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DEMAND AND PROVISION FOR POST-EARTHQUAKE EMERGENCY SERVICES: CASE STUDY OF SAN FRANCISCO FIRE DEPARTMENT

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SUMMARY

Building collapse search and rescue (SAR), post-earthquake fire (PEQF) and hazardous materials (Hazmat) releases are sources of enormous earthquake damage potential in major industrialized urban areas. Presently, damage due to PEQF can be quantitatively estimated, while emergency response needs for SAR can be but have not been, and hazmat cannot. Preparedness for these hazards is poor. Quantification of PEQF has led to significant mitigation measures, which would indicate that quantification of the other hazards would similarly improve mitigation. Many issues impede mitigation of these hazards, including lack of credible damage scenarios, lack of effective search and rescue techniques, control of ignition and hazmat release, adequate damage reconnaissance, alarm and/or detection systems, reliable water supply, and the special problem of high-rise post-earthquake fire.

INTRODUCTION

Building collapse search and rescue (SAR), fire and hazardous materials releases following earthquake are the most complex and challenging aspects of urban earthquake hazards reduction today. In both Japan and the United States, fire has been the single most destructive seismic agent of damage in the twentieth century. Building collapse search and rescue is the most graphic image associated with earthquakes, and a very serious problem (Ref. 1). It requires response within hours or, at most, a few days, Figure 1.

While not widely perceived, Post-earthquake Fire (PEQF) continues to pose a very substantial threat in several countries today, including the USA, Japan, Canada and New Zealand. Release of hazardous materials (Hazmat) has not been a major agent of damage in earthquakes to date, but under ordinary conditions has demonstrated potential for major life loss and property destruction. These three topics, SAR, PEQF and Hazmat, are treated together because they share several commonalities:

(1) Firstly, their <u>first response</u> is by the same personnel, the local fire service, who must make critical resource allocation decisions immediately

following the earthquake, between these hazards and other problems (such as emergency medical treatment).

(2) Second, they are often interactive, where a release of hazardous materials can lead to fire and/or explosion, or a fire can result in wide dispersion of hazardous materials, or victims trapped in a building collapse are threatened by fire.

(3) Lastly, PEQF and Hazmat are both dynamic, requiring rapid response and mitigative action, else acquiring catastropic proportions.

This paper first briefly summarizes the state of knowledge and preparedness for these hazards in the United States today, next discusses issues confronting present US mitigation programs, and lastly presents some thoughts on how improvements in mitigation might proceed.

PRESENT KNOWLEDGE AND PREPAREDNESS

Building Collapse SAR: Building collapse search and rescue is very underdeveloped. The 1985 Mexico City experience alerted many individuals to this. The situation may be summarized as follows:

* While many techniques exist for the location of victims in collapsed buildings (e.g., dogs, infrared, vibration monitoring, remote TV cameras, artificial sniffers, ground penetrating radar, etc), effective means are presently lacking for the reliable location of victims in collapsed buildings,

* Furthermore, when located, rescue techniques presently consist almost solely of tunneling and burrowing, which is tedious and very time-consuming.

* Lastly, most rescue teams, including even professional medical and emergency treatment personnel, are not adequately versed in rescue medicine. Special problems, such as injury to the spinal column, and "crush syndrome" are largely unappreciated (F. Krimgold, personal communication).

A recent limited investigation into Heavy Debris Removal and Rescue (Ref. 2) concludes that "handheld and small power tools, useful in burrowing and tunneling, are required to extricate victims from collapsed buildings follwing a major earthquake", rather than the more common perception that heavy equipment is needed. Further, that "heavy debris and associated rescue-related problems will generally occur in any multistory non-wood buildings that collapse as a result of earthquake shaking".

With regard to preparedness, very little is being done in an organized manner in the US. A recent modest effort on the part of the US government (Ref. 3) now permits rapid visual screening of seismically hazardous buildings, which may in the future form the basis for identification of those buildings most likely to collapse and result in numerous trapped victims.

Post-Earthquake Fire: Although fire following the 1906 earthquake was the overwhelming cause of the damage San Francisco and Santa Rosa, and has continued as a significant cause of damage since, it has received relatively little attention. This is due to a number of factors (Ref. 7) including the lack of an analytical framework within which to model the many factors involved in post-earthquake fire, and to quantify these factors and the outcome: many small fires, or conflagration? Recent work, based on work in Japan, has developed a probabilistic post-earthquake fire ignition and spreading model (Refs. 4-6), Figure 2, which has been applied at two levels: (i) Jurisdictional: a detailed modeling, with ignitions, fire loading, engine location and other parameters modeled gridwise at about the 10 hectare level of resolution. Due to the sizable data collection and computational effort involved, this model has only been applied to one US jurisdiction, the City of San Francisco, and(ii) Regional: a coarser model based on approximations derived from the Jurisdictional model. Applied to San Francisco, Figure 3, this model has permitted quantified estimates for the first time of the aggregate losses due to fire following earthquake. Dissemination of the results of this model has assisted in a major improvement program for the water supply system of the San Francisco Fire Department.

Hazardous materials: (abbreviated hazmat) following earthquake is a topic in an extremely nascent stage, due to several factors, including lack of an analytical framework permitting quantification of the potential problem.

Preparedness for PEQF and Hazmat: General preparedness for fire and (a) fire apparatus will be taken out of the stations in the event of an earthquake, (b) a representative, usually the chief officer, will serve at the jurisdictional Emergency Operations Center, (c) in some cases, a damage reconnaissance will be performed.

In general, many important factors are ignored, including: (a) generally, fire stations are not structurally adequate, especially older ones, (b) location and nature of ignitions will not be known, due to overload on the reporting systems (typically, the telephone system),(c) reliability of the water system is an unknown quantity (one exception is San Francisco, where a special seismically-reistant Auxiliary Water Supply System, separate and redundant from the ordinary water supply, was installed following 1906), (d) work load (i.e., number and nature of fires, hazmat incidents, building collapses and other demands) is completely unestimated by responsible agencies, (e) damage reconnaissance is usually assigned to the fire service, to be performed while driving about in their apparatus. This ignores the fact that they will be responding to emergencies immediately, so that the initial reconnaissance will not be performed until other agencies are re-assigned to this task, in an ad-hoc fashion.

Preparedness for hazmat is if anything worse than the above. It basically consists of isolating the incident until special teams can be called in to assess and clean-up. Whether sufficient capability exists in the US for the situation following a major earthquake appears to be unknown, due to the aforementioned lack of an analytical framework permitting quantification of the potential problem. One consolation is that, under recent legislation,

locations and volumes of hazmat are being recorded by local agencies (often the fire department).

STEPS TOWARDS IMPROVEMENTS IN MITIGATION

Based on the above, issues confronting present US post-earthquake fire and hazmat mitigation programs appear, in summary, to include the need for useful damage scenarios, ignition and hazmat release, rapid post-event damage reconnaissance, alarm and detection systems for fire and hazmat, reliable victim location and extrication techniques for SAR, and good water supply (for PEQF).

ACKNOWLEDGEMENTS

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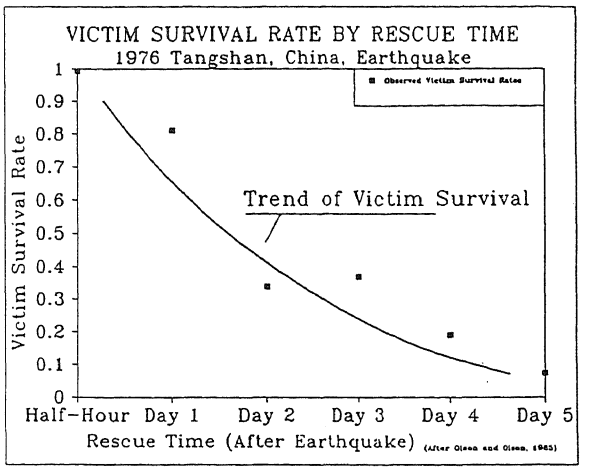


Figure 1 - Rate of victim survival (in terms of percent of rescued victims who survive) as a function of the length of the time after the earthquake until rescue. Data were taken from the 1976 Tangshan, China earthquake.

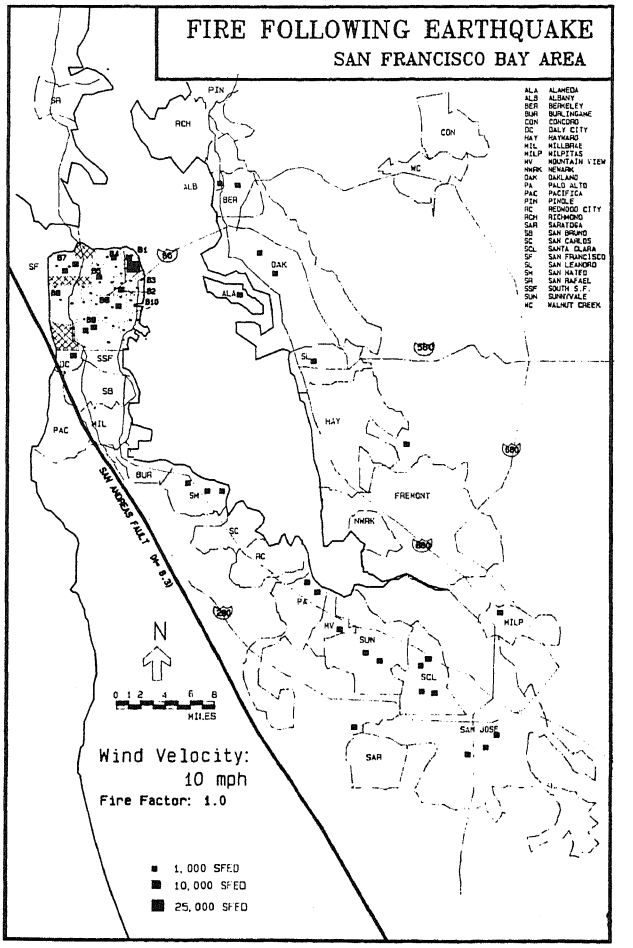


Figure 2:

Results of Regional Model for San Francisco Bay Area

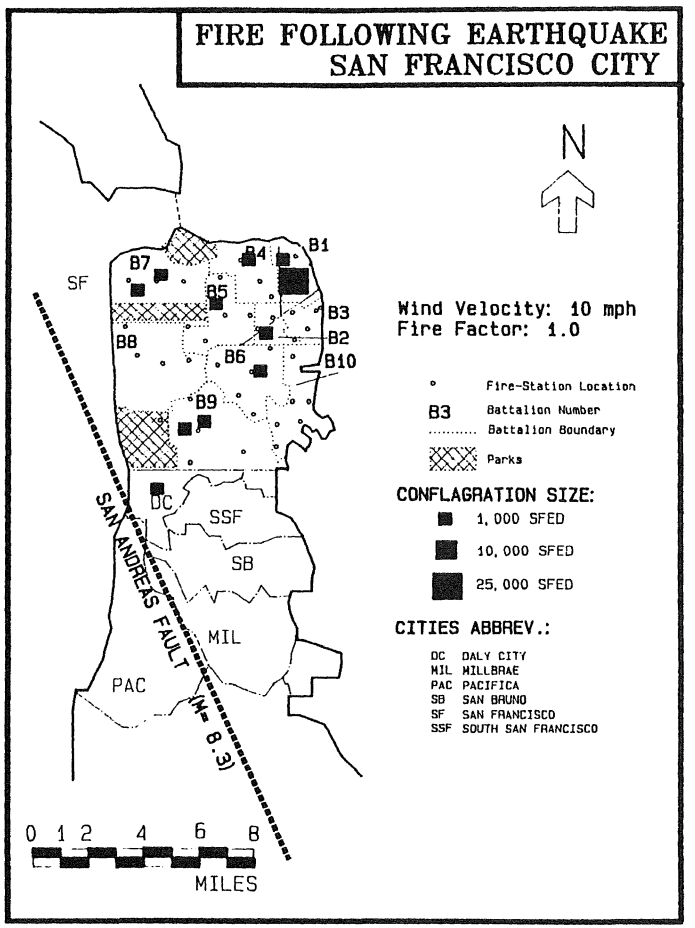
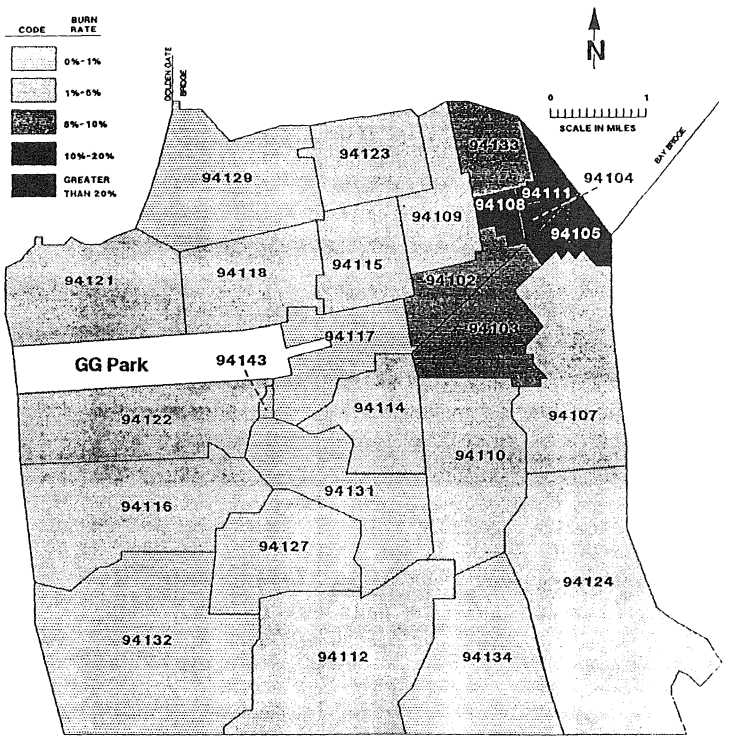


Figure 3: Results of Regional Model,
City of San Francisco, Location of Fires



PROPERTY LOSS RATES FOR FIRE FOLLOWING EARTHQUAKE
SAN FRANCISCO, LEVEL II EARTHQUAKE (10 MPH WIND)
(Percent of Insured Value, by Zipcode)

Figure 4: Results of Regional Model,
City of San Francisco,
Final Burnt Fractions