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STRUCTURES IN FIRE AND EARTHQUAKE

S. Tesfamariam[1]

ABSTRACT

The resulting fires of the 1906 San Francisco, 1923 Tokyo, and 1995 Kobe earthquakes have caused catastrophic damages. The possibility of fire following earthquake is a threat not only to Japan and the United States, but to any area that is susceptible to earthquakes. This necessitates the need for the development of a risk assessment model to predict the sequences of events that lead to, and following a post-earthquake fire. This paper is part of the special session on Structures in Fire and Earthquake, and addresses the questions posed by the organizers.

1. Is fire and earthquake research an emerging area?

In Japan and the United States, fire has been the single most destructive seismic agent of damage in the twentieth century. It has been reported that fire following earthquake can result in losses up to ten times those due to earthquake shaking alone. Fire following an earthquake is a major cause of damage to building and other structures. The current trend is developing a research in a multi-hazard framework, where the likelihood and impact of fire and earthquake are quantified.

2. Why is it important to support research and development on safety and design of structures subjected to earthquake and fire?

The recent devastation of fire induced damage shows the need for developing robust multi-hazard (fire, earthquake) based framework. This has to be corroborated through analytical and experimental work. There is a need for garnering research funding in this area.

3. Can we quantify the likelihood of a fire in structures after an earthquake?

In order to quantify the likelihood of fires in structures, different causes of ignition need to be identified. The causes of ignition are dependent on earthquake magnitude, hazardous material release, overturning of electrical devices, gas pipeline rupture, and number of fallen power lines. Thus, considering the likelihood of earthquake occurrence, the different sources of ignitions can probabilistically be quantified and the fire load can be generated.

[1] Assistant Professor, School of Engineering, The University of British Columbia - Okanagan, 3333 University way, Kelowna, BC, Canada, V1V 1V7, Tel: (250)-807-8185, E-mail: Solomon.Tesfamariam@ubc.ca

4. Large numbers of building structures in the North America are constructed with lightweight framed construction. Does this mean that this area is in high risk of fire after an earthquake?

The lightweight framed constructions are prone to damages as a result of fire following earthquakes. The ease of spread refers to how likely it is that a city's characteristics will facilitate fire spread. For example, dense areas composed of mainly wooden structures allow ignitions to jump from building to building quickly. The speed at which fires develop and spread determines whether or not conflagration will occur.

5. Thousands of structures are exposed to fire in the world every year. What are the measures should be taken into consideration for protection of these buildings against a future earthquake?

The best source of protection entails mitigation of the source of fire ignition. This can be undertaken through a risk management framework, where the hazardous material release, overturning of electrical devices, gas pipeline rupture, and number of fallen power lines are managed. Furthermore, other defensive measures that can be considered are improving fire protection system of the building and suppression ability of the city fire fighters.

6. Can an earthquake create a fire in a building structure during an earthquake and how would the fire load be significant?

This scenario of earthquake and fire load has a compounding effect. The earthquake load can potentially degrade the structural capacity of the building and also damage the fire protective layer. Subsequently, when the building is subject to fire following earthquake, the lower structural capacity coupled with less fire protective layer, can severely be damaged during the fire load.

7. What are the dilemmas of the fire departments to control the building fires in such events?

The earthquake induced structural degradation and damage will make the buildings prone to collapse. Consequently, the dilemmas the fire department will be faced is to identify the critical buildings that need immediate attention and less likely to collapse.

8. How significant is the effect of fire on a structure, after it is damaged by an earthquake?

Seismic shaking from the earthquake may cause building damage from internal damage due to fallen contents to a severe case of structural collapse. Building damage will be assigned a state of None, Minor, Moderate, or Major. In the more severe cases, emergency crews will be needed on site, and will decrease the amount of equipment and manpower available for firefighting purposes. Building damage is therefore dependent on earthquake magnitude, and affects response time.

9. Is there any design code that includes assessment and design of structures for fire and earthquake?

The codes deal with fire and earthquake as separate loads. It is important, however, to consider development of a multi-hazard (fire, earthquake) load scenarios.

10. What are the structures/infrastructures that their failure as the result of fire after an earthquake could have a significant impact on the rescue missions?

The rescue mission can be impacted as a result of road closure and bridge damage that has a direct influence on mobility. Damage refers to any form of road impediment from the presence of debris, cracking in the pavement itself, and failure of bridge link. A decrease in mobility affects not only mitigation, but also controls the speed at which emergency vehicles can respond. One of the main factors that caused conflagration following the 1995 Kobe earthquake was the impedance of the fire fighting department by traffic congestion and road obstructions.

11. What are the areas related to structures in fire and earthquake which require immediate research and development?

The resulting fires of the 1906 San Francisco, 1923 Tokyo, and 1995 Kobe earthquakes have caused catastrophic damages. The possibility of fire following earthquake is a threat not only to Japan and the United States, but to any area that is susceptible to earthquakes. This necessitates the need for the development of a risk assessment model to predict the sequences of events that lead to, and follow a post-earthquake fire.

There is a need for developing a multi-hazard decision making framework, where the likelihood of fire and earthquake their impacts are quantified. This entails research on fire following earthquake requires information on quantification of likelihood of earthquake occurrence and initiation of fire, and potential for damage. All this have to be encapsulated in a risk assessment framework. The risk assessment framework requires developing a fragility curves for buildings damage due to earthquake and exposure to fire.