1. Introduction

1.1. Padang City Profile

Padang City is capital city of West Sumatra (Sumatera Barat) province, Indonesia, located in western coast of Sumatra island. Total area of Padang city is 1,414.96 km$^2$; consist of low land and mountainous area with 21 rivers and 19 islands. Average temperature is 22°C - 32°C. Exact location of Padang city is 00 04' 00'' - 01' 08'' 35'' LS and 100 05' 05'' - 100 34' 09'' BT, lies along the shore facing Indian ocean with total length of sea shore is 68,126 km excluded the small islands. There are 11 sub-districts in Padang city.

As center of economic, education, health and governmental, the population growth in Padang City keeps increasing by year and becomes the busiest city in the west coast of Indonesia (see Fig.2).

1.2. Big Earthquake Disaster in Padang City

In September 30th, 2009 at 17:16:09 West Indonesian Time (WIB), earthquake with 7.6 magnitudes on scale Richer (SR), with epicenter located at 0.84LS - 99.65 BT at 71km depth and 57km southwest direction on the coordinate of Pariaman district West Sumatra happened.

Table 1. Fatality Number due to 2009 Earthquake

<table>
<thead>
<tr>
<th>Type of building based on occupancy</th>
<th>Heavy</th>
<th>Moderate</th>
<th>Slight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>33597</td>
<td>35816</td>
<td>37615</td>
</tr>
<tr>
<td>Hospital</td>
<td>13</td>
<td>17</td>
<td>51</td>
</tr>
<tr>
<td>Education</td>
<td>1464</td>
<td>906</td>
<td>781</td>
</tr>
<tr>
<td>Religion</td>
<td>115</td>
<td>83</td>
<td>72</td>
</tr>
<tr>
<td>Social/Foster house</td>
<td>10</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Commercial</td>
<td>10</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Tourism</td>
<td>25</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>Government office</td>
<td>275</td>
<td>393</td>
<td>183</td>
</tr>
<tr>
<td>Bank</td>
<td>20</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Figure 1. Map of Padang City, West Sumatra Province Indonesia

Population Growth in Padang City 2010-2016

Figure 2. Population Growth in Padang City 2010-2016

With the highest population 1st (865,814 people as 2008) and very high density (2nd), 8500 people/km$^2$, Padang city becomes the most damaged areas due to this earthquake, with more than 1000 casualties, for exact 1117 people were killed, 1214 severely damaged.
injured, 1688 slightly injured, and 3 were left missing (see Table 1). The earthquake also destroyed many houses, buildings and infrastructure, reported 114,797 houses were heavily damaged, 67,198 moderately damaged and 67,837 slightly damaged. If this event occurred earlier on working hours, the number of fatality would be definitely higher. Figure 3 show comparison of damage data of all of provinces in Indonesia exclude Aceh province where the damage mainly caused by tsunami hazard based on National Disaster Agency of Indonesia (BNPB). West Sumatra suffered highest number of housing damages.

1.3. Future Mega-Earthquake in Padang City.

Even though there were many big earthquakes occurred, including 2009 earthquake Mw 7.6 and 2007 earthquake Mw 8.4, the 700-year record of Sumatran megathrust super cycles implies that 8.4 Mw earthquake was the beginning of an episode of the failure of Mentawai patch. Those are not the one which is concerned more by Indonesian government.

There is another one which will be generated by subduction zone with unreleased energy for 200-300 years ago and the will be enough to generate a Mw8.8 earthquake 3). Professor McCloskey from University of Ulster in Northern Ireland said that Mentawai segment of megathrust further south under Siberut, just west of Padang, had not ruptured since 1797 and the centuries of accumulated stress would generate shaking in western Sumatra and can produce damage in Padang and neighboring cities and villages. Historically, this fault caused mega-earthquake which triggered a big tsunami which swept away west coast of West Sumatra and neighboring province 4).

1.4. The Environmental System towards Disaster Risk Reduction in Padang City

The experience of earthquake reveals that even developed urban area is quite vulnerable, although the provisions against seismic hazards have been considerably improved. This due to complexity of the system that exist on the area which is affected each other, both physical and non-physic e.g. policy and local socio-system.

Earthquake disaster reduction on a regional level relies on the integrated strategy that can cut the chain of the disaster that is created when the action from earthquake load is subjected to a system resulted on the reaction of the system. The system can be any element at risk located on earthquake hazard prone area, including building, infrastructure, community, and so on. If the system has enough capacity to accept the action, the damage can be minimized that is called resilience, but if the system is damaged due to the earthquake, that is called vulnerable. In case of that, there should be a strategy to strengthened/enhanced the system to increase its capacity which can reduce the damage experienced by it. In doing so, an assessment to measure the probability of expected damage during ground shaking is needed.

A critical component of the chain of risk assessment is fragility function that is defined as probability of exceeding different limit states such as physical damage on the building at a given level of ground shaking. Fragility function can provide the necessary link between seismic hazard assessment at a site and the corresponding effect of the structure 5).
3. Methodology

Methodologies were used on this research includes interview with experts from building offices in Padang City, in order to collect reliable information regards to the situation of buildings and the system supported the buildings, e.g. regulation, inspection system and construction method. Google earth street view has been utilized to get images about the building’s types which are distributed in Padang City which then has been confirmed with street survey by taking many pictures of building. Almost 300 building’s documents also have been collected and analyzed to get the detail information about the building, regards to its structural types, storey, materials and occupation types.

Building law, building code and building local regulation have been reviewed, which is contributed to excel the understanding about the building’s environmental system in Padang City.

4. Environmental System of Padang City

4.1. Building Typology

In order to develop a fragility function that represent the condition of existing building, the first critical step is examining the building typology in Padang city.

Using interview, document analysis, google street survey and street survey, (see Fig.5,6) has been concluded that Reinforced Concrete (RC) building with low-mid storey is the most populated building compared to other type of building e.g. Steel building, timber building and Unreinforced Masonry (URM), (see Figure 7).

4.2. Building Code and Regulation

Building code in Indonesia is issued by National Standardization Agency (Badan Standardisasi Nasional (BSN)) named by Indonesian National Standard (Standar Nasional Indonesia (SNI)). Stipulation of every current building code in Indonesia must follow the Law no.28 year 2002 about building construction (see Fig.8). This law is stipulated on 16th December 2002 containing 10 chapters and 49 verses. This law establishes the definition of building and construction process which cover all of the activities on construction starting from design, construction process and operation, preservation also demolition activity.

Figure 9 describes Building Code amendement establishment after first Indonesian Concrete Standard 1955 (PBI) and after some devastating earthquake e.g. Padang (2009) and Yogyakarta (2006). Especially after 2009 Earthquake, in 2013, new version of code for concrete building was issued named as SNI-2847-2013. SNI-2847-2013 which is refers to ACI 318-08 and ACI 318-11 that establish some fundamental revisions to accommodate...
some new material specification, material testing method, and detailing of reinforcement.  

Figure 9. Building Code Establishment and Disaster Occurrence Time

4.3. The Implementation of Building Standard on Construction Site

Observation regards to building construction method in Padang City has been conducted, and has been found that even though the building code has been improved periodically, the quality of building construction has not agreed with the standard. Construction defect such as improper reinforcement arrangement, poor quality of concrete casting and compaction which is lead to high porosity on concrete and poor formwork arrangement were found as can be seen at Figure 10.

Figure 8. Building Standards Organization Chart of Indonesia

4.4. Land Acquisition

More than 85% of West Sumatra, including Padang City is habited by MINANGKABAU PEOPLE. Their village management systems known as Nagari (before 14th century), established based on adat (custom) principles and the center of the system is women (matriakhat) which is the only one in Indonesia and the largest one in the world. The objective is to protect the rights of community member, including the right of communal land/tribe land. Therefore, the land cannot be sold because must be inherited from generation to generation for woman in the communal/tribe. By the time the land area become not clear and complicated for government to manage including to control building construction causing low quality of building construction. This finding has been supported by previous research (JICA) then considered as one of the root of problem of poor building construction.

Figure 10. Common Construction Method

5. Conclusion

This research found that the building typology is dominated by RC Building low-mid storey with > 50% of building population. Review of building law, code and regulation
compared to observed construction method, show that the seismic vulnerability is high. The land acquisition problem related to unique tribe system contributed to the low quality of building construction in Padang City.

6. Future Works

It is needed to conduct detail and rigorous field study for existing condition of building and construction method in Padang City.

(Manuscript received. October 20, 2017)

Reference

2) http://tourism.padang.go.id
6) Tegnan,H.2015, Legal Pluralism and Land Administration in West Sumatra: The Implementation of Local and Nagari Governments’ Regulations on Communal Land Tenure.BICAS,
7) Public Work Dept. Standar Nasional Indonesia untuk Bangunan Beton Bertulang 2013 (in Indonesian)