The Role of Urban Planning to Reduce the Vulnerability against Earthquake: A Review

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Abstract: During the last few decades, the world has become increasingly vulnerable to natural disasters such as earthquakes. The new reality is that population growth and increased concentration of physical assets in high- risk areas are leading to increased exposures to adverse natural events. Earthquakes, when they happen in an urban area, may result in serious consequences as disasters to damage urban life and infrastructure. The impact of such disasters could be enormous and hamper the process toward the development of sustainable cities. To reduce the damage and ease difficulties in the recovery process, many studies have been performed. This paper reviews some of this research, has tried to emphasize the perspective of urban planning. The results indicated that using strategic city planning aimed at decreasing focus and too much congestion, optimizing communication networks, fortifying and adding equipments to vital constructions and emergency services, developing detailed seismic micro zoning map of earthquake prone regions, making use of geology maps such as PGA1 and appropriate distribution of clear ground spaces in town regions seem to be effective solution for decreasing human susceptibility against earthquakes and increasing city stability.

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1. Introduction

Although today's advance science has understood so much information about how earthquakes happen and its consequences nevertheless the phenomenon is still unconquered. As number of cities have increased in different regions and earthquake prone regions, Cities have gotten bigger so many fault regions are located inside town regions and the increased population of cities have all contributed to the increased number of earthquake human casualties. Knowing these has required that we pay attention to construction buildings and location, construction methods that would prevent the probable risks incurred by earthquakes in human societies. Considering that we can change the pattern of cities so the city would be less susceptible to earthquake dangers, city would become more stable this article has studied the role of city planning to this end. This article has two man sections: In the first a summary of all opinions and studies related to the above subject has been presented. In the second the arguments and the final discussion result are given.

A. Planning to reduce urban vulnerability against earthquake

Adolf Ciborowski in his article, Physical development planning and urban design in earthquake-prone area (1982), believes that the task of comprehensive physical development planning is the spatial distribution of all components of the social and economic development programs with special attention being paid to interactions between the natural and man-made components of the environment and with the applied timing of the functionally interrelated implementation processes.

By that definition physical development planning is responsible for manipulation of the spatial distribution of the development components in relation to various hazard zones, for some measure of controls of vulnerability and for orchestration of spacial and functional interrelations between components of various levels of vulnerability and sensitivity.

1. Special task of physical development and strategic plans

While every physical development plan defines the patterns of spatial distribution of the development programs in an objective or static manner and tends to achieve the 'final' harmony, the process of successful implementation, which will offer satisfactory results in all of the consecutive stages of development, must be based on the strategic concept of spatial and economic development operations.

A strategic plan will therefore operate within a time sequence and will define the leading spatial development factors (analogous to the British structure plans) and their interdependence in timing of construction and/or development. The definition of these interdependencies, priorities and dependable secondaries has considerable importance in every development planning and policy formulation.

But in disaster-prone areas that strategical concept of physical development is of even greater importance. An appropriate strategy for reconstructing a destroyed city is a precondition of a fruitful operation which satisfies the inhabitants. The sequence of building and development activities may have an impact on the levels of vulnerability and temporarily even on levels of hazard (especially those related to the chain of events).

The physical development plan, supported by the strategy for its implementation and elaborated for an earthquake-prone area has to meet numerous special needs, in addition to all other regular ones. These tasks are:

(1) To control the magnitude and character of catastrophe

(2) To limit potential chains of events

(3) To limit social and economic consequences of catastrophe

(4) To facilitate emergency rescue operations

(5) To develop a system and mechanisms of preparedness

(6) To define socially and economically justified limits for and costs of protective measures

(7) To facilitate recovery and reconstruction processes

(8) To harmonize the timing of development and/or reconstruction in relation to economic and social factors.

Physical development plans should be most often elaborated at two distinct levels and with corresponding levels of insight. At the macro level they are: (a) The national physical development plan. That plan defines the national patterns of distribution of productive forces and of population, and national systems of settlements and infrastructure (most often prepared on maps of the scales 1: 1 000 000 and 1: 500 000). (b) The regional physical development plans, elaborated for distinct geographic or economic regions and for metropolitan regions. These are prepared on maps of a scale 1: 300 000 or 1: 100 000, or 1: 50 000.

At the micro level or local level they are: (a) Local physical development plans, often termed master plans. These are elaborated for a single city, town or rural community, have strong statutory force and serve as an obligatory guideline for all development activities which change the environment and land-use patterns. Those plans are usually drawn to a scale of 1: 10 000 or 1: 5000. (b) Detailed urban designs which define patterns of spatial composition, detailed functions of land and of buildings and formulate guidelines for shaping of buildings and other engineering structures. These plans are mostly to a scale of l: 1000 or 1:500. Measures to manipulate hazard Contrary to some other natural disasters such as floods, landslides or even fire, where the magnitude of the devastating forces, catastrophe, and areas affected may be controlled to some degree by man-made protective measures, the violent ground movements caused by seismic forces and violent air movements (cyclones, tornadoes, etc.) cannot as yet be successfully mitigated. Therefore when confronting the problem of how to deal with earthquake hazard one should use the notion of manipulation of both hazard and land-use zoning, and not that of active control, which is applicable to vulnerability issues.

A knowledge of the seismic and tectonic characteristics of given areas is fundamental for the manipulation of distribution of the differentiated development programs in regard to various hazard zones. Maps of seismic hazard which will differentiate the whole area of a country, a region or of a locality into zones of various levels of hazard are therefore essential. These maps should indicate zones of relatively lower and higher hazard levels and, whenever possible, should present information on past and expected characteristics of ground motion. It is worthy of note that in recent years a number of approaches have been developed, e.g. seismic microzoning mapping, application of computer simulation of earthquake hazards, etc.

2. Measures to control vulnerability

In contrast to the level of hazards, which depends on natural conditions and forces, the level of vulnerability of human settlement as a whole and of their major components depends primarily on human actions and on the application by man of protective and mitigating measures. Examining further the character of vulnerability of settlements we have to differentiate between the vulnerability of a group and that of a single member. The vulnerability of the population of a city cannot be expressed by the sum of the vulnerabilities of all members of that population. The probability of an individual's loss of life depends on a number of different factors; in the probability of a given level of loss in a group, density of population within the affected area will play an important role.

Spatial distribution patterns of members of a group play an important role in shaping destruction patterns, especially when the unequal distribution of hazard within the given area is also taken in account. Close similarity to these group distribution rules may be observed in the vulnerability of economic activities. However, the vulnerability of groups of buildings of similar structural characteristics seems to be much closer to the sum of vulnerabilities of single buildings, although even in these cases higher levels of destruction corresponding with higher density of buildings situated within the comparable hazard zones have been noticed. This is probably explained by very detailed irregularities in the distribution of damaging forces within a generally homogenous hazard zone and a higher chance of being damaged with the increased concentration and density.

Concentration and density

These are the two key problems at every level of physical planning exercise and in their economic implications. In cases of development planning in earthquake-prone regions, these two factors of development will condition the magnitude of the catastrophe and its further consequences.

Concentration describes the proportion between that part of the population (or economic activities or other components of the environment) assembled within one part of a given space and the total population of the total space respectively. Extreme examples of concentration in urbanization processes represent the so-called 'primary cities', typical of many developing countries. It happens that some of those cities have a concentration of up to 80% of the total urban population of the country and an even higher percentage of the manufacturing and economic activities.

Density is a measure of the number of users per unit of a given area (persons per hectare, dwellings per hectare, etc.). The direct level of vulnerability depends on the level of density. Growth of density (often economically justified) increases the potential toll in the event of a similar magnitude of destructive forces. The level of density of buildings, of inhabitants, of capacity of services (number of users, visitors, schoolchildren, etc.) of employees, etc., corresponds directly with the accumulated vulnerability to violent earthquake forces within the given area.

The level of density also has a direct impact on the follow-up events: higher density of buildings increases potential hazard of fire storm and hinders (endangers) evacuation and rescue operations. An increase in the density of people gathered together in the affected area multiplies the danger of panics and may paralyse evacuation operations.

Urban interiors (streets, squares, pedestrian walks)

These should be considered to be as sensitive, from the point of view of human life and of the community's operational capabilities, as the interior of any public or office building. However, experience so far indicates that major attention of designers has been given to the safety (resistance) of individual buildings and of the people inside them, disregarding the fate of the urban spaces between these buildings and of visitors that are in them.

While in the modern, suburban, residential zones there are often enough open spaces and the access streets have the appropriate rights-of-way, even in the most recently designed central business districts the space is overcrowded with huge buildings, the streets are narrow and the squares miniscule. In the event of an earthquake, while modern, well designed buildings will survive, the system of over-crowded urban spaces may easily turn into an inferno. Appropriate design measures to decrease vulnerability of such urban districts such as width of the streets, close vicinity of and easy access to the major thoroughfares, number of large squares (to serve as the immediate evacuation grounds), distances between tall buildings, and over-head protection of pedestrian walks adjacent to buildings should be applied.

Shape of buildings

The present author's observations of the behavior of buildings of various horizontal and vertical shapes, but of similar building structures and materials in a number of recent earthquakes offers some initial proof that buildings of the more complicated shapes (especially horizontal ones) are more vulnerable than those of a single rectangular design. The most vulnerable appear to be the comer-sections of L-shaped buildings or the points between wings in those that are T-shaped.

The modern urban design of residential areas tends to involve free-standing buildings, which is generally sound, but depends on the buildings being rather short and of simple horizontal shape. Furthermore, the distance between the buildings should be sufficient to avoid collision between them when they start moving during an earthquake and which will allow for free space, unaffected by falling debris from collapsing structures.

In 2009 UNDP 2 and ERRRP 3 had studied Earthquake risk reduction and recovery preparedness program for Nepal; they studied Earthquake hazard preparedness and evacuation in four parts:

1. Evacuation and Recovery Plan

Risk due to natural hazards can cause serious effects to the entire society. The urban population is living daily in an environment that is confronted with tragic consequences due to negligence of urban risk

[2] United Nations Development Program (UNDP)

[3] Earthquake Risk Reduction and Recovery Preparedness Program (ERRRP)

management, resulting in disasters risks that could have been prevented. Disastrous accidents such as earthquake in large public and residential areas usually results in tragic consequences for people and environment. Therefore, such accidents have clearly showed that the need for the reliable systems supporting rescue operations is urgently appealing.

The response and recovery are the phases in post disaster scenario. The overall role of the activities that takes place in this stage is to meet the life preservation and basis subsistence needs. Search and rescue of the victims and survival are the most important parameters in the response phase. However, for proper and timely response it is important to delineate the staging areas, evacuation sites with proper emergency medical services and basic facilities. Beside this, the other important factor which plays a crucial role in the whole scenario is a proper evacuation route from the incidents to facilities.

Therefore, in post earthquake scenario also fleeing speed, choice of shelter and evacuation route are key factors to the security and survival of the victims. If the function of the route system is unable to operate normally, it will influence the effect of taking refuge and to relieve the victims. Thus, sound planning of evacuation route considering various criteria (vulnerability of building, road, and available resources) can minimize the losses and damages enabling the quick response and rescue operation. Finally, the information regarding evacuation site and route should flow in the local level for its positive effectiveness in real time scenario.

2. Evacuation sites and Staging Areas

The open space is regarded as an integral part of the land use planning decisions and importance of open spaces to urban environment and quality of life is increasingly recognized over the cities of developed countries. However in developing countries like Nepal, there is no general agreement on the desirable planning criteria as to how much open space is needed, where the open space is to be located and how the open space should be used. Moreover there are no such standards for the placement and quality of open space in Nepalese context.

The term open space refers to the any open area of land that is owned by government or other organization and dedicated for conservation or the social motives. Open space is defined as land that is, or will be managed in an undeveloped or developed form for a range of natural and human purposes.

The open spaces in a urban areas are also recognized as the "green infrastructure" which has immense role in the environment and urban ecology.

The main purposes of open space are:

- Provision of recreational opportunities
- Protection, preservation and enhancement of biodiversity, conservation, habitat and heritage places;
- Protection and enhancement of landscapes and amenities
- Educational, scientific and other research opportunities,
- Provision and management of utilities and services
- Ensuring opportunities exist to meet unforeseen and emergency needs and
- Contribution to the livability and appeal of the sub-metropolis for residents of the sub-metropolis.

Typically, open spaces includes parks, gardens, trails, habitat corridors, utility reserves, sports grounds and conservation reserves. Some open space sites may have buildings and services on them to enhance their capacity to meet the needs for which they are reserved or because their uses are compatible with the open space purposes. The importance of open space ranges not only in the provision of opportunity for recreational activities but also providing a range of social, economic and cultural benefits or values to the community. Although open space itself seems as a simple concept, it has complex interaction with physical, social, economic environmental factors of the community and plays crucial role in planning process.

3. Accessibility to Evacuation Sites and Critical Infrastructure

Transportation Infrastructure plays a vital role in natural hazards like earthquake. It covers road networks, bridges, tunnels. It is very important to assess vulnerability of transportation networks itself as it is crucial in ensuring normal traffic circulation. Basically, the vulnerability of transportation infrastructure depends not only on its physical parameters but also on other types of infrastructure that spatially relative to it. The road blockage level due to collapse building is another factor for the road vulnerability assessment in post earthquake scenario.

3.1. Transportation in Post Earth Quake Scenario

In a post earth-quake scenario, one of the most important things that local authorities need to do is to evacuate dead and injured people. People are not killed or wounded by an earthquake itself, but they are victims of collapsed infrastructure like buildings or overpasses etc. Certainly, for a given number of wounded people, if an evacuation plan is well organized, the numbered of dead will be significantly reduced. Since road network plays an important role in transportation in the evacuation plan, the assessment of the functioning of the road network in a post earthquake crisis becomes crucial.

3.2. Access to Evacuation Sites

In residential area, factors that significantly determine loss of lives are built-up density, Built-up frequency density and population density. People are trapped and wounded by collapsed buildings, then may suffer from fire or electrical shock. Therefore, good evacuation activities should be done in such a way that firstly, the injured need to be moved from collapsed buildings to vacant spaces or temporal evacuation sites nearby. Those spaces should be close to accessible ambulance roads. Secondly, after first aid activities, the injured people need to be evacuated directly to hospitals by ambulances.

Therefore, the assurance of accessibility to the evacuation site from the vulnerable area is the first and major steps in disaster preparedness plan.

3.3. Access to Critical Infrastructures

In post earthquake scenario it is essential to remain critical facilities operational. The critical facilities include hospitals, schools, fire and police station, emergency operation centre and communication centre, water supply system. It is necessary that the critical facilities have no structural weakness that can lead to collapse.

In fact, easy access to critical infrastructure has significant contribution in the recovery process of victims. Hence, the effective routing from evacuation site to critical facilities is of prime importance to be determined such that the recovery action can be effective within a short period.

The critical infrastructure such as hospitals should not only be in proximity but also accessible. In fact, the Euclidean distance is not practical to be considered while determining the possibility of service provision. Although, hospital which is not in close vicinity can provide service compare to the close one due to easy accessibility .In post earthquake situation, the number of patience needs to be taken from evacuation site to hospitals in case of emergency and critical stage because every facilities are not feasible to be provided on the site.

Similarly, issues of social security also count very important because the probability of crime increases after happening of disasters. Therefore, security services such as police station should also be easily accessible.

Unlike analysis of other infrastructure, water supply infrastructure is an integral system. In fact availability of water is a major issue which is required to accomplish in the evacuation plan. Therefore, easy accessibility to water source from the evacuation sites is of major concern.

4. Criteria for Evacuation Route

In post earthquake scenario, the proper functionality of road is very important .Different literature has suggested the different criteria to evaluate the best possible route during emergency. The shortest route depending upon the distance and travel time does not give the practical result because there are other important factors which determine the condition of road after happening of disaster.

While determining the evacuation route, the physical vulnerability of road as well as spatially associated features which can effects the route due to blockage need to be considered. These broad factors determine the traffic flow, available road in real time situation which ultimately affects in the rescue operation.

Several criteria have been used in order to develop the vulnerability curves for roads which depends upon physical characteristic of road like design code, shape, material, age, embankment height etc.

Therefore different methods have been developed considering the above criteria to assess the physical vulnerability of existing road network. The JICA4 method has classified road into nine categories according to the function of road (National highway, Feeder road major, Feeder road minor, District road bituminous, District road gravel , Ring road, Urban road major, Urban road minor, Urban road gravel) and only the road segments that crosses slopes more than 50mm higher are considered as hazardous points in earthquakes.

The other method developed by RADIUS (United Nations, 1999) in which the road types are divided into two categories (Asphalt and Non asphalt) and fragility curves has shown for two types of road. The fact is damage level of these two types of road is different under the same condition. However, if both types suffer the same Peak Ground deformation, the asphalt road will certainly be less damaged than the earthen road as strength of basement and surface of the asphalt road is higher than that of the earthen road.

The result shows the percentage of damage infrastructure corresponding to the MMI5 value. In this method, since the percentage of damage infrastructure shows corresponding to total length, the location and damage state of infrastructure are not identified.

Similarly the other method was developed, known as HAZUS method, in which road has been categorized as major roads and urban roads. In this, the fragility curves are defined for different probability of damage states in terms of PGD. This method is data demanding so it is not much feasible to use.

Similarly, there are various criteria to determine the blockage level of road. The factors influencing the possibility of debris from buildings blocking the roads

[4] Japan International Cooperation Agency (JICA)
[5] Modified Mercalli Intensity (MMI)

are the number of collapse buildings, characteristic of building along the road and the ratio between the building height and distance from front wall of buildings to the road centre line. The other factors which govern the accessibility in the road network are the road width. The route consisting of road width greater than and equal to 5m are taken as wide enough for the easy passage of ambulance. In Iran case, as stated in the paper, the road width less than 6m width are considered as vulnerable urban tissues.

Allen and Bryant (2010) in their article namely the critical role of open space in earthquake events focusing on San Francisco exclusively studied the role of open spaces in the event of earthquakes. They mainly referred to five subjects in this regard:

1. Urban Morphology

What do we mean by the open space network and how do we analyze it? According to Lefebvre, cities are conglomerations of processes (social, economic, political, and ecological) and forms (buildings, streets, infrastructure, parks, monuments etc) (Lefebvre, 2003). The two co-exist and are mutually interdependent. Urban form is a product of relationships and in particular, the relationship between built form and open space. Morphological analysis is the examination of that relationship and the way it changes over time, in response to a wide range of influences. It is sometimes used to highlight the capacity of a city to adapt and is typically conducted at a range of scales; the scale of the city, the neighborhood and the lot (Moudon, 1983, Lipsky, 1999). It is a useful way to quickly analyze the open space/built form relationship of a city in terms of the amount, distribution and configuration (at the scale of the city) and in terms of structure and function at more detailed scales. In the literature of urban design and landscape architecture, open space has a range of meanings, from 'green space' (parks, greenways, reserves etc) to all public open space (including streets and squares) to private open space (gardens, courtyards) (Swanick, 2003). More recently, in response to the growing intensification of cities, other spatial types have been considered for their potential to connect invigorate and provide support for urban life, for example public-private land, temporarily vacant spaces and car parks, road verges and the leftover space between buildings (Pollack, 2006). For the purposes of this research, and since we are looking for latencies, we have considered all of these categories, in other words, everything outside the building envelope.

2 Earthquakes and Open Space

Documented responses to earthquakes from around the world suggest that ample and adaptable amounts of open space surrounding buildings are of enormous value both during and after an earthquake event (Godschalk, 2003). Open space becomes a refuge for, and a temporary home to thousands of people who need to quickly adapt to their new environment for days, months or even years. After a major earthquake, the open space network becomes a kind of 'second city', providing multiple complex functions such as gathering and shelter, the distribution of goods and services, the re-establishment of commerce, temporary inhabitation, commemoration, and the storage of contaminated or hazardous materials (McGregor, 1998, Middleton, 2007). The network becomes charged with new meaning; its spaces and their components are re-assessed for their capacity to support survival and recovery.

3 Urban Design Theory

Current urban design theory would suggest not. 'Good' urban design and best practice earthquake planning are sometimes contradictory. Many earthquake planning recommendations, including the provision of large quantities of unstructured open space, can result in dispersed rather than compact urban form, making it difficult to achieve livable, diverse and sustainable urban environments. This has been a criticism of the relatively recent reconstruction of Tangshan in China. The city may be less vulnerable to earthquakes, but its wide streets, low rise buildings and lack of an identifiable centre has left it without 'urbane refinements' (Mitchell, 2004).

In any case, this type of major reconstruction is rare. Even after a catastrophic event, change to the built environment is more likely to be achieved through small, expedient and incremental developments (MacDonald, 2004) where mitigation of hazards and the facilitation of recovery are usually seen as a constraint, rather than an opportunity. The unpredictability of hazards means that earthquake planning takes a back seat to planning our way out of the traffic snarl that disrupts us every day on our way to work.

4 Urban planning and recovery planning

Urban development in Wellington is controlled by the City's District Plan. In keeping with national policy, the Plan takes an all-hazards approach, recognizing the need 'to avoid or mitigate the adverse effects of natural and technological hazards on people, property and the environment'. It mentions 'mitigation, preparedness, response and recovery' but only discusses mitigation, at any length. Open space has its own section in the Plan where the focus is on preserving character, amenity and ecosystem health; its agency in recovery planning is not discussed. The Plan's General Design Guides don't discuss hazards at all. They cover urban design considerations, which are largely aesthetic or visual and relate to character, context and amenity.

Recovery planners on the other hand, have recognized the need for a holistic approach to recovery. But in 2004 Resilient New Zealand: Focus on Recovery, the Ministry for Civil Defense and Emergency Management refers to the built environment as a collection of individual elements rather than as an integrated whole. Open space is not recognized as a component of the built environment, but instead is covered in a section on the natural environment. The focus in the document is on recovery of these environments rather than their capacity to support recovery. Pre-planning or urban planning is mentioned as a way of taking advantage of 'opportunities presented by destroyed infrastructure' rather than as a way of developing strategies that might guide incremental, everyday change. Strangely missing from the body of the document, despite its emphasis in the introduction, is a detailed engagement with the concept of resilience and how it might influence strategies for recovery.

The majority of the document focuses on sustainability; in fact the two concepts seem to be used interchangeably.

5 Urban Resilience

Resilience and sustainability are related concepts, but the activities and processes associated with them, the rules we make for them and the way we design for them are often quite different. The overwhelming goal for sustainability is the mitigation of impacts. The concept of resilience, strongly influenced by systems thinking and defined here as the capacity of a system to respond to disturbance while still maintaining structure and function (Holling, 1973), is useful because it shifts the focus away from controlling impacts or threats towards developing a system's capacity to respond to them. Ecologists Holling and Walker have developed a resilience model that suggests that a thorough understanding of a system's existing structure and function and its history of disturbance allows us to design for and manage resilience (Walker, 2004).

Cities are complex systems and communities, as an integral part of those systems, play an important part in the adaptive response. While recovery planners are concerned with encouraging communities to adapt, urban designers are beginning to be interested in how the design of cities might encourage that to happen. Both disciplines are making tentative moves, albeit unconsciously, towards the other.

Because an earthquake may never happen there is likely to be a reluctance to retrofit a city to accommodate the needs of recovery, particularly if there are cost implications. But if urban design strategies and earthquake recovery planning strategies are aligned, through a focus on urban resilience, then the ongoing and incremental retrofitting of a city for day to day purposes will automatically create opportunities to facilitate effective recovery should an earthquake occur. The common denominator for urban design and recovery planning is a city's open space network: the streets and parks and left over spaces that are part of the everyday city, and that come to life as the 'second city' during recovery.

Reja and Shajahan (2011) in their article, Analyzing the earthquake vulnerabilities for urban areas, mention that earthquakes are the most deadly of the natural disasters that may affect the human environment. About 60% of world-wide casualties associated with natural disasters are caused by earthquakes (Coburn & Spence, 2002).

Urban vulnerability to natural hazards such as earthquake is a function of human behavior. It describes the degree to which socioeconomic systems and physical assets in urban areas are either susceptible or resilient to the impact of natural hazards. Over the past two decades, vulnerability has come to represent an essential concept in hazard research and in the development of mitigation strategies at the local, national, and international levels (White & Haas 1975, Hewitt 1997, Mileti1999, Alexander 2000). Several models of urban vulnerability have been proposed to address the various ways by which society becomes subject to hazard impacts (Cutter 1996, Menoni & Pergalani 1996, Menoni 2001).

Urban vulnerability is an inherently spatial problem since it almost always deals with communities within a defined urban space. The implications of the type of problem-solving methodology for urban vulnerability analysis are limited because many concepts, rules, and principles associated with vulnerability in cities are not sufficiently certain, nor are all the elements and processes contributing to it acknowledged or articulated.

Vulnerability defines the inherent weakness in certain aspects of the urban environment which are susceptible to harm due to social, biophysical, or design characteristics, whereas risk indicates the degree of potential losses in urban places due to their exposure to hazards and can be thought of as a product of the probability of hazards occurrence and the degree of vulnerability (i.e. risk=hazard X vulnerability) (UN, 1991). Urban earthquake risk today derives from the combination of local seismicity combined with high dense built environment, informal settlement or unplanned development in urban areas, large numbers of poorly built or highly vulnerable dwellings, poor infrastructure, contiguous building character, lack of proper land use planning against hazard zoning, etc.

Earthquake Vulnerability Reduction for Cities (EVRC) is a concept of action has developed to ensure safety of human lives and reduce losses from earthquakes that may occur tomorrow. Some studies are established the topic 'Vulnerability Reduction for urban areas due to earthquake hazard' as 'Urban Earthquake vulnerability Reduction' (ADPC, 2003). There are a wide variety of ways to facilitate risk reduction or earthquake vulnerability reduction and rapid post-disaster recovery.

Regulatory and legal measures, proper land use policy, metropolitan disaster prevention plan, policy based design solution & proper implementation, improved analytical and methodological capabilities, financial planning, political commitment, institutional reforms, etc are the options for risk reduction.

They particularly did their studies about Chittagong city in Bangladesh. Stressing the two main subjects of Land use pattern and physical vulnerability in existing built environment they presented the following results and solutions:

1. Solutions for sustainable land use planning with seismic microzoning map

The land use pattern and the physical development of the built environment all affect the consequences of an earthquake. The linkages between land use master planning for earthquake protection and other urban planning protection measures and the control of building quality are so interrelated that the professionals whose are the responsible for the development of effective earthquake protection measures should establish a strong coordination between them at the very beginning. The whole procedure may divide into three layers.

They may be termed as above surface, surface and subsurface. First one is land use of the city and last two cover the seismic microzonation of the geological earthquake hazards. By combining the three layers we can plan to shape a safer city. After analyzing the three layers, it may be possible to avoid building on some areas of potentially higher hazard zone. This zone might be left as park areas or dedicate as green belt for the recreation of city dwellers. By building on areas of potentially lower hazard, future earthquake damage and loss can be reduced.

2. Seismic Vulnerability map of the buildings of the city and earthquake prevention plan for urban areas

Earthquake protection needs information on construction materials, building height and size, building configuration, structural outline, engineering design quality, age and other indicators which are related to seismic vulnerability. Vulnerability assessment by detailed methods must be conducted for preparing seismic vulnerability map because this map encompasses the physical attributes of the building stock. To create a city for the 21st century, every city should have earthquake prevention plan. Under this prevention plan there would be numerous countermeasures for earthquake vulnerability reduction in city.

An evacuation path or an emergency exit route should be designed in a highly dense urban area especially for those which have been identified as earthquake vulnerable zone. This emergency path should lead towards or connect the major open space and public buildings thus it could be used as post disaster shelter.

Any water body or any source of water should be a part of this emergency path due to after earthquake fire hazard. Evacuation path of a particular area will be selected in a way such that it will be the most convenient to use as the exit route for the people experiencing an earthquake. Every evacuation path will be led to a predefined safe evacuation centre. Length of path should be as small as possible. An evacuation path should have a minimum width all the way through. In general, the minimum width = Fire fighting vehicle width + car width. If the existing width of the proposed evacuation path is less than the required minimum, then the structures on the besides of the path may have to be destructed to increase the width. As these paths should be free from all kind of damage, building adjacent to this road should be earthquake resistant. Special measure should be taken to retrofit the vulnerable one or destroy the most risky built form. It should be designed as such that all lifeline facilities those go beneath the street should be after earthquake and least damage will occur. Roads should be designed in a segmental manner. Thus damaged portion can easily be replaced after disaster and a simple crack can't hamper the whole path during disaster. Again, utility pipes should be innovatively designed through using damper.

For better action after earthquake, this path should be free from all kind of damage related to disaster, thus building adjacent to this road should be earthquake resistant. Boundary walls should be designed as such that it not only ensure privacy and security but also reduce the risk of being collapsed or creating hazards during disaster period. Closely spaced building should be retrofitted by making all the building at same height thus they will shake as a single unit during earthquake.To prevent soft storey effect in existing building proper retrofitting measures should be taken.

The only solution to earthquake hazard is a tangible and long-term plan to refurbish the unplanned part of the city and remove the hazards that its residents are being exposed to every day. This study tries to assess the prevailing condition in unplanned part of Chittagong city and tries to depict the condition what may happen if an earthquake occurs. Finally an intensive literature survey has been helped to establish countermeasures for minimizing earthquake disasters. Thus in unplanned urban areas, vulnerable elements should be identified & assessed to establish guidelines for reducing after earthquake losses & causalities. Addition of seismic microzoning map in preparing land-use plans or development master plans for fairly straightforward & comparable study maps that will contribute to the planning process (Coburn & Spence, 2002). On this regard, different multi-professionals should work together to built a safer city.

Ancas and Others (2006) in their article, Stressing risk management in crisis have studied city system dealing with the crisis such as earthquakes. They mentioned that urban development and functioning depend on a numerous internal relations between its urban components. The damage caused by an earthquake to the same elements of risk in two different cities will not create the same disruptions and consequences for the whole system. The corresponding impact of the disaster will depend on internal and external relationships, and possible functional substitutions of damage elements. This means that the risk analysis must not only consider the vulnerability of elements at risk, but should also assess the failure and resistance chains due to interdependency of the main functions, activities, decision- making, and human behavior in an urban system.

Thus a city can be defined as an open working system, as it is the place of numerous social, economic, political, and physical exchanges. The urban system is not only dependent on inner flows, but also on its external environment and relationship at regional, national and international levels.

In analyzing the risk for an urban system, the following seven components are defined:

a) Populations: inhabitants, workers, tourists, transients, demographic distribution, demographic growth, etc. The inhabitants are the city's heart and a part of the city's vulnerability.

b) Urban space- natural environment, built- up environment (building, infrastructure, lifelines, etc.), and policy environment (spatial organization, land-use, urban fabric and natural features, natural resources).

c) Urban functional activities and services bear on the main urban services: housing, supply, sanitation, transportation, communication, social and emergency functions, presenting different levels of adaptation to seismic threat.

e) Urban government and actors: institutional, socio-economic, and political organizations, urban actors, urban policy, decision- making process with special emphasis on emergency management.

f) Identity and culture: social cohesion, local culture and history (with special emphasis on the culture and memory of risk), symbolic images and representations, etc.

g) External radiance: symbolic features, external image and representations, regional position, etc.

Considering an analytical approach, the Urban System can be characterized by three groups of elements: material, human, and immaterial- groups of elements that are potentially exposed to natural risks.

A. Material elements represented by class of

a) Building: housing, economic activity units, administrative activity units, cultural and sports activity units, urban- function units;

b) Main infrastructures and roads: transportation terminals, civil engineering infrastructures, highways, roads, streets, bridge, etc.;

c) Lifelines and reservoirs: energy systems (electricity, gas, oil, etc.), drinking- water system, sewage system, waste- disposal system, telecommunications system, radio system, etc,;

d) Patrimony: natural resources as woods, waters, etc., historical buildings, other physical symbols;

e) Areas or geographic units: identified as being homogeneous according to the urban frame.

B. Human elements:

a) City users: citizens, visitors, workers, etc.;

b) Urban actors: institutional and socio-economic managers, political and economic-management specialists, etc;

c) Outstanding personalities: key political figures, captains of industry, well- known artists, etc. Such persons can play determinant roles in city life, either directly such as the mayor or indirectly such as captains of industry.

C. Immaterial elements that correspond to certain symbols or representations of the city related to inhabitants, its image, its culture, or to its social fabric or history. One place will be considered as particularly young and dynamic, whereas another will be known for its calm and good life. Such immaterial and subjective- though quite real- elements share in a city's development and its position in relation to the outside world. Just like the other elements, they are vulnerable to a major disaster such as an earthquake:

a) Identity: culture, history, social cohesion, preparedness;

b) Radiance of the system: projected image, external relationship.

To evaluate the consequence of a disaster such as an earthquake, the method aims at identifying the essential elements for the functioning and development of an urban system. This refers to the elements of 'significant value', in terms of social or utility value for city operations. This ranking is necessary for fine- tuning the vulnerability analyses, by subjecting the main issues to in- depth analysis and limiting the secondary use to a rapid evaluation.

The aim of the Urban System Exposure approach is to evaluate the role of these elements with risk in the urban system's functioning. In order to do it, it's necessary to use some adapted tools.

David Brunsdon and Andrew King review the key lessons learned over the past two decades from major earthquakes with respect to the physical, built and social environments. The mitigation achievements are highlighted, as are the challenges in communicating the risk issues more widely.

The key lessons are summarized briefly under the headings of physical, built and social environments in Table 1. Progress and achievements are noted alongside each lesson. Additional issues arising for each of these categories are discussed below.

1. Physical environment

With new methods and techniques for determining seismic hazard, the results are expressed in terms that indicate greater certainty. However the means with which to convey this sophisticated information to audiences as diverse as owners of key facilities and the general public in terms that they can understand has not advanced in a similar fashion. This risk communication 'gap' remains.

An example of the challenge of filling this gap is liquefaction hazard. Further consideration needs to be given to how broader-scale liquefaction hazard information should be used by planners and designers. This information is general in nature – just because an area is shown as having high liquefaction vulnerability, it doesn't mean that the whole area would ever liquefy in a single event.

2. Built environment

The technical improvements resulting from the physical lessons have been incorporated into design standards for new buildings. As New Zealand earthquake engineers have been at the forefront of seismic code development, our design standards are equivalent to those in earthquake prone countries such as the United States and Japan. Damaging earthquakes in these countries, where much of the built environment is similar to New Zealand, have generally confirmed that buildings designed and constructed in accordance with modern seismic standards (ie. post mid-1970s) can satisfy life safety objectives by withstanding moderately intense shaking without collapse. The effect of a large earthquake (M7+) within an urban area has yet to be determined.

The challenge of addressing the large range of existing buildings constructed prior to modern codes however remains. Major overseas earthquakes have repeatedly highlighted the sudden and brittle failures of concrete and steel buildings that feature what are now recognized as critical structural weaknesses.

The degree of physical earthquake risk mitigation undertaken in New Zealand varies considerably. While sectors such as commercially focused lifeline utilities have invested in significant 'network toughening' over the past decade, individual building owners have not tended to be so willing. The consents and compliance arm of city and district councils have an important leadership responsibility in applying national regulations, which is often at odds with the economic development role of local authorities. This issue is as much one of risk perception amongst owners, tenants and politicians as it is a technical question.

3. Social environment

Previous NZSEE reconnaissance teams have involved representatives from the Emergency Services and Civil Defense Emergency Management to cover emergency response issues. Lessons and recommendations from NZSEE reconnaissance teams relating to the social environment have therefore tended to relate to response and economic issues.

Given that the majority of lessons listed in Table 2 were observed at all earthquakes indicated in Table 1 (i.e. since 1985), the considerable time period involved in achieving action and outcomes is readily apparent. In New Zealand, the prime example of this are the projects to develop an urban search and rescue capability and to upgrade the seismic monitoring network, which have taken until 2001 to be commenced.

Table 1: Summary of Key Lessons from Major International Earthquakes

Aspect	Lessons	Actions/ Outcomes
Physical Environment Permanent Ground Deformation (fault rupture, liquefaction, land sliding)	• The extent of physical damage to both natural and man-made facilities due to ground deformation is much greater than that from ground shaking.	• Greater awareness of the dangers of building new facilities in areas with the potential for permanent ground deformation, and the nature of damage that can be expected.

Seismic hazard assessment	• The importance of identifying and mapping seismic hazard and sound land use practices. • The uncertainty associated with recurrence intervals - just before the 1999 Taiwan earthquake, the Chelungpu Fault was assessed to have a frequency of rupture of more than 10,000 years.	• Seeking responsible risk disclosure and appropriate land development. • Awareness of the need to not be dismissive of the consequences of assessed low probability events.
Built Environment Buildings and bridges	• Many early concrete and steel structures designed prior to modern seismic codes (mid-1970s) contain critical structural weaknesses • Buildings and bridges designed and constructed according to modern seismic standards generally survive major earthquakes well in terms of life safety. • Modern buildings do however sustain appreciable damage which can render many unoccupiable for quite some time • The importance of maintaining a presence by the designer during construction to ensure specific seismic resisting design features is properly constructed.	• NZSEE 6 & the Building Industry Authority have undertaken a major program to widen the legal definition of earthquake prone buildings beyond early masonry buildings. • Justifies the design and construction provisions of current standards (which are much more onerous than older standards). • Owners and tenants do not expect or understand this. • Building codes on their own are not sufficient to ensure construction quality – codes and compliance go hand in hand.
Lifeline utilities	• The Lifeline utilities of cities are highly vulnerable to the effects of earthquake. A city will suffer severe economic loss and disruption if the utilities are disabled and transport is not flowing freely in the days following an earthquake. • Port facilities are particularly vulnerable to liquefaction due to their use of hydraulic fill and location on reclaimed areas.	• Lifelines Projects in NZ 7 have developed a collaborative regional approach to co-ordinating utility mitigation activities.
Social Environment Response	• The value of high-quality real-time earthquake data in rapidly establishing the scale of a major earthquake in order to mount an appropriately scaled response. • The necessity of having a heavy rescue strategy, including a management plan for handling international rescue teams • Communities with advanced disaster. Preparedness awareness and arrangements were able to recover much more rapidly.	• In 2001, a significant upgrade and extension of the national hazard monitoring network (Geonet Project) was announced • In 2000, a project was initiated to establish a national urban search and rescue (USAR) capability.
Economic	• The scale of economic losses from earthquake are considerable, noting that indirect (non-quantifiable) costs are often as significant as the direct (measurable) costs.	• An appreciation that a major earthquake in NZ would have a far greater effect on the national economy (in % of GDP) than in larger countries.

[6] New Zealand Society of Earthquake Engineering (NZEE)
[7] New Zealand

Conclusion

Crisis such as earthquakes cause human casualties, economical losses, social hurts that these inflect considerable damages to the cities. As it was mentioned above in this article what that would protect the city uniformly against earthquakes (and other natural disasters) is that the city safety would be involved in all levels of planning and city management actions. To this aim if city management and planning would bond bilaterally together employing a strategic policy suitable for Iran conditions that are flexible enough these two could enact the safety measures against earthquakes. Based on these it is necessary that crisis management as the most vital level of management be considered in city affairs. Although without connecting with (or establishing a poor connection) city planning (that has aim at reducing city susceptibility against earthquakes and increasing city stability) as a dynamic process it would not be possible to be successful in crisis management. As finding a ground location for constructing has tight relevance with the use for that construction and that is enacting a scientific and basic selection for that particular use it is necessary that in all studies related to city grounds considering earthquake factor would be an effective factor in determining and identifying the suitable building locations for building city constructions on. Developing Seismic micro zoning map is an effective step to this end.

Such emphasize on city grounds use and paying attention to how they fit together by these we can take effective step towards reducing damages inflected by earthquakes. Based on these, in order to build appropriate city constructions the particularities of the uses, locations, adjoining of these uses, how they are placed in city, dividing the grounds, the methods of constructions on these and side solutions inside the city should all be taken into account. Here it should be noted that although the bases and principles of many of location finding theories are economical reasons and profit taking ideas. Nevertheless in constructing appropriate city structures that are stable against earthquakes we should leave aside profits and losses for the benefit of correct use. We should consider that the increased stability of city constructions aimed at decreasing human casualty costs is particularly important.

In addition to the above what are important in city planning are also factors such as the amount of grounds on which structures are built, streets, road accesses to the main roads in cities, human and building congestions along with other social and population factors and the amounts of public use open spaces all of these are determinants in reducing city susceptibility against earthquakes.

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