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ScienceDirect

Procedia - Social and Behavioral Sciences 119 (2014) 894 – 901

Procedia
Social and Behavioral Sciences

27th IPMA World Congress

Risk Breakdown Structure for construction projects on existing buildings

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Abstract

Governments and private investors are increasingly becoming aware of the marketing power and the importance of seismic safety of old cores of their cities. Hereby the interest in preserving the original look and often even the original, but improved construction of the buildings becomes imperative and a demanding task for engineers and project managers. The main goal of project management is controlling the outcome of a project through control of elements like quality of the final product, costs and time, whereas practice shows that these types of projects very often overrun cost and time limits. Therefore these are the main research questions: Can construction projects on strengthening and preserving existing buildings be successfully governed with existing risk management tools? If not, how can we improve the existing risk management tools?
In this paper development of a new risk breakdown structure for construction projects on existing and historical buildings is presented. The risk breakdown structure is developed based on previous project experiences and in collaboration with a series of experts.

Selection and peer-review under responsibility of the IPMA.

Keywords: risk breakdown structure, existing buildings, project management, risks

1. Introduction

Governments and private investors are increasingly becoming aware of the marketing power and the importance of seismic safety of old cores of their cities. Hereby the interest in preserving the original look and often even the original, but improved construction of the buildings becomes imperative and a demanding task for engineers and project managers. The main goal of project management is controlling the outcome of a project through control of

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Selection and peer-review under responsibility of the IPMA.
doi:10.1016/j.sbspro.2014.03.100

elements like quality of the final product, costs and time, whereas practice shows that these types of projects very often overrun cost and time limits.

The main questions of this research are: Can strengthening and preserving existing buildings construction projects be successfully governed with existing risk management tools? If not, how can we improve the existing risk management tools?

The seismic vulnerability of existing buildings has since decades been a center piece of research for many structural engineers, but the global interest for seismic safety, and value of preserving the existing buildings has gained on importance just recently. The increase in the interest in these types of projects was partially stimulated by huge losses in human lives and material losses during the past earthquakes, but the main reason for the increase in interest is due to long term fiscal instability of the by earthquake influenced countries, and its surrounding economy. The instability caused by several seconds of earthquake can cause a decade of investing into a region to get it back on track (NRC, 2011). The raising interest in securing the critical infrastructure of the cities, as well as providing safety for their citizens can also be evidenced in increasing numbers of regulations that are prescribing the special care for existing commercial and dwelling buildings (IRC and NRCC, 1993; PWGSC, 2000; NIST, 2002; SIA, 2004).

Although there is lack of research and data on this topic, some indications, as meeting reports and regulations, coming from private investors (insurance companies, banks), non-profitable organizations (World Bank, 2008) and governments (Canada, California, Switzerland, Austria, (EU, 2008)) are signaling that seismic strengthening of existing buildings are the next big thing.

The problem of retrofitting existing buildings has already been recognized, and although very few, some reports have been written about project manager's challenges in retrofitting business. In the project management world seismic strengthening and preservation of old city cores and other existing buildings has still not been discovered. Hereby also the project management tools, as e.g. risk identification tools, for seismic strengthening, retrofitting and historic buildings preservation projects are missing.

- Risk breakdown structure according to risk sources in Table 1 (Radujković, 1997)

Table 1. Risk breakdown structure for construction projects (Radujković, 1997)

1. External sources of risk in projects				
1.1.Legal risks	1.2.Political risks	1.3.Economic risks	1.4.Social risks	1.5.Natural risks
Local regulations	Change in politics	Economic politics	Education, culture	Climate
Permits, approvals	Elections	Prices, taxes	Seasonal work	Foundation
Changes in law	War	Financing conditions	Strikes	Fires
Standards	Treaties	Currency value		Earthquakes
				Floods
2. Internal sources of risk in projects				
2.1.Management risks	2.2.Design documentation	2.3.Human factor	2.4.Delivery and logistics	2.5.Contractual risks
Unrealistic goals	Superficiality	Productivity	Shortages	Type of contract
Poor control	Inaccuracy	Illness	Availability	Short time frames
Technology	Incompleteness	Motivation	Reliability of equip.	Unrealistic prices
Organization	Updated documents	Errors	Insufficient workers	Party relations

In project management qualitative risk analysis is considered as the most important phase. The analyst benefits from qualitative risk analysis in terms of project understanding and its potential problems. Qualitative risk analysis is also including the risk identification and classification with all the elements that are acting as risk triggers (Radujković, 1997). The most used risk categorization type is categorization according to risk sources. This approach has been accepted by PMI (PMI, 2000) by defining the risk sources by categories of possible incidents.

Standards Australia (Australia, 1999) is considering that by identifying the risk sources identification of the risk themselves is enabled. So far projects on existing buildings were mainly managed with already developed risk identification and management tools. In table 1 one of the first risk breakdown structures for construction projects is presented.

Generally accepted risk classification for construction projects is according to risk sources, but categorization varies according to the need in the specific type of the projects. A series of risk categorization types were studied, but for the further modification the selected categorization is as shown in Table 1.

2. Research

2.1. The motivation

When managing the construction of new buildings, tools for project scope definition, risk identification and cost management have long been developed, and successfully implemented. The rate of successfully accomplished projects is always increasing, but is still quite low (Radujković, 2012). But when managing either retrofit, seismic strengthening, preservation or redesign of an existing building, it is considered that already developed tools can cover the needs of a project manager who is obliged with the often ungrateful task. It seems that managing these types of projects is considered similar to new building construction projects, whereas practice convincingly shows otherwise. It is not rare that construction projects on existing buildings overrun time and/or the budget limits, sometimes even twice as originally agreed.

On the other hand the governments and private investors are increasingly becoming aware of the marketing power of old cores of cities. Hereby the interest in preserving the original look and often even the original construction of the buildings in the cities becomes imperative and a demanding task for engineers and project managers.

On behalf of these two statements the need to develop new or adapt existing tools emerges. The tool has to be usable for all kinds of existing buildings and built heritage construction or reconstruction projects.

2.2. The tool creation

In order to improve project management tools for construction projects in existing buildings we needed to research how different construction projects in new and old buildings really are.

The first step in this research was to create two generic work breakdown structures (WBS). The first generic work breakdown structure was created as a type of a checklist work breakdown structure which is supposed to describe all project parts needed for a construction of a new generic building. This work breakdown structure was created on basis of existing work breakdown structures that were created for previous projects.

The second work breakdown structure was created to accommodate a generic reconstruction, strengthening or retrofitting project for an existing building. This work breakdowns structure was created as a type of a checklist breakdown structure.

Now both work breakdown structures for construction projects on new and existing buildings were compared. The differences in scopes of work between the new and old building project were clear. It was clear that the major differences between the construction projects on new and old buildings are mainly consisting of preparatory works as structural investigation, preparation works, project logistics and implementation planning. The rest of the construction project on old buildings seemed to be in compliance with the construction project of a new building. At this stage the first question was answered: “Can strengthening project and preservation of existing buildings projects be successfully governed with existing risk management tools?” The suggested answer was: No, the strengthening and preservation of existing buildings construction projects CANNOT be successfully governed with existing risk management tools. This is due to the a part of the project, the investigation and project planning stage, which sets the important foundations for managing the risks in these projects.

Therefore our final product, a new or modified existing risk breakdown structure for construction projects on existing buildings needed to be invented. This meant that the already existing risk breakdown structure could just be amended with additional risk types.

In order to enable a quality risk identification process with as much risks identified as possible, the second work breakdown structure, intended for a generic construction project on existing buildings, had to be decomposed further in order to include all work packages that could be undertaken on this type of a project. Decomposition of the work breakdown structure was aided by several different bills of quantities. The bills of quantities were chosen from 3 completely different projects. The first bill of quantities was taken from a restoration project of a historical building. The second bill of quantities was taken from a construction project in a historical building that was to be repurposed from a residential dwelling into a retail store, and the third bill of quantities was originally created for a project of seismic strengthening of an old existing building.

Now this work breakdown structure could be used for "What can go wrong?" analysis. In addition to this analysis to cover as many risks as possible a special set of non-structured interviews with experts in that field was conducted. These were the experts' interview remarks:

- Even with existing historical documentation, the real structure of the building is not known. – Historical buildings used to be designed in one way, but then the design could be changed on site by the decision of the master builder without changing the design plans. This way if some parts of the building design were changed they can remain undiscovered, e.g. the foundations, or some construction parts.
- If assessing the building based on the typology of the building and the era they were built in, there is a great possibility that some constructive parts you are hoping to relay on are changed, or not used, e.g. brick vaults in the main hallway.
- Localized degradation of materials, as e.g. historic buildings were built without bathrooms, and when bathrooms were introduced they usually create wet spots in structures which are not able to handle constant moisture.
- Risky can be also previous construction works that were not documented or are done and are not allowable according to modern engineering knowledge, e.g. removal of structural walls at the ground floor level in order to achieve greater areas for shops.
- The expert assumptions. – assumptions on the material quality, structural design, etc.
- For historical buildings it is possible that the authority assigned for built heritage preservation changes the building protection level after the works have begun, or requests a drastic change in work plans.
- It can be that major problems are revealed while trying to solve another problem, e.g. while trying to prevent moist walls it is possible to discover that the building has weak or no foundations.
- Some interventions are not suited for all types of existing buildings and may cause even greater damages.

With the brainstorming sessions and expert interviews a broad list of potential risks was created, these were structured and a modified risk breakdown structure was created.

3. Resulting risk breakdown structure

The resulting risks from this research are categorized according to their source. The categorization is divided into two main categories: external risks and project risks. These two categories are mainly defined through their subcategories, as shown in the table 2.

External risks can be defined as risks that are defining the projects outcome, but are not a product of the project and cannot be triggered by any action from within the project. External risks are closely described with six subcategories:

- Legal risks – legal risks can generally be described by issues that are governed by legislative, regulatory frames, etc. But since existing and especially historical buildings are governed by specific regulations and laws, but also not rarely complicated ownership problems, that define the framework for the whole project, these risks need to be taken into account in this category as well. The legal risks are also defined by working and/or construction approvals that are regulated by law, but an important role in this problem is playing the Chamber for cultural heritage protection.

- Political risks – can change, or stop the flow of the project. These risks are emerging from and because of political interests. These risks are: government shifts; political election; wars; conventions;
- Economic risks – economic risks are including monetary politics, inflations, changes in financing type
- Social risks – are defined with next set of risks: strikes either from within the project organization (workers…) or from the outside of the project as civil strikes; ecological risks; culturally based risks as prohibited works during some national or religious holydays; seasonal working as e.g. forbidden works during a touristic season
- Natural risks – natural risks are defined by force majeure risks as earthquakes, fires, floods, or extreme temperatures
- Technical risks – these risks are specific for existing and historical buildings. These risks are the “hidden data” of the building that sometimes cannot be known even by extensive research works, like the hidden or repaired cracks in the construction, weak points created due to local specificities, or even the influence of the surrounding objects. Often historical buildings were built without any design documentation whatsoever, and sometimes when the design documentation exists, the historical buildings were built with major changes in the construction which were planned on site, but were never evidenced in the design documentation as e.g. weaker foundations than originally designed.

Table 2. Risk categorization for construction projects on existing buildings

External risks					
Legal risks	Political risks	Economic risks	Social risks	Natural risks	Technical risks
Ownership Laws Regulations and standards Work and construction approvals	Government shifts Political elections Conventions	Monetary politics Inflations Financing type changes	Strikes Ecology Culture Seasonal working	Earthquakes Floods Fires Extreme temperatures	Historic design documentation Not evidenced changes Past problems register
Project risks					
Management risks	Design documentation	Human factor	Delivery and logistics	Contractual risks	
Not realistic goals Bad control Arrangements Organization	Insufficient investigation Expert estimations Bad design documentation	Users Omission Workers Motivation	Insufficient materials Not available workers Not approachable areas	Contract type Prices Chain of control	

Project risks are defined as risks that are influencing the project outcome and are coming from within the project. These risks can have their triggers in the project itself. These risks can be described through five subcategories:

- Management risks – management risks can be described as risks that are a result of badly defined, or ever changing goals; bad project control; not contractually defined agreements that can harm either party of the project; organizational or technological issues.
- Design documentation risks – these risks are defined as not wanted results of bad expert estimations, bad or insufficient investigation works, bad analysis techniques which are characteristic mistakes when planning projects on existing buildings. On the other hand risks also include risks that are characteristic also when

planning new buildings as: Not completed and incorrect documentation or changes in design that are not delivered to all users.

- Human factor risks – human factor risks include problems that are emerging from users not willing to collaborate; or organizational omissions as e.g. securing the working areas; planning and organizing relocation of building inhabitants and their stuff. As a risk to this category problems with working staff can be included as lack of motivation and other humanely omissions.
- Delivery and logistics risks – these risks are not specific only for construction projects. These are lack of materials, or bad materials on stock, lack of workers, warehouse areas, etc.
- Contractual risks – these risks result from contractually defined margins, or from framework that should have been contractually defined, but was let out for whatever reason. These risks are: types of contracts; short terms that can badly influence the execution of the project on existing buildings; collaboration and organization of interested parties and project participants.

4. Risk breakdown structure for construction projects on existing buildings fine-tuning

In order to fine-tune the newly created risk breakdown structure for construction projects on existing buildings consultations with experts in this field of work were held. The experts were presented with the new risk breakdown structure, and were asked to comment and criticize. They were also asked to suggest improvements to the presented risk breakdown structure.

Three experts with extensive experience in different areas of construction projects were chosen. These were minimum needed conditions for experts: each expert needs to be from academic and professional circles; with more than 20 years of professional experience; experienced on at least 5 construction projects of this type.

The first expert was selected due to his longtime experience in field of project management and also experience in managing projects on existing and historical buildings. The second expert was selected for his experience in theoretical analysis, design and planning of construction projects on existing and historical buildings. The third expert was chosen for his longtime experience in organization and technology planning and execution of construction projects on existing and historical buildings.

The experts' remarks and suggestions are shown below:

- The quality control and the execution of projects in the past time differed from the practice today. Although some projects were correctly designed their construction was from time to time not according to the original design, not due to omission, but due to construction technology, e.g. the way the reinforcement was prepared for installation.
- Due to a specific planning and approval procedure that is the practice for construction works on historical buildings, for which a special approval from of the Chamber for cultural heritage protection is needed, the feasibility of the project can get to a critical point where works can be slowed down or stopped completely.
- The construction projects are a complex set of triggers and risks and therefore two experts concluded that there is a set of project risk sources that cannot be fitted into existing subcategories, and therefore an additional subcategory in category of project risks is proposed: Project realization risks
- Uncertainties in the project, both during the planning, or realization phase can significantly influence time and costs of the project realization.
- Chamber for cultural heritage protection gives important margins to every project on historical buildings, especially risky if user's and chamber's "needs" cannot be reconciled.
- Buildings are often built on grounds that are prone to landslides and/or liquefaction.

According to these remarks risk breakdown structure has been modified, and the resulting risk breakdown structure is shown below in table 3:

Table 3. Risk categorization for construction projects on existing buildings

External risks					
Legal risks	Political risks	Economic risks	Social risks	Natural risks	Technical risks
Ownership Laws Regulations and standards Work and construction approvals	Government shifts Political elections Conventions	Monetary politics Inflations Financing type changes	Strikes Ecology Culture Seasonal working	Earthquakes Floods Fires Extreme temperatures	Historic design documentation Not evidenced changes Past problems register Ground-building; Building-building interaction
Project risks					
Management risks	Design documentation	Human factor	Delivery and logistics	Contractual risks	Project realization risks
Not realistic goals Bad control Arrangements Organization	Insufficient investigation Expert estimations Bad design documentation	Users Omission Workers Motivation	Insufficient materials Qualified workers availability Not approachable areas	Contract type Prices Time Chain of control	Feasibility Expertise and experience of realization group Users-Heritage protection needs

According to experts opinions an additional subcategory in the project risks category was added (Table 3). The additional subcategory is named “Project realization risks”. These are a special set of risk sources that can cause changes in project outcome, and are originating from within the project. Project realization risks are specific and can be triggered in the execution phase of projects on existing buildings. Project realization risks are originating from the complexity of the works that are present on these projects and therefore are requesting expert engineers, workers and supervision. Complex planning and technology is often needed for project execution, but even well planned, the application of the complex technology can be impossible due to local problems of the construction. Insufficient education, knowledge or improper working approvals regarding the works on historical buildings are also risks to be taken into account in this subcategory.

5. Conclusion

To recapitulate the main research questions: Can strengthening and preserving existing buildings construction projects successfully governed with existing risk management tools? If not, how can we improve the existing risk management tools?

As the research results suggested due to existing and important differences between the construction projects on new and existing buildings the already existing risk management tools as risk breakdown structure cannot be used, and a creation of new risk breakdown structure is needed.

Through a series of different research methods a list of possible risks that could result in project scope, cost or time change were identified, structured and a modified risk breakdown structure was created, as presented in table 3. Unlike other existing risk breakdown structures two additional subcategories of risk sources were identified and added to modify the original risk breakdown structure. This way a new risk breakdown structure suitable for construction projects on existing buildings is created.

Although the presented risk breakdown structure was validated by experts, use of presented risk breakdown structure for construction projects on existing buildings is suggested, but with increased caution.

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