Development of Earthquake Crisis Management Strategic Plan for Metropolitan Motorway Systems

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Summary

The paper presents the development of a new methodology for prediction, rapid diagnosis and assessment, and management of the consequences of a strong seismic event affecting an urban transportation network. The methodology is divided in three stages: (a) pre-seismic risk assessment of major structures along the motorway, (b) estimation of strength and vulnerability of structures, and (c) parametric analysis of the consequences of different seismic scenarios, both in terms of structural damage and with regard to traffic operations. This way, the expected damage for the various structures of the network and its consequences are estimated before the occurrence of a possible future seismic episode, allowing timely preparation of a robust strategic plan for rapid assessment and crisis management. The strategy encompasses the actions to be taken by the network administrator in order to ensure safety and achieve optimum serviceability of the motorway.

Keywords: motorway; crisis management; risk assessment; earthquake; bridges; tunnels

1. Introduction – The need for a Crisis Management Plan

In a strong seismic event, a motorway transportation network may experience:

(a) *Temporary closure of lightly damaged sections*, until post-seismic inspection is completed.

(b) Prolonged closure of moderately damaged sections, in fear of possible aftershocks.

(c) Long-term closure of severely damaged or collapsed sections, until rehabilitation is completed.

(d) Deterioration of the serviceability of the motorway system.

(e) *Additional injuries or even fatalities* due to possible collapses during aftershock(s) of already damaged (during the main shock) damaged infrastructures.

Apart from the obvious socio-economic consequences, the lack of a strategic crisis management plan is likely to bring about feelings of insecurity and resentment to the users of the motorway system, hence proliferating the generalized sense of panic and causing further disruption.

An effective crisis management plan should:

(i) Ensure the safety of motorway users.

(ii) Allow rapid diagnosis of the post-seismic capacity of critical motorway infrastructures.

(iii) Minimize the response time of the system administrator.

(iv) Optimize the performance of the system.

In view of this need, this paper presents a methodology for: (a) pre-seismic risk assessment, (b) estimation of strength and vulnerability of critical motorway infrastructures, and (c) parametric

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analysis of the consequences of possible seismic scenarios, both in terms of structural damage and traffic operations. This way, the expected damage for the various structures of the network and its consequences can be estimated before the occurrence of a possible future seismic episode, allowing timely preparation of a robust strategic plan for rapid assessment and crisis management.

2. Methodology Overview

The consequences of a seismic event can be distinguished in: (a) structural damage of motorway infrastructures, and (b) deterioration of the serviceability of the motorway. The latter can either be due to a *decrease of the capacity* of the network due to damage of motorway infrastructures, or to the *increase of the demand* due to damage within the neighbouring urban environment.

The main dilemma will be whether or not to interrupt the operation of the network. Preventive closure may seem as a safe option. However, it may lead to dramatic losses, since it will lead to obstruction of transportation of critical groups, such as rescue teams. In addition, such an action would prevent the use of the motorway as a means of evacuation. On the other hand, maintaining the network in operation without inspection may jeopardize the safety of users and rescue teams.

Prior knowledge of the seismic vulnerability of structures is necessary: (i) to rationally decide whether there is a need for emergency inspection, and (ii) to ontologically allocate the inspection teams, allowing for minimum disruption of traffic operations.

Such prior knowledge will enable prediction of potential damage distribution, facilitating the detection of sensitive areas. This way, realistic seismic damage scenarios can be devised beforehand, to estimate the potential capacity deterioration of the motorway network, as well as the increased demand due to damage in neighbouring urban areas. These scenarios can then be utilized to test (through traffic analysis simulation) the effectiveness of possible emergency response actions.

The final outcome of the proposed procedure is the development of an *Emergency Response Plan* that will rationally set the actions to be taken by the system administrator in order to manage the earthquake-generated crisis as effectively as possible.

The paper provides an overview of the necessary steps to develop such a strategic plan :

1. Development of GIS Database
2. Seismic Risk Assessment
3. Vulnerability Assessment and Prediction of Structural Damage
4. Earthquake Classification
5. Prediction of Traffic Serviceability Deterioration
6. Emergency Response Plan

3. Socio-economic Benefits

From a *strictly economic point of view*, the investment for the development of an *Emergency Response Plan* will yield a measurable profit *if and when* a major seismic event will occur. For countries (such as Greece) or states (such as California) of large seismicity, such an event will likely occur during the life of the motorway. In such a case, the Motorway Operation Authority will be able to minimize the inspection time, keep lightly damaged motorway sections in operation, and re-open moderately damaged sections the soonest possible.

Evidently, the *socio-economic benefits* are substantially higher. Even long before the occurrence of such an event, motorway users will feel confident that even in a natural disaster, the Motorway Operation Authority will be in the position to assist them in the most professional way, and maintain the motorway under safe operation. Naturally, campaigns will be required to raise public awareness (e.g., leaflets dispensed to users at Toll Stations). Such confidence will increase the use of the motorway system, yielding a substantial – *although indirect* – economic profit for the Motorway Operation Authority.

Finally, the importance of *strictly societal benefits* should not be underestimated. The minimization of the risk of casualties, and the availability of the motorway system for rescue operations, cannot be measured in monetary terms, but are at least of equal importance.