EARTHQUAKE RISK MANAGEMENT USING NANOTECHNOLOGIES: A STUDY ON CENTRAL PARTS OF METROPOLITAN TEHRAN

Alireza GHAFOURI ZARANDI
M.Sc. of Geography and Urban Planning, International Institute of Seismology and Earthquake Engineering (IIEES), Tehran, Iran
zarandi@iiees.ac.ir

Zhila POOYAN
Assistant Professor of Urban Planning, International Institute of Seismology and Earthquake Engineering (IIEES), Tehran, Iran
zhpooyan@iiees.ac.ir

Sharareh BANKI
Expert of Geology and GIS specialist, International Institute of Seismology and Earthquake Engineering (IIEES), Tehran, Iran
banki@iiees.ac.ir

Fereshteh KAMALPOOR
Expert of Geology and GIS specialist, International Institute of Seismology and Earthquake Engineering (IIEES), Tehran, Iran
kamalpoor@iiees.ac.ir

Keywords: Earthquake Risk Management, Nanotechnology, Tehran City

ABSTRACT

Using nanotechnology in earthquake risk management in 21st century is an inevitable task due to its multi-dimensional aspects and spread. Nanotechnology increases human capabilities in confronting hazards and events which cause huge damages in different sectors. Considering earthquake risk management as a planned process with assumed practices in different locations and times, for evaluating the performance of different organizations and personnels involved in disaster managemen, nanotechnolgy is an effective instrument for improving human administration in applying risk management. In this paper, the earthquake risk management through nanaotechnology in central parts of Tehran considering the Ray Fault scenario is discussed. The main findings of this study include using nano silica in constructing resistant structures with different usages, using congitive sciences for finding safe places in times of disaster and self-rescue and relief based on recent experiences in Iran and in other countries, using nano skin cover for recovering from disaster injuries, chemical and electrochemical nano-sensors for controlling environmental pollutants and evacuating disaster affected people from polluted areas and using cyclodextrin polymer for refining polluted waters in post-disaster period. Such parameters develop along with nanotechnologies improvement and hence they could not be achieved in short time.

INTRODUCTION

According to some experiences in Iran and other countries disaster management authorities might be killed due to earthquake damages and thereupon regularities and orders might be destroyed. In Bam Earthquake (2003) experience in Iran due to ligh levels of damage, many disaster response authorities lost

their lives and only Red Crescent director and few other authorities stayed alive (Anbari, 2005). This indicates that disaster consequences such as lack of disaster management authorities cause many challenges in rescue and relief phase. Such challenges interrupt emergency response activities that increase complications and bewilderment. In Bam experience, the identification of affected people and supplying their emergency needs started one week after the earthquake. Moreover, the available polluted waters was a serious problem even after several months (Anbari, 2005). In other experiences such as Hanshin Earthquake (1995) in Kobe City, Japan, more than eighty percent of human losses were due to housing damages and fire breaks. In this event many injured people were rescued by their neighbours. Around sixty percent of human losses happened during the first fifteen minutes after the earthquake occurrence (Seramiforoushani, 2003). Besides, the water of some parts of Kobe city stopped and all raods inside the City were blocked and also demolition of bridges disrupted resuce and relief activities that were being carried out by rescue and relief teams. The main highlight of this event was the widespread volunteer activities by local residents in damaged areas. This indicates the importance of cooperation between residents and authorities in times of disaster (Yakawa et al., 2004). In Aquila Earthquake (2009) experience in Italy, the earthquake happened on April 5, 2009 at 3:30 a.m. in historical city of Aquila that is located in 120 kilometers north-eastern of Rome. The failure of electricity and water of 15000 houses caused serious problems and blockage of most roads to Aquila caused no ground access to the city. 179 people were killed and 1500 people were injured (on second day after occurrence) and 34 people were disappeared. The Relief Coordination Center of Aquila City declared that 100 people were rescued during first 30 hours. Considering the high volums of damages, the rescue teams could not save all victims buried alive on second day of occurrence. Besides there was no medical center for treatment of injured people because some parts of main hospital of Aquila City were evacuated to prevent potential hazards for patients. As a result the injured people could not been hospitalized.

The main lessons of these expereinces are:

- Mental disorders such as stress, anxiety, disappointment and phobias developed among affected people.
- Injuries such as fractures or mutilation were most important hurts among affected people.
- Hospitals and health centers could not be used due to structural damages.
- Fire fighting centers suffered non-structural damages and could not perform their activities.
- Lifelines such as electricity, water, drainage and gas system had serious damages.
- Raods were blocked and thereupon there was no access to affected areas.
- Most public buildings were unusable due to structural damages.
- Most human losses were due to settlement demolition, fire breaks and impossibility of rescue.
- Affected people emphasize on measures to reduce human losses, mental pressures and economic damages.
- These experiences indicate the importance of public education in evacuation, rescue and relief.
- Many people were rescued by their neighbors and local residents.
- There was no awareness about damage reduction in affected communities.
- Risk management and preparedness are as important as post-event activities.
- Local community, volunteers and local rescue teams play important roles in rescue and relief.
- Some times rescue teams could not save victims buried alive due to high volums of destruction and damages.
- Vulnerable structures were the main cause of damages and accordingly resistant structures are the main solution for damage reduction.

These experiences indicate that self-recue and relief in times of disasters is very important. Self-rescue and relief is started at community level and includes pre-occurrence activities, during occurrence and post-occurrence activities. This paper addresses a process assuming that self-relief with current sources is a difficult task and supplying resistant shelter and preparing people to confront disasters in pre-event, needs high levels of capabilities in both structural and non-structural sections. Considering this assumption, the successful self-relief could be achieved when the knowledge is realized. In this paper the central parts of Tehran City as densed areas comprising different land–uses such as residential, commercial and health

centers is studied. The earthquake scenario is based on Ray Fault considering highest amount of damage and most critical conditions.

SEISMICITY AND VULNERABILITY OF CENTRAL PARTS OF TEHRAN

Based on studies on Ray Fault activities, the central parts of Tehran (regions 11 and 12) have the highest seismic risk (25th and 26th ranks) (JICA, 2000). The seismic risk and damage parameters include earthquake intensity, structural damages, human losses, population density, open spaces and narrow pathways. According to evaluations, the mentioned parameters could be scored by thirty and the thirtieth has the highest level in risk and vulnerability. The central parts of Tehran has 25th and 26th ranks (regions 11 and 12) (JICA, 2000), In JICA study (2000) the structural damages based on Ray Fault scenario were calculated (the commercial buildings and factories were not included and secondary hazards such as liquefaction, land slide, fire break and explosions were not considered too). for the central parts of Tehran the results showed that regions 11 and 12 have structural vulnerability as %78.6 and %77.1 (Fig. 1) (JICA, 2000).

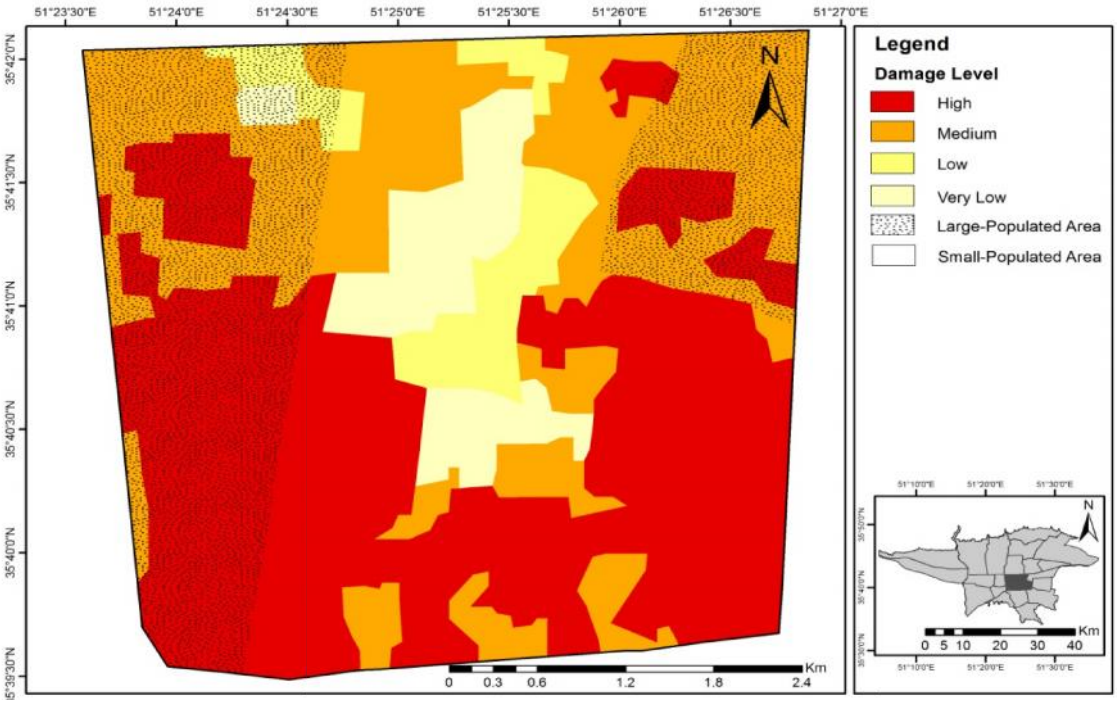

Figure 1. Damage level and popoulation in study regions

POPULATION AND HOUSING IN CENTRAL PARTS OF TEHRAN

This area has 214536 population and its areas is 21.5 km^2 (National Statistics, 1996). The study area includes 3.6 percent of the population of Tehran City (Rousta et al., 2011) and has the highest number of immigrants from all over the country. This situation is due to working opportunities and working capital in these regions and the existence of large national commercial markets and ultra-local markets. At the same time the highest levels of deteriorated urban fabrics exist in these regions and thereupon high human and locational vulnerability in central parts to southern parts and north-eastern parts are observed.

HEALTH CENTERS IN STUDY REGIONS

There are 140 health centers in the study area but there is no equal access to these centers by residents and also there is no balance between the population ratio and the residents' need to health centeres in times of disaster (Figure 2).

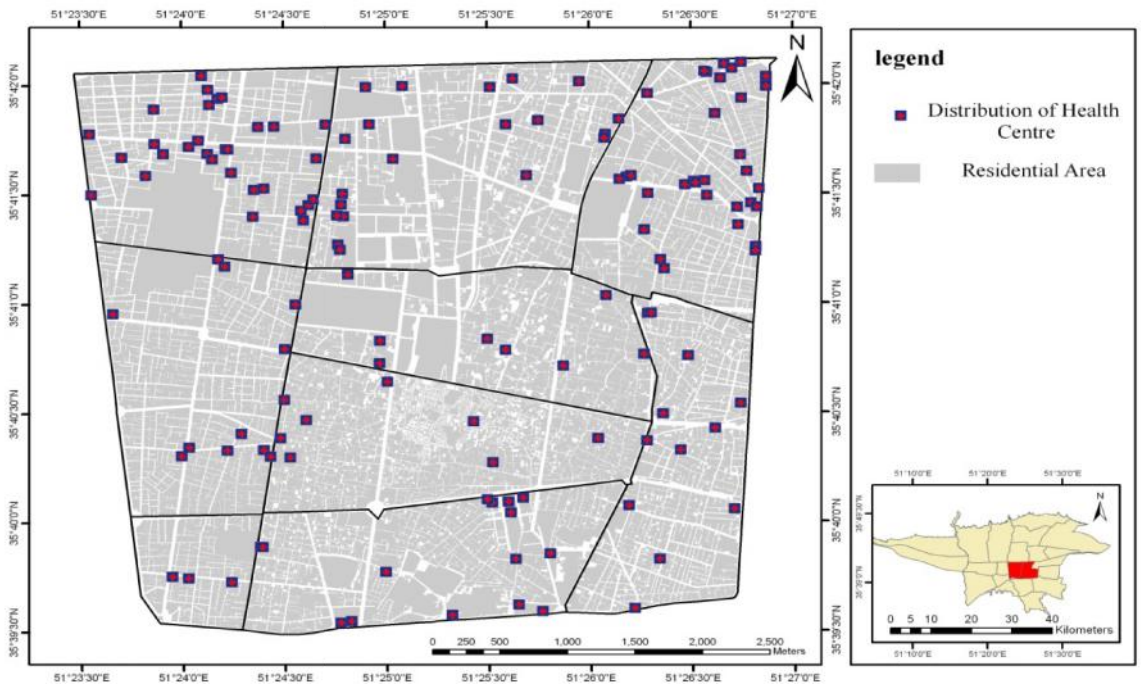

Figure 2. Distribution of health centers in study regions

THE SITUATION OF SAFETY, RESCUE AND RELIEF IN STUDY REGIONS

The lifelines including water, electricity, gas, telecommunications and transportation paths in metropolitan Tehran do not contain safety parameters in times of disaster and considering the damage spread in case of earthquake occurrence, could not operate properly. Besides, vulnerable highrise buildings located on sidelines of narrow paths that could cause road blockage, increase vulnerabilities and dangers. Vulnerable structures and the possibility of fire breaks due to electricity wires and gas leakage, fuel leakage in gas stations and the existence of hazardous materials in manufacturing workshops, (Fig. 3) could interrupt or hamper the rescue and relief activities (Barati, 2004).

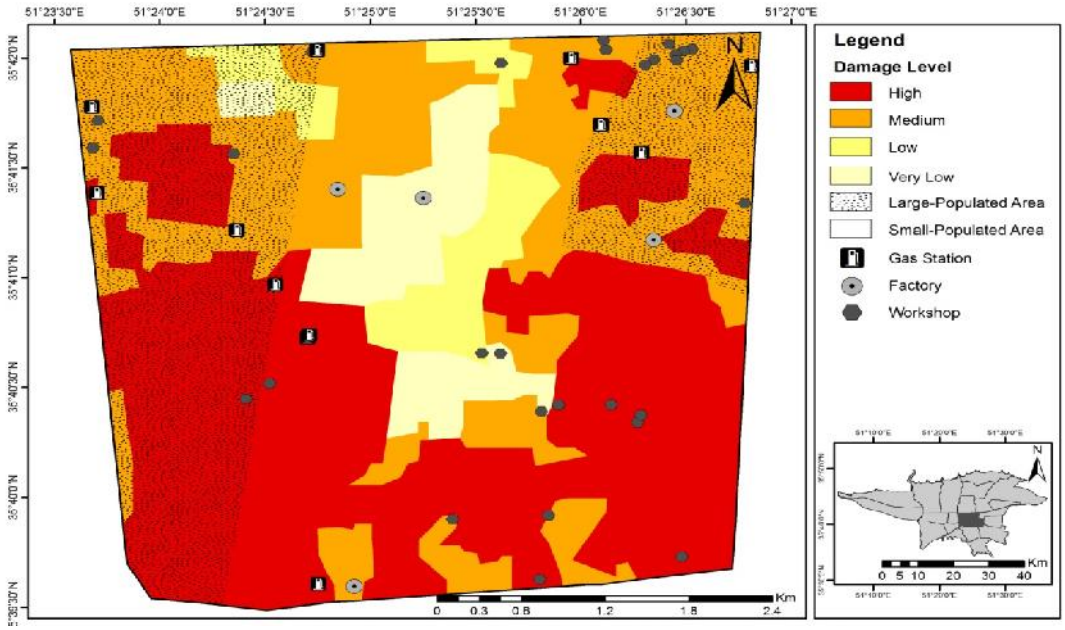

Figure 3. Distribution of gas stations, factories and workshops in study regions

Lack of trained and skillful personnel and the structural vulnerability of critical building for rescue and relief in times of earthquake occurrence, could cause serious problems. Hospitals are the most important

buildings and most hospitals in study regions are vulnerable (RPC Tehran, 2006), If the hospital buildings could not be operational during first hours in post-event, the human losses will increase and the affected people could only be rescued through self-rescue (Anbari, 2005).

EARTHQUAKE DISASTER MANAGEMENT BASED ON NANOTECHNOLOGY

Disaster management process plans for confronting hazards and their effects in pre-event to motivate authorities and organizations for taking damage reduction measures. In this management process the responsiblities of authrities and organizations have been defined. But such process is insufficient without applying new technologies (Syed Abeer, 2012). For example in the study regions in central parts of Tehran if the paths get blocked due to earthquake occurrence, how rescue and relief could be fulfilled by inside and outside rescue teams? Even the affected people could not rescue themselves and other people in a disordered and polluted environment. Individuals have different abilities and adaptations in confronting dangers and critical situations and thereupon their decisions are based on their adaptations and abilities. Nanotechnology could be helpful in improving defensive mechanisms in critical environments (Ciutan et al., 2010) (Fig. 4).

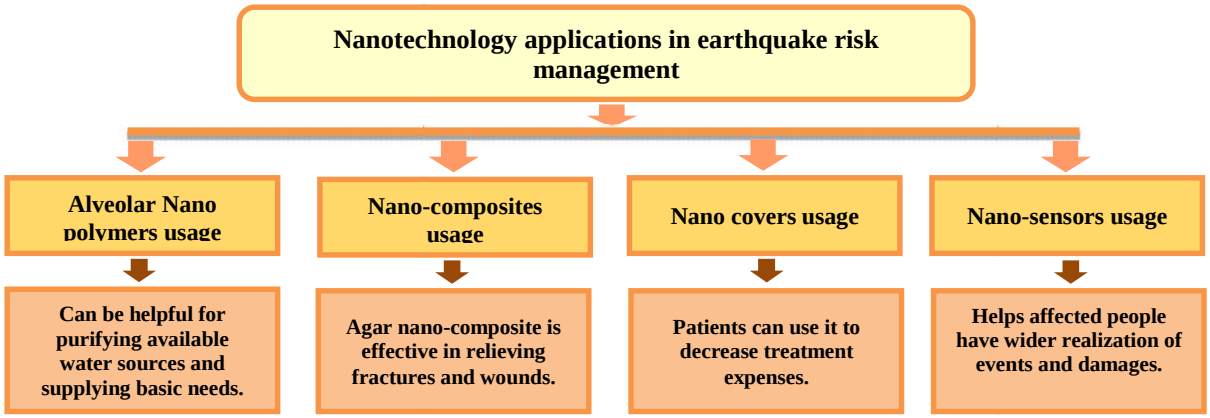

Figure 4. Some nanotechnology applications in earthquake risk management

Some applications of nanotechnology in earthquake disaster management are presented in following sections**:**

- **Cognitive Sciences:** Cognitive sciences have become very important because they deal with human being cognition of himself, other people and their environment. They also investigate the interaction of each person with these factors. Cognition includes basic performances of five senses instead of complicated activities like what we know about self-consciousness such as attention, consciousness, three-dimensional perception, muscles control and movement, learning and memories (SCCR, 2011). People's learning through these sciences is the first step toward proper standard interaction between affected people during a disaster occurrence. Cognitive sciences proceed with studying the cognitive functions of brain and developing the technologies derived from this new science which is a modern, dynamic and applicable knowledge. Cognitive sciences have been mentioned among the first priorities in the Comprehensive Scientific Plan of Iran. In article 3, paragraph 7 of this document, promoting creativity, invention and risk management in cognitive sciences and developing technologies and their practical aspects have been indicated. In article 7, paragraph 16 of this document, all educational, cultural, therapeutic, mass media, economic, social and defensive organizations and institutes are recommended to consult with capable researchers in cognitive sciences and technologies about their findings (SCCR, 2011). Considering risk management as a protective/defensive instrument against earthquake, the correlation link between disaster management and cognitive sciences is well defined by this part of the document.

- **Nanosciences:** Using nano-sensors in electrical fields helps humans to have more power on information so affected people and responsible organization could have wider realization of the

event and damages. This helps them to act better in rescuing affected people. In self-rescue after an event, using nano skin cover for wounded people includes applying pectin nanoparticles containing activated relieving and antibacterial substance which is another instance of disaster self-management. This wound covering consists of negative and positive polymers that covers and protects the wounds. The wound covering substances and anti-bacterial nanoparticles are released in a controlled manner, and accelerate the recovery process. This product is easily used and can be used by patients themselves, therefore this is an effective method in decreasing the treatment expenses (NIRC, 2012)

- **Water Purification:** Another problem for the affected people is drinking water. In central parts of Tehran which are high populated regions, the problem becomes more noticeable. Because of the shortage of drinking water, alveolar nano polymers can be considerably helpful for purifying the available water sources and supplying basic needs. Such combination is a polymeric combination which consists of particles with cylindrical holes. These particles can purify water from organic pollutions. Cyclodextrin polymer can be also produced in the form of powder, grains or thin layer for making tools and other various applications. However, cyclodextrin polymer is used for purifying drinking water, groundwater, cleaning up of chemical wastes and also oil wastes.

- **Eliminating Pollutions:** Cyclodextrin eliminates a wide range of organic pollutions including benzene, hydrocarbonic polyaromatics, florins and pollutions containing nitrogen, acetone, fertilizers, pesticides and many others. Experiments show that cyclodextrin polymer can decrease these pollutions up to PPT[1] limit while activated carbon and zeolite decrease them up to PPM[2] limit. In addition, this polymer links organic compounds with each other hundred times more than activated carbon. The cyclodextrin polymer is not affected by humidity, and can be used in humid areas without being saturated and deactivated. Also this polymer does not allow the absorbed pollutions to pass. Each gram of cyclodextrin polymer can load 22 milligrams of organic pollutions which is comparable with 58 milligrams for one gram of activated carbon. This polymer needs 5 seconds for getting into polluted water, and does not lose its capacity during reduction and can be used unlimitedly. Producing cyclodextrin polymer is not expensive and can be derived directly from starch with 100% conversion. It is expected that mass production of this polymer reduces its expenses than activated carbon and zeolite expenses (Jafarpour, 1393).

- **Nanotechnology in Earthquake:** In earthquake expereinces, most of the wounds include fractures that using agar nanocomposites is very effective and accelerates relieving such wounds. Agar nanocomposites, xanthan gum/montmorillonite which is added by polyvinyl acetate and linked with glutaraldehyde is a useful system for transferring alendronate to the injured osseous texture. Alendronate is mainly used for treating osteoporosis. Its consumption reduces the fracture of spinal column, pelvis and wrist in those people who have osteoporosis up to 50%. Nanocomposites that are produced with 3% agar, 2.5% xanthan gum, 3% montmorillonite, 2.81% polyvinyl linked with 1% of glutaraldehyde, can loading up to 69.32% of alendronate and release 53.4% of this medicine in 7 days having suitable physical-chemistry characteristic. Its inflation variability in two days is 444.32% and its biodegradation is 0.3% during a day. Human mesenchymal cells could grow up well on agar nanocomposite (Varshosaz, 2012)

It should be pointed out that new achievements in nanotechnology are still obtaining and such achievements could improve the risk management area profoundly. This study is just a brief presentation of the usage of this science and technology in risk management.

CONCLUSION

Central parts of Tehran is vulnerable to earthquakes due to existing deteriorated urban fabrics, vulnerability of population, structures, shortage of facilities and besides the vulnerability of hospitals'

[1] Part(s) per thousand
[2] Part(s) per million

building and disaster management centeres in times of disaster occurrence. This indicates that if an earthquake of Mw=6 happens in Tehran, high volumes of damages will be expected. To decrease the potential damages, new sciences and technologies on self-relief and disaster management considering pre-event instructions could be applied. Such instruction are:

- Using cognitive sciences that is related to human self cognition and his environment and the interactions between people and their environment. Cognitive sciences are effective in increasing self-conscious and attention, consciousness, three dimensional perception, muscles control and movement, learning and memories. Also cognitive sciences are helpful in standard interaction between individulas and disaster stricken environment because the affected environment puts much pressure on individuals due to events' damages, pollution and mental shocks. This indicates that cognitive sciences could be used by individuals to rescue themselves and other people.
- Using nano-sensors is effective in identifying the event by individuals and organizations about event type and damages. This in turn is useful in offering services to rescue affected people.
- Self-rescue in times of hazard occurrence by using nano skin cover for skin treatment is another example of individual disaster management during events. The nano skin cover is a treatment and accelerates recovery from injuries.
- Using alveolar nano polymers in purifying accessible waters and providing the basic needs of disaster stricken people in times of emergencies is very helpful.
- Since most injuries during emergencies include fractures, using agar nanocomposites is effective in treating such injuries and accelerates the injury recovery. This is important in returning the active human labour to affected society and eliminates the negative consequences such as being handicapped and depressed in stricken society.

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