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CASE STUDY OF ARCHITECTURE AND URBAN DESIGN ON THE DISASTER LIFE CYCLE IN JAPAN

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ABSTRACT :

Architecture designs should accommodate earthquakes, urban design in populous areas should consider the need to prevent the spread of fires, and resettlement sites for victims of tsunami disasters should be sufficiently removed from the ocean to avoid future tsunami disasters. Although spatial design is an essential component of disaster management, the interrelationships between these fields have rarely been considered in literature. The purpose of this paper is thus to provide a scheme for integrating the areas of spatial design and disaster management based on architectural, urban design, and landscape design case studies in Japan. Since Japan is one of the most disaster-prone countries in the world, numerous disaster-related mitigation measures have been developed. This paper describes the significance of these developments from the viewpoints of the location and social background, and a variety of historical and regional examples related to disaster management are also introduced within this context. The examples are classified into four categories with regards to the purpose for which they were implemented (mitigation, preparedness, response, and recovery) and are defined by the theoretical notion of Disaster Life Cycle for disaster management which will be explained later. Finally, the author proposes a systematic scheme to understand poorly defined relationships between spatial design and disaster management, and advocates a new interdisciplinary field between architecture and disaster management.

KEYWORDS: Architecture, Urban Design, Landscape, Japan, Disaster Life Cycle, Mitigation

1. INTRODUCTION

1.1. Background

Architecture designs should consider earthquake resistance in earthquake-prone areas, urban design in dense urban areas with many wooden houses such as Tokyo should be planned to prevent the spread of disastrous fires, and the resettlement sites of tsunami victims should be located a suitable distance from the ocean to avoid future tsunami disasters. Although spatial design (architecture, urban design, and landscape design) is an essential component of disaster management, the relationships between spatial design and disaster management have rarely been discussed in the literature.

Although the two words, “disaster” and “architecture”, appear to be unrelated, history shows the connections. Marcus Vitruvius Pollio, a Roman architect in the 1st century BC, asserted that a structure must exhibit the three qualities of strength, usefulness, and beauty in his only surviving work *De Architectura*. In 1964, the World Health Organization (WHO) suggested that safety is an indispensable element for maintaining a high quality of life as well as health, efficiency, and comfort.

It is within this context that Charleson and Taylor (2000) describes architectural design possibilities considering earthquake engineering as the concept of earthquake architecture coined by Arnold (1996). In addition, these authors introduced the Earthquake Architecture Studio Program undertaken by their students (Charleson and Taylor, 2004). This study describes and reviews certain spatial design concept by considering architecture, urban design, and landscape design in order to provide a framework depicting the relationship between spatial design and disaster management in Japan.

1.2. Japan as a disaster-prone country

Japan is one of the most disaster-prone countries in the world. Its location, on the boundaries of four tectonic plates (Philippine Sea Plate, Pacific Plate, Eurasian Plate, and North American Plate), mean that it is highly susceptible to major earthquakes and volcanic eruptions, the nation's history records several devastating fires that have destroyed huge swaths of densely populated urban areas that were packed with wooden houses. Furthermore, the nation's steep mountainous landscape and rapid river currents often combine to subject urban areas to intense flooding. As a result of these adverse environmental factors, the Japanese nation as a whole has evolved what can be termed a "disaster-resistant culture" and have worked diligently to develop and incorporate disaster-resistant urban designs and architectural forms. For example, the relative frequency of earthquakes has motivated engineers to design improved earthquake-resistant reinforcements for existing structure while designing regulations that will ensure the safety of new buildings. Furthermore, the extreme damage suffered by seacoast villages due to tsunami has resulted in the development of tsunami evacuation buildings. It is of worth to consider architectural vocabulary related to disaster in Japan such as the before-mentioned examples, in order to appropriately prepare physical environment for future disasters.

1.3. Methodology
In this paper, the author will examine various historical examples of physical environment related to disaster management. First, earthquake-resistant buildings, fire-resistant houses and towns, urban parks designed as evacuation places, vernacular villages, urban development, and architectural vocabulary will be introduced with those backgrounds and meanings. Second, examples based on the Disaster Life Cycle theory of disaster management will be presented to show how activities can be classified into the four categories of mitigation, preparedness, response, and recovery. Then, in the final section, the author presents a systematic scheme aimed at helping explain the somewhat indistinct relationship between spatial design and disaster management.

2. ARCHITECTURE AND URBAN DESIGN RELATED TO DISASTER MANAGEMENT IN JAPAN

Diverse architectural designs relevant to disaster planning are readily apparent in Japan. In this section, six examples are introduced: some were to designed to prevent damage from future disasters such as strong wind, fire, volcanic eruptions, and earthquakes. Others are the results of disasters themselves.

2.1. Stone walls in response to Typhoon in Ehime
Historically, a region's disasters are closely connected to its climate and geography, and these environments had developed some regional characteristic vernacular designs. Rudofsky (1965) called architecture of vernacular, anonymous, spontaneous, indigenous, and rural in the world, in *Architecture without Architects*. However, we will now observe such vernacular villages from the viewpoint of disaster management.
Photograph 1 shows stone walls of Sotodomari, a mountainous village in Ehime Prefecture. The stone walls were constructed in the 19th century to prevent damage from both salt corrosion and strong typhoon winds.


Photograph 1 Stone walls to prevent damage due to strong wind and salt from the ocean, Ehime

2.2. Pinewoods to respond to Tsunami in Akita
A coastal area in Noshiro City, Akita Prefecture, is surrounded by pine trees as shown in Photograph 2. Although the trees were originally planted to serve as a windbreak and to prevent sand mitigation from coastal

areas, they also contributed to reducing the damage caused by the tsunami that followed the 1983 Nihonkai Chubu Earthquake. This green belt demonstrates both efficiency and the possibility of landscape designs in the disaster prevention and mitigation in coastal area. This form of coastal greenery also proved to be effective against tsunami in several other countries when the 2004 Indian Ocean Tsunami occurred.

Photograph 2 Pinewoods to prevent damage due to tsunami, Akita

2.3. Stand-up Dam in response to Volcanic Eruption in Nagasaki

When Mount Unzen, which is located in Nagasaki Prefecture, erupted in 1990 after being dormant for about 200 years, it caused serious damage to a number of local communities. The most severe damage occurred when the largest pyroclastic flow of the volcano struck Shimabara city in June 1991, killing 43 people. After the volcanic activity abated, the government constructed a sand-trap dam (Photograph 3) in an effort to prevent future pyroclastic flows from destroying other villages. This mountain scenery has been said to leave an unforgettable impression on most visitors.

Photograph 3 Sand-trap dam constructed after the 1990s pyroclastic flow, Nagasaki

2.4. Architecture and urban design after the catastrophic disasters

As can be seen many of the most recent disasters such as the Wenchuan Earthquake in 2008, Hurricane Katrina in 2005, and the Indian Ocean Tsunami 2004, natural disaster can sometimes damage a city catastrophically. In the recovery phase following most disasters, both short- and long-term, design elements are typically discussed, including recovery policies and the implementation of plans for affected members of the public. Photograph 4 shows temporary housing constructed after the Miyagiken Hokubu Earthquake in 2003. Temporary housings in Japan are systematically constructed based on Disaster Relief Act, and standardized to immediately respond after the event. It can be more architecturally considered to improve living environment for victims, readiness for quick response to disasters, and architectural life cycle considering disposal after the resettlements. Various forms of temporary housing exist around the world. For example, the Saou Tribe living in the mountainous area of central Taiwan built traditional shelters from bamboo after the 1999 Chi-Chi Earthquake; and victims living in northeast Sri Lanka produced thatched rooms to cover the temporary shelters provided by

NGOs after the 2004 Sumatra Tsunami.

Serious disaster damage to a city can sometimes result in dramatic changes to the physical environment of the affected area and it is often possible to identify cities that were tremendously influenced by catastrophic events. Examples include Chicago after the Great Fire in 1971, London after the Great Fire in 1666, and Tokyo which was seriously damaged twice; once by the Great Kanto Earthquake in 1923 and by aerial bombardment in 1945. After the 1995 Great Hanshin Earthquake, the most affected region of Kobe City developed into HAT Kobe (Photograph 5) which is a new urban complex area including resettlement residential sites for victims as well as business/cultural districts.

In order to make urban recovery plans after an event occurs, it is necessary to have a future vision as well as a sufficient amount of expertise. In the most cases, architects joined with (local) governments during efforts to make urban recovery plans.


Photograph 4 Temporary housings, Miyagi


Photograph 5 HAT Kobe as a resettlement site after the 1999 Great Hanshin Earthquake, Hyogo

2.5. Earthquake-resistant reinforcement work

Most of the deaths, approximately 90%, that occurred in 1995 Great Hanshin Earthquake were caused by collapsing houses and buildings. Thus, strengthening buildings is one of the most significant measures that can be taken in preparation for future earthquakes. However some districts in Tokyo remain densely packed with small wooden houses as shown in Photograph 6. These congested districts pose serious problems, not only in Tokyo, but in other cities of Japan, because such old-style wooden houses are extremely vulnerable to earthquakes, and should one occur, the debris resulting from house collapses are almost certain to spread fire.

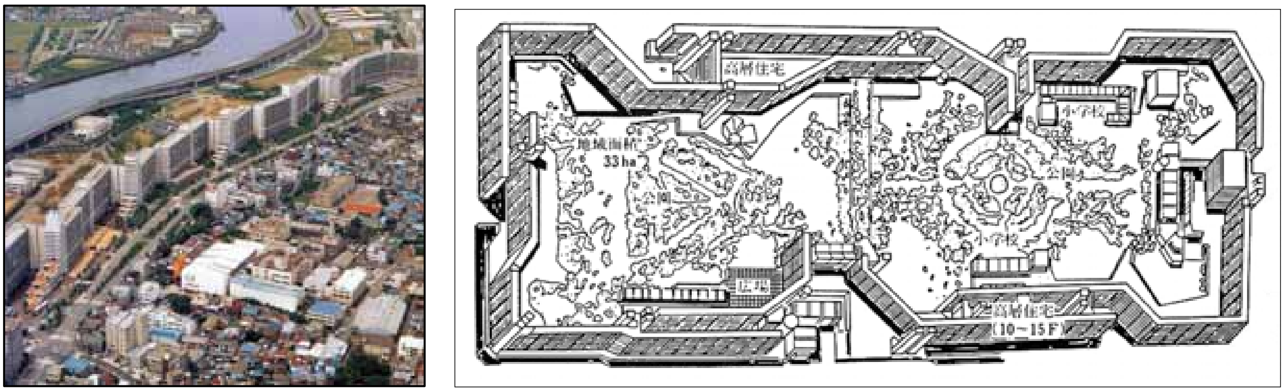
Educated by the experiences of the 1995 Earthquake, the Japanese Government began serious work on earthquake-resistant reinforcement plans. Because public facilities are considered to be a critical part of the response to various disasters, the work on school buildings are being conducted as a top priority. Because of this, the façades of reinforced buildings are sometimes changed, as can be seen in Photograph 7. This indicates that the methods used to reinforce buildings will be important factor for ex-post architectural design.

Photograph 6 Wooden house congested districts and vulnerable houses


Photograph 7 earthquake-resistant building, Ibaraki

2.6. Shirahige Higashi Disaster Prevention Base in Tokyo

More than 100 thousand peopled died in the 1923 Great Kanto Earthquake, hundreds of thousands of buildings were damaged or destroyed and a major part of the city burnt to the ground. Although those burnt areas were redeveloped, many of the unburned areas in the eastern part of Tokyo remain as vulnerable as before. In the 1960s, in order to reduce the potential damage of future earthquakes or great fire in the area, the government in began consideration of disaster prevention plan which would include a complex set of open evacuation spaces, urban disaster facilities, and a series of high rise apartments building that would serve as a 1.2 km long firewall aimed at preventing the spread fires from the congested part of the city to another. The plan, which is now known as the Shirahige Higashi Disaster Prevention Base, was realized in 1986, as shown in Photograph 8.
The disaster prevention base contains various facilities including firewalls, a school, a kindergartens, a hospital, evacuation areas, ground, storage areas, shutter, drencher, water tanks, and other assets. While very rare, this project offers an example of how a gigantic urban area can be redesigned to incorporate urban safety plans.



Photograph 8 Shirahige Higashi Disaster Prevention Base and the concept, Tokyo (Murakami, 1986)

3. SPATIAL DESIGN AND THE DISASTER LIFE CYCLE

In the above section, the author provided some Japanese architectural examples related to disaster management. The question then arises as to how the physical environment can best be utilized? To this aim, Disaster Lifecycle, which is a theoretical concept for disaster management, can be appropriate.

3.1. Disaster Life Cycle

Disaster Life Cycle is defined by FEMA (2007) as follows:

Disaster Life Cycle*: The disaster life cycle describes the process through which emergency managers prepare for emergencies and disasters, respond to them when they occur, help people and institutions recover from them, mitigate their effects, reduce the risk of loss, and prevent disasters such as fires from occurring.*

Disaster Life Cycle is basically classified into four stages, mitigation, preparedness, response, and recovery. The Following are definition of each stage by FEMA.

Mitigation*: Activities aimed at eliminating or reducing the occurrence of a disaster and reducing the effects of unavoidable disasters.*

Preparedness*: Activities taken to help save lives and minimize damage by preparing people to respond appropriately when an emergency is imminent. Preparedness includes planning to respond when an emergency or disaster occurs and working to increases available to respond effectively.*

Response*: Activities occurring during or immediately following a disaster designed to provide emergency* *assistance to the victims of the event, reduce the likelihood of secondary damage and to expedite recovery operations.*

Recovery*: Activities traditionally associated with providing Federal supplemental disaster recovery assistance under a disaster declaration. Recovery includes individual and public assistance programs that provide temporary housing assistance, grants, and loans to eligible individuals and government entities to recover from the effects of a disaster.*

3.2. Spatial Design on Each Phase

The relationship with the physical environment at each stage will now be respectively explained from the viewpoint of disaster management.

3.2.1 Physical environment for Mitigation

Basically, there are two types of mitigation to consider, structural mitigation and land-use mitigation. The first type includes 1) earthquake-resistant design (e.g., earthquake-proof structures and vibration control systems), 2) building designs that are fireproof both to prevent fires from occurring and to prevent them from spreading (e.g., fireproof structures and use of unburnable materials), 3) stilted houses to reduce flood damage, 4) seawall or levee to protect coasts, harbors, or riversides from the force of waves or flooding, and 5) stone walls and heavy roof construction to prevent damage from strong wind (caused by Typhoon, Cyclone, or Hurricane) and salt corrosion. As for the second type, the form of disaster mitigation can be exercised by living apart from disaster prone areas. It contains building regulation on active faults to avoid earthquake damage conducted in California, New Zealand, and Taiwan, and coastal area building regulation for Tsunami disaster damage reduction.

3.2.2 Physical environment for Preparedness and Response

When examined from the spatial point of view, it is not easy to distinguish between Preparedness and Response. Because, making place for activity to quickly respond after the disasters should be prepared before disasters. Shirahige Higashi Disaster Prevention Base as shown in Photograph 8, which was developed to mitigate fire spread and to respond in the crowded area as an urban evacuation place, might be an exponent of the space for preparedness and response. Apart from the urban complex, you can see several small parks in Tokyo, often so-called pocket parks (Photograph 9). These have been developed, primarily due to the calls of residents, after disasters in congested areas. "Udatsu", a Japanese architectural vocabulary term, traditionally refers to avoid spreading fire to one's neighbors (Photograph 10). Tsunami evacuation buildings constructed in the coastal areas in Japan can also be classified as part of this category.

Photograph 9 Pocket park, Tokyo

Photograph 10 "Udatsu", Ishikawa

3.2.3 Physical environment for Recovery

The recovery phase involves several individual/public activities aimed at supporting victims and affected government agencies. The most relevant space to the recovery phase for the affected citizenry is seen in the temporary shelters/housings and permanent housings. In terms of social contexts, regional characteristics, and political situations, a wide diversity of design can be seen in residences around the world. In addition to the architectural elements of houses, other urban recovery aspects are indispensable for catastrophically damaged cities. In fact, most such aspects of the present city of Tokyo were developed based on the recovery planning that took place after the 1923 Great Kanto Earthquake and the aerial bombardment in 1945. These include the creation of open spaces by removing debris. 52 Shinsai Fukkou (Earthquake Disaster Recovery) Parks closed to elementary schools were allocated to be used for evacuation in the future. Facilities for disaster memorial which might be established after disaster are architecturally connected with concept of disaster recovery.

The scheme of above-mentioned relationship between spatial elements and Disaster Life Cycle is demonstrated in Figure 1.

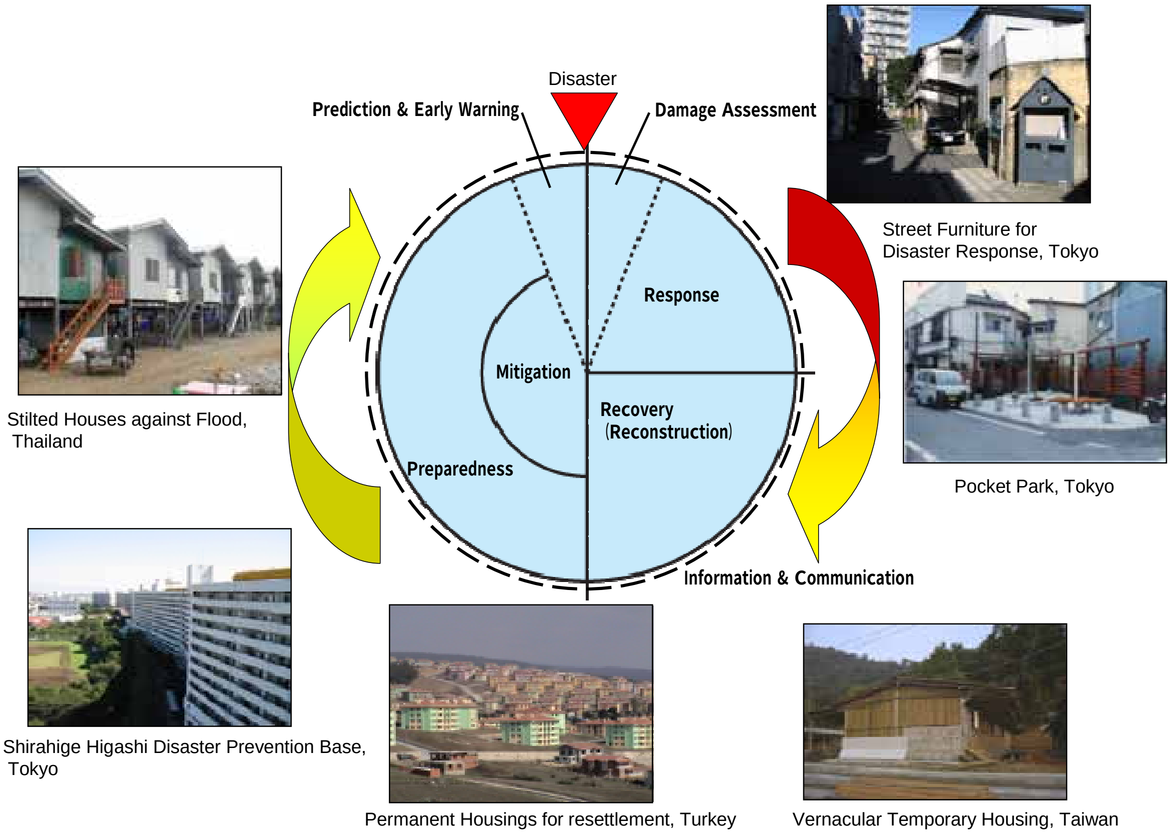


Figure 1 Architecture and Urban Design on Disaster life cycle

4. CONCLUSION

This paper presented several cases of architecture and urban design in Japan that can be considered relevant to disaster management and taking into consideration the Disaster Life Cycle.

The author's research group began creation of the Architecture and Urban Design for Disaster Management Database (Figure 2), which focuses on Japanese examples, in 2008. The database consists of seven fields, 1) location, 2) architectural vocabulary, 3) disaster type, 4) constructed era, 5) source, 6) type of authorization, and 7) size of spatial element. It is a trial to arrange and to analyze those diverse spatial elements shown in the society in the world. The study is expected to open a new interdisciplinary field involving both architecture and disaster management.

Figure 2　A form of Architecture and Urban Design for Disaster Management Database

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