

## 2.7 BIOLOGICAL OR CHEMICAL HAZARDS

International codes for biological and chemical hazards for buildings and their users do not exist. One big challenge regarding these hazards is the diversity of the possible biological or chemical agents. A nearly endless list of possible agents exists as well as measures to protect people against these agents. Therefore, it would be possible to protect people against some agents but not against all. Furthermore, the probability to become a victim of a biological or chemical agent in the EU is extremely small; compare [11, figure 4.11].
Therefore, the research team sees no need for new regulatory activities regarding biological and chemical hazards and does not recommend to the EU to initiate those.

## 2.8 FLOODING

International codes or guidelines to protect buildings against flooding do not exist. Although flooding is a current hazard scenario, these kinds of codes or guidelines do not exist because in most countries not the building itself is protected against flooding but a certain landscape or even the whole country. In the Netherlands for example, the whole country is protected against flooding from seaside because of their special geographical circumstances (a big part of the country is below sea level). In order to achieve this, there are several codes worked out regarding dykes, retaining elements and water barriers. So, they do not have a leak of regulations. In other countries the concept to protect people and infrastructures against flooding is comparable to the case of the Netherlands.
The research team sees no need for new regulatory activities regarding flooding hazards on buildings and does not recommend to the EU to initiate those. The reason is that buildings, which are the topic of the research project ELASSTIC, are not directly protected against flooding, but landscapes or countries are. The protection of landscapes against flooding was not part of the research project ELASSTIC and therefore the need for a regulatory framework cannot be evaluated by the research team.

## 2.9 EVACUATION AND ITS SIMULATION

International codes or guidelines regarding the dynamic evacuation of buildings do not exist. The state-of-the-art is that every building owner is obliged to have a static evacuation plan. But the codes which deal with these static evacuation plans differ from one European country to the other or even within the countries. That means that you have to consider different codes if you design a building in Berlin or Hamburg. Furthermore, dynamic evacuation models are still not accepted by the authorities and are not allowed to substitute a static evacuation plan.
Software developers and users of dynamic evacuation models have two challenges:

1) Many different codes regarding evacuation in the EU and
2) Authorities which have to be convinced that a dynamic evacuation model can substitute a static one.

The first challenge should be accepted by the software developers because different codes can be implemented in one software tool. The second challenge should be accepted together by authorities, software developers and users. All three parties should find a way how a dynamic evacuation can substitute a static one. The EU could support this process by tendering a research project with this objective.
The research team sees no need for new regulatory activities regarding evacuation and its simulation and does not recommend to the EU to initiate those. But the research team recommends tendering a specific research project with this topic.

## 2.10 MULTI-CRITERIA ANALYSIS

International codes or guidelines regarding multi-criteria analysis for buildings do not exist. One reason is that this subject is still unknown in the area of architects and building engineers, although it has been applied for centuries. But normally a multi-criteria analysis is done in the mind of the building owner, the architect or the engineer or during a discussion of all of them. For example the reasoning - Façade A looks nicer than B, but B has a better thermal insulation than A. A good thermal insulation is more important than the appearance of the building. So, façade B is chosen. – is a multi-criteria analysis. The difference to the multi-criteria analysis which was applied in the ELASSTIC-project is that in the ELASSTIC-project the (written) multi-criteria analysis was done by a described method and by points in order to calculate the meet of requirements of different design solutions. The advantage compared to the state-of-the-art is that a decision can be objectively justified by a written multi-criteria analysis. This advantage could be interesting for public projects or bigger private organisations where project managers have to justify their decision in front of their superiors.

Because of the lack of experience with these written multi-criteria analyses in the field of buildings, the research team sees currently not the right moment for regulatory activities and does not recommend to the EU to initiate those. Initially, this new way of multi-criteria analyses should be accepted by a part of the building sector and afterwards regulatory activities might start.

## 2.11 BUILDING INFORMATION MODELLING (BIM)

In the EU, no official codes about Building Information Modelling (BIM) exist. If a building owner wants its planners to use BIM he or she cannot make a reference to a certain code. Building owners have to describe themselves what their understanding of BIM is and what the different project partners have to do regarding BIM. So today, a BIM-standard only exists per project and it can differ a lot from one project to the other project. And this is done in form of making BIM protocols. This is even a new business model for some building consultants.

This is exactly the way planners are working with CAD for many years. Every planner uses its preferred software and the building owner wrote a CAD-guideline for the specific project, which the assigned planners had to fulfil. So, the planner applies its preferred software in a way that its products, mostly pdf-, dwg- or dxf- files, fulfil the building owner's CAD-guideline. The question is whether this state-of-the-art is satisfying for a BIM process, too.

One field of standardization could be IFC. IFC is a certain file format which is already standardized by international software users and developers. But it is still not exact enough. Therefore, by using ifc-files to transfer data a lot of data is getting lost because parts of the original model do not fit into the ifc-format. One solution for this problem is that certain building owners work out more detailed ifc-formats for their special needs, e.g. national authorities for roads and bridges. But the research team thinks that a general EU ifc-standard should not be the objective because if it should fit all it will be not detailed enough.

The research team thinks that BIM is a dynamic field of innovation and development for the building industry and its aligned planners. Therefore, the research team recommends to the EU to support the building industry and its aligned planners regarding BIM, e.g. by research projects. But currently the research team sees no clear objective for regulatory activities and does not recommend to the EU to initiate those.

## 2.12 SENSORS AND THEIR COLLECTED DATA

In the ELASSTIC-project two kinds of sensors were used: temperature sensors to measure high temperatures during a fire and microphones, used as pressure sensors, to measure high pressures during an explosion. Both products are well known and several standards exist to describe and calibrate them,

e.g. International Temperature Scale of 1990. The innovation within the ELASSTIC-project was to (theoretically) install them into a structural element and to use the data for the dynamic evacuation modelling.

The research team sees no need for new regulatory activities regarding the used sensors and does not recommend to the EU to initiate those. Codes for the used sensors already exist and the connection of sensors with a dynamic evacuation modelling is still not used in practice. If in the future this connection becomes more and more reality, a regulatory process by the EU could be a useful activity.

# 3 Conclusion

This report delivers a dense summary of the interviews and discussions that the authors had with different experts of the ELASSTIC research team regarding possible regulatory activities of the EU. During these discussions it was worked out that the research team recommends to the EU to initiate regulatory activities regarding risk analyses of buildings and time-temperature-curves for fires in buildings initiated by an impact of a plane, a truck or a car.

For the other topics treated during the ELASSTIC-project, the research team sees no need for regulatory activities. The reasons are diverse, but for many topics like earthquake, fire or wind the EU has already established codes, which reflect well the state-of-the-art. Other events are too seldom to be codified or the developments are not mature enough to start a regulatory process, e.g. dynamic evacuation or BIM. For both mentioned topics the research team recommends to the EU to start further research activities because both topics have the potential for further innovation and application in practice in the near future.

# 4 Acknowledgment


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