Conference Title (26th IPMA World Congress, Crete, Greece, 2012)

An effective disaster recovery model for construction projects

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Abstract

This article studies disasters during the development phase of construction projects and seeks for effective recovery methods. Disasters can be based on various reasons –i.e., natural, technical etc.-, can be observed in many cases –i.e., the mountain sliding during the tunnel opening at Tempi, Greece; the explosion of the British Petroleum (BP) oil pumping platform in the Gulf of Mexico; and the San Esteban mine collapse in Chile- and question the risk estimation and analysis methods that had been performed before project’s commencement, and the business readiness of the project organization. Moreover, disasters can cause significant delays and cost rises to a project, while they can lead to construction’s cancellation in cases of extensive damages or of site’s natural disasters.

In this context, this paper aims to structure a generic model that consists of principles and processes, which can recover a construction project after a disaster effect. Various terms (i.e., hazard and risk analysis, safety planning and disaster) and the international project management standards are explored for the purposes of this paper and accurate existing disaster recovery frameworks and models are investigated. The outcomes of this analysis are used for the composition of the proposed model.

Finally, the efficiency of the proposed model for a wide area of projects was tested via a survey, which was performed on a group of expert engineers in construction management. Experts’ perspectives and experiences were questioned regarding the proposed disaster recovery model and their answers used for the revision of the proposed model.

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Keywords: disaster; disaster recovery; recovery; recovery plan; project management; construction; construction management; risk; hazard; crisis; safety.

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1. Introduction

Various unwelcome situations can occur during the implementation of a construction project, which are based on natural phenomena (i.e., hurricane, flood, earthquake etc.), on socio-political conditions (i.e., war, political crisis, financial recession etc.), on technical and complexity reasons (i.e., inexperienced workers’ faults) or even due to site’s conditions (i.e., ground failures). Each of the unwanted situation can cause damages to the project, which vary from delays, extended costs and changes, to complete cancellation (i.e., in cases of entire site’s demolition). These unwelcome phenomena are called disasters (Blackhard, 2006), “crises” (Loosemore, 1999) or “failures” (Kerzner, 2011).

Disasters vary according to their sources, to their size and to their effects on a project, while a project could recover from a disaster that does not affect its definition and feasibility. Project managers and project management international standards suggest detecting dangers with multiple available techniques, while they promote controlling uncertainty and avoid taking risks that expose the project to hazards.

This paper explores the context of disaster recovery in construction, while it studies existing project recovery frameworks, methods and techniques, which can be capitalized by project managers for recovering constructions from feasible disasters. A recovery model is proposed that consists of appropriate perspectives that suggest the proper reviving procedure. This model is based on the knowledge areas of the Project Management Body of Knowledge (PMBOK) (PMI, 2007) and it could be considered generic for construction projects. The effectiveness of this model is questioned by a group of expert construction engineers, who provided this paper with their experiences for project recovery and with the proper review directives of the proposed model.

The remaining article is structured in the following sections: the background section 2 describes the paper’s objectives, while it presents the domain analysis of disaster recovery and provides with terms’ definition and clarification. Section 3 illustrates existing recovery frameworks, which are combined to a draft recovery model according to the PMBOK knowledge areas. In section 4, this draft model is given to a group of expert construction managers who empirically evaluate it and suggest revisions to the finally proposed model. Finally, section 5 contains conclusions and future thoughts regarding the outcomes of this study.

2. Background

2.1. Problem definition

Various disasters may appear during the development phase of construction projects. Three particular accidents inspired this paper: British Petroleum (BP) oil-drill platform’s explosion: BP had undertaken a project for oil-drilling in the Gulf of Mexico and it had installed the Macondo drill platform with the participation of Deepwater Horizon and Halliburton companies. On April 20, 2010 an explosion caused more than eleven deaths and more than seventeen injuries, while an extensive pollution to the Gulf’s waters was resulted. The response to this emergency was late and without a pre-defined plan, which could handle the situation and limit the disaster’s implications. An investigation that was performed by the White House Energy Committee concluded to a set of reasons that led to the above disaster –i.e., materials of low standards, mistaken manipulations etc.-, while an inefficient safety plan and the total absence of an emergency plan were determined (New York Times, 2010).

The San Esteban mining company in Chile was drilling coal and gold at the San Jose mine, when on August 5, 2010 the mine was collapsed and a list of 33 miners were trapped. After a seventeen day period, the miners were determined to be alive 700m below the surface and a successful innovative rescue plan...
was organized. Inefficient safety plans and the total absence of an emergency plan were determined in this particular case too (New York Times, 2011).

The Aegean Highway project (Maliakos – Kleidi / MKC Project) concerns the development of a Greek highway, which contains three identical tunnels of a total length of 22Km. One of them passes closely to the existing national road and it is analyzed in the Southern (T2S) site –contracted with the AEGER Constructions S.A.- and Northern (T2N) site –developed by the Aktor & Hochtief coalition-. On December 17, 2009 huge rocks fell to the existing national road and caused death to the Project Manager of the T2S site. The accident showed that no safety planning measures had been taken regarding the nearby national road, although the Experts’ Committee that investigated the accident did not conclude whether the tunnels’ opening works caused the rock fall or it was a natural phenomenon. However, no emergency plan had been prepared, the project stopped for a few weeks, and the construction coalition was obliged by the State to recover from this disaster and to secure the national road with fence across the mountain. Although the expenses were undertaken by the State, the project changed regarding its definition, organization and duration.

The abovementioned disasters showed that these projects were damaged differently, either due to technical or to natural reasons. All of these projects were not secured efficiently with safety planning measures, while no emergency/recovery plans were prepared to deal with unpredicted phenomena. The size of the disaster in all these cases varied but it was significant, while their implications to the environment and to the community were crucial. These accidents define the objectives of this paper, which aims to investigate recovery methods and techniques that can be effective and efficient for feasible disasters during construction projects, in order for a generic recovery model to be structured.

2.2. The context of disaster recovery

Disasters may occur as the result of unpredictable conditions or of underestimated risks (Blackhard, 2006) and can be concerned as the outburst of a natural disaster, a technical accident or a failure that causes damages, fatalities and injuries, and even unwelcome implications to the workers, the community, the environment or the project (FEMA, 1973). This definition classifies disasters according to their sources such as natural (i.e., flood, hurricane, earthquake etc.), technical (i.e., complexity, innovation, inexperienced workers, materials of low quality, ineffective construction methods etc.) and socio-political (i.e., political instability, war, financial recession etc.) or to their effects. Sheehan and Hewitt (1969) describe disasters as the events that cause at least a hundred human deaths or a hundred human injuries or at least $1 million economic damages. Moreover, Horlick-Jones and Peters (1991) introduced the Bradford Disaster Scale according to the resulted fatalities (magnitude of disaster), while the damage scale is influenced by the exposed area and the access to reviving resources (Carroll, 2001). Disasters’ characteristics concern the length of forewarning; the magnitude of impact; the exposed geographical area; the duration of the effect; and the speed of onset (FEMA, 1973).

Disaster recovery is the process of bringing the organization or the project that was affected by the damage to the before-the-accident condition (Nigg, 1995). Disaster recovery is synonym to business continuity, which is defined as a prevention and rehabilitation plan against enterprise’s internal and external threats, which secures business integrity and competitiveness. However, business continuity is mostly a preventive method, while disaster recovery is a restrictive one.

Pardede and Tetsuo (2007) defined a two-stage model for the post-disaster recovery process: the short-term stage where a reaction against the disaster is undertaken; and the long-term stage that concerns the activities that recover the organization’s operations or the project. These two stages overlap and their duration and the initiation are not determined. The plan that controls the execution of a disaster recovery
process is called *disaster recovery plan* or *emergency plan* and has several attributes for hazard detection, risk minimization, safety planning and resource capitalization.

In this paper, the targeted recovery model tries to commonly handle an unwelcome situation regardless disasters’ classification. Each effect is analyzed in two phases: (a) the *pre-disaster* and the (b) *post-disaster*. The pre-disaster phase contains activities concerning detection, estimation and preparation with safety planning against hazards and risks that can cause a disaster. On the other hand, the post-disaster phase concerns the activities that have to be undertaken in order to handle the disaster effects and make the project returning to the pre-disaster level with the minimum –possible- damages.

On the other hand, crises describe *unexpected, potent and cryptic events which require rapid response* (Loosemore, 1999). It is concluded that a crisis can generate a disaster and vice versa, while a crisis can be a long-term phenomenon (i.e., financial recession, war etc.). Crises are the results of mismanaged risks too and require proper planning during the project design phase and control during their appearance. Crises can also appear during construction projects and their management process concern reactions against the crisis effects (Loosemore, 1999).

A *hazard* concerns the probability of a disaster to occur or a potential unwelcome situation (Baybutt, 2003). *Hazard analysis* concerns the recognition and estimation of a threat and it is the process of identifying and measuring a hazard. Various hazard analysis methods have been developed, such as the what-if, the Fault-tree, the HAZOP, the Event-Tree, checklists etc. (Baybutt, 2003). A *risk* on the other hand describes a positive or negative situation that leads to divergences from initial project’s objectives. (Baker et al., 1997). Risk is associated with uncertainty during a project, while it is influenced by project’s complexity, changes and its general eco-system, variants that generate vulnerabilities to a project. Moreover, hazard affects project’s *Value* in terms of human lives, properties and construction processes.

*Safety planning* is the procedure for detecting and avoiding accidents during a project (Hallowell, 2010). Project management international standards (PMI, 2007) and national, supranational and international legislature recognize the importance for safety and health and provided the construction industry with rules and methods for safety planning.

3. Disaster recovery approaches

3.1. Contextual frameworks and methods

Disasters are usually treated as crises in construction projects and no generic management theory -that oversimplifies crises- has been proposed. A limited literature review returned the following construction crisis management methods and frameworks:

Loosemore (1999) gave four propositions for crisis management, which concern (a) the stimulation of a temporary communications network within the construction project organization; (b) the determination and control of the different phases of behavior that characterize the reaction process (Loosemore, 1998); (c) the enhancement of crisis management efficiency and communications network’s structure; and (d) the avoidance of conflicts that discourage collective responsibility.

Sutrisna and Barrett (2012) proposed Rich Picture Diagrams (RPD), which are based on the Grounded Theory Methodology (GTM) in order to improve crises’ presentation in storylines and to enable their thorough analysis. Their diagrams concern a two dimensional matrix putting the reaction stages in columns and the major impacts in rows.

Coleman (2004) defines crises as single incidents that cause consequences to organization’s viability, they attract unprecedented attention which can identify parallel problems or magnify otherwise minor incidents. In this view, he proposes measurement methods for the financial impact of crises; he considers...
the existence of up-to-date emergency plans crucial, while he encourages the execution of management methods that meet stakeholders’ expectations against technically excellent solutions.

Kerzner (2011) defines a generic method for reversing a failure project, which consists of the evaluation and the recovery phases. The evaluation phase contains steps regarding failure’s understanding, auditing, tradeoffs’ determination and negotiation. The recovery phase consists of the restart and the execute steps that focus on the project management success triangle (time/cost/scope) and to a modified triple constraint system (value/quality/image-reputation).

Hallgren and Wilson (2008) classified various crises’ sources, analyzed a number of case studies and concluded to the following set of activities for project recovery: (a) effective risk management during project planning; (b) the existence of a dual structure in the company’s organization for crisis management and for catastrophe avoidance; (c) instantaneous communication of crises between site team and project team; and (d) simultaneous operation of formally and informally developed teams.

Fung et al. (2009) combined disasters with risk underestimates and with inefficient safety planning. From this view they defined a risk assessment model (RAM) for construction safety. Their model evaluates risks and safety plans according to historical data of accidents and disasters, while they suggest principles for disaster avoidance: (a) installation of safe workstations and construction sites; (b) continuous workers’ training regarding safety; (c) construction method improvement; and (d) effective safety planning for both the workers and the project.

Rozenfeld et al. (2009) introduced the “CHASTE”, which is a construction hazard assessment framework. Their framework combines risks with resources’ occupancy, it classifies the construction activities according to their risk levels and it displays the ones with risk level that overcomes a predefined threshold. Then, the construction activities have to be rearranged in a manner that reduces risks to an acceptable rate.

Regarding the international project management standards, the International Project Management Association (IPMA, 2006) recognizes crises coming out of conflicts in its Competence Baseline (ICB), as part of the behavioural competences and describes a set of process steps for crises management. Furthermore, health, security, safety and environment are part of the desired contextual competencies and their analysis process is proposed for project’s planning. Finally, risks are part of the technical competencies and a risk management process is illustrated. On the other hand, the Project Management Institute’s (PMI) Body of Knowledge (PMBOK, 2007) recognizes risk and safety planning as integral parts of the construction management process, it proposes tools and techniques to deal with risks and safety but it does not provide managers with elements for disaster management. The British Office of Government Commerce recognizes disasters as the result of a risk, which is one of the seven themes in their PRojects IN Controlled Environments (PRINCE2) (CCTA, 1999) management method, and puts risk and risk analysis in the managing stage boundaries process.

3.2. The proposed disaster recovery model

As a result of the previously presented approaches, models, frameworks and standards regarding disaster recovery, the following model is structured that combines their experiences and contributions. The proposed model is inspired by the implementation model that was introduced by (Anthopoulos and Tsoukalas, 2006) and suggests a number of perspectives to project managers who deal with disasters. The PMBOK knowledge areas were used to identify the model’s perspectives -in order for this model to become generic for managing disasters efficiently-. Moreover, the model uses the Rich Picture Diagram (RPD) (Sutrisna and Barrett, 2012), where the perspectives concern the diagram’s rows and the recovery steps compose the columns. The RPD illustrates the assignment of an indicative recovery process to the
model’s perspectives (Fig. 1). The process is analyzed in an ordered set of steps, each of which is executed with the priority of its index number.

Fig. 1. The proposed disaster recovery model for construction projects

Five different perspectives and four stages compose the proposed model and address the development of an indicative eleven steps’ recovery plan. The perspectives concern: (a) integration perspective that contains the integration, risk and safety management PMBOK knowledge areas. It handles the processes regarding risk analysis, disaster management board’s development and its response to the disaster’s incident. (b) Preparation perspective includes the scope, time and procurement management PMBOK knowledge areas and it defines and controls the recovery preparation steps. (c) The communications perspective addresses the communications, human resource and claim management knowledge areas and contains the steps for determining the disaster management board, the communications schema and to control behaviors during the incident. (d) The recovery perspective aligns to the cost, financial and environmental management knowledge areas and considers the recovery and business continuity steps, while it performs damage calculations. Finally, (e) the quality perspective considers awarding and evaluation/review steps of the recovery plan, which align to the quality management PMBOK knowledge area. The model’s stages on the other hand, illustrate the recovery process’s steps that align to the PMBOK’s processes emergency plan, regarding (a) initiation; (b) planning; (c) execution; and (d) control and review.

4. An experts’ review on the disaster recovery model

The previously presented model follows the existing literature’s approaches to disaster recovery. However, testing and evaluation were necessary in order to measure its applicability and effectiveness against feasible disasters. In this context, a structured qualitative questionnaire was composed and submitted to a group of thirty seven (37) engineers who are experts (with more than fifteen years of professional experience) regarding construction project management. The target group was selected by the authors due to previous collaboration with their companies in construction project, while the survey took place between 10 and 30 of March 2012, and twenty two (22) of the submitted questionnaires were collected. The survey sample was homogenous, since all the questioned people hold a graduate certificate in civil engineering, they had the same level of experience and they work as employees for construction
companies in central and northern Greece. Eight (37 percent) of them were female, while all were aged between 30 and 45 years old.

Table 1. Disaster recovery proposed model’s review

<table>
<thead>
<tr>
<th>Question group</th>
<th>Answers</th>
<th>Percentage (%)</th>
<th>Alternative Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business impact analysis</td>
<td>18</td>
<td>81.8</td>
<td>Behavioral management has to be performed</td>
</tr>
<tr>
<td>Resources’ and board’s definition</td>
<td>16</td>
<td>72.7</td>
<td>A dual structure in project’s organization</td>
</tr>
<tr>
<td>Disaster recovery plan’s suitability</td>
<td>20</td>
<td>90.9</td>
<td>The incorporation of steps for handling un-exposed threats</td>
</tr>
<tr>
<td>Model’s perspectives applicability</td>
<td>21</td>
<td>95.4</td>
<td>To incorporate legal and ethical perspectives against fatalities and injuries</td>
</tr>
<tr>
<td>Recovery testing calendars and simulations</td>
<td>22</td>
<td>100</td>
<td>No alternative suggestions were given. Negative answers claimed that construction companies do not invest in risk analysis.</td>
</tr>
<tr>
<td>Events’ calendars for disaster recording</td>
<td>19</td>
<td>86.4</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. The revised disaster recovery model for construction projects

All of questioned engineers had faced disasters during their projects, which were mostly triggered due to technical sources, innovative constructive methods and to human errors, while none of the disasters was managed via a pre-defined recovery plan. Before the survey, they all considered disasters as an integral part of safety planning, while they all welcomed the survey for clarifying the notions of crisis, disaster, risk and safety. The survey questions were classified in six groups regarding, (a) the significance of business impact analysis; (b) the importance of resource pre-allocation and disaster management
board’s determination; (c) the disaster process’s steps definition, relation and ordinance; (d) the applicability of model’s perspectives; (e) the incorporation of recovery testing calendars and simulations’ execution outcomes; and (f) the adoption of events’ calendars that store disasters, their impacts etc. The survey results are illustrated on (Table 1).

The above findings report a sufficient effectiveness of the proposed model, while the most important alternative opinions can be summarized in: (a) the necessity for incorporating a legal & ethical perspective, which would separately handle the disaster’s implications to human lives. This perspective would incorporate the claim and safety management PMBOK’s areas. (b) The incorporation of steps for handling threats that do not activate, although they appear during project development. An additional stage for managing inactive threats can be incorporated in the proposed model or an alternative disaster recovery plan can be defined. (c) Resource pre- allocation is not considered cost-effective and experts suggest the Hallgren and Wilson’s (2008) dual structure’s existence in the project’s organization, which will undertake disaster and crisis management. (d) The communications step of Stage 3 must deeply account behavioral management (Loosemore, 1998). Experts’ abovementioned opinions and suggestions do not decline but strengthen the proposed model, which can be easily revised to (Fig. 2).

5. Conclusions and Future Thoughts

This paper was inspired by disasters that have been occurred during alternative construction projects, which have caused feasible damages to the projects, have been treated inefficiently by projects’ organizations without the existence of management plans and which have induced severe implications to human lives, the environment, the business reputation etc. From this point of view, this paper studied the notion of feasible disasters in construction projects and clarified the alternative terms that deal with damages (i.e., crisis, accident, safety, risk etc.). This paper explored existing disaster recovery approaches, models and frameworks, while it presented how the international project management standards deal with disasters. Finally, it proposed a disaster recovery model, which was based on the existing approaches and on PMBOK’s knowledge areas, in order for being considered generic for different construction projects and feasible disasters. Finally, the proposed model was evaluated and reviewed by a group of experts and some suggested aspects were respected. Some future thoughts concern the proposed model’s testing on numerous disaster phenomena.

Acknowledgements

This paper is based on the results of the postgraduate dissertation entitled “The Effectiveness of a Disaster Recovery Plan for an Under Development Construction Project”, which was developed by the authors during the academic years 2011-2012 at the Construction Management Postgraduate Program of the Hellenic Open University (HOU), Greece.

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