

## Lessons learned from destructive earthquakes Iran 1990; Armenia 1988; California 1989

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### INTRODUCTION

Many countries suffer from destructive earthquakes which cause many deaths and much property losses. Whether or not an earthquake causes a disaster depends upon 1) the magnitude of the earthquake, for a small earthquake will not cause a disaster, 2) the distance of the earthquake from the city, for if the earthquake is sufficiently far away it will cause no disaster, 3) the vulnerability of the city, for if all the structures have a high degree of earthquake resistance there will be no disaster. The Tangshan, China earthquake of 1976 is a "worst case" example. The earthquake had a magnitude 7.8 which is a very large event. The causative fault went through the city and thus was a zero distance. The city of about 1 million inhabitants had not been zoned in the building code for seismic design; therefore, most of the buildings were weak and brittle and 80% of the structures collapsed or were so badly damaged as to be unuseable and it was reported that 243,000 persons lost their lives. The 1960 Agadir, Morocco earthquake, M5.7, occurred very close to this city of about 30,000 inhabitants. Approximately one-third of the inhabitants were killed by collapsing buildings. The vulnerability of a city depends upon the quality of earthquake engineering that is employed in designing buildings, bridges, utilities, industrial facilities, etc., so it is important that engineers try to advance the state-of-the-art of seismic design.

Earthquake engineering faces the problem that most of the structures that are of concern are too large to undergo dynamic tests that generate stresses and strains representative of real earthquakes. Proof-testing is only done by an earthquake. The occurrence of an earthquake should, therefore, be looked upon as an engineering test from which to learn about the nature of ground shaking, the performance of structures, and the effectiveness of earthquake preparations and relief and reconstruction. In recent years there have been many damaging earthquakes in the world from which much could be learned. However, in most cases it was clear that more could have been learned

had thought been given to the proof-test before the earthquake.

The three earthquakes reported on in this paper occurred in quite different situations. The materials, the methods of design, the methods of construction, the earthquake preparation, relief and recovery were radically different. This demonstrates that although each country can learn from the earthquakes in other countries, much information is pertinent just to the country of origin itself. The four main thrusts of learning from earthquakes are:

1. Improve the assessment of earthquake hazards and risks.
2. Correct hazardous seismic safety conditions in existing structures.
3. Build new structures with adequate earthquake safety at affordable costs.
4. Prepare for prompt, effective, and economic response to and recovery from earthquakes.

It is especially important to learn from earthquakes now to prevent great disasters in the future. The population of the world is increasing by 100 million persons per year. During the past 100 years the population has quintupled and at this rate it will quintuple in the next 100 years. Experience shows that the increasing population tends to coalesce in large cities. There are now many more cities with population exceeding 1 million and there are now also supercities with population of 10, 15, 20 million inhabitants. There is now much greater exposure of people and structures in large cities which are vulnerable to a single large earthquake. The inhabitants are threatened not only by the possibility of damage and collapse of structures but are also threatened by damage to lifelines. The functioning of a large city depends upon electrical power, gas, water, sewer system, transportation system and communication systems. In addition to the collapse of structures, a city is also vulnerable to damage to lifelines thus, we can expect super-disasters in the future unless vigorous steps are undertaken to provide adequate seismic resistance to new structures and lifelines and also to minimize the risk posed by old hazardous buildings.

The growth of supercities with populations of

10-30 million inhabitants brings the potential for super disasters. The inhabitants of a large city are threatened not only by the collapse of buildings but also by damage to lifelines that interrupts the functioning of a modern industrialized city.