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"STRUCTURAL POST-DISASTER DAMAGE CLASSIFICATION WI CONSIDERATION OF LIQUEFACTION DUE TO FLOOD: MANEK UF KELANTAN, MALAYSIA"

Mohammadamin Azimi[1]† --- Asma Bagherpourhamedani[2] ---- Sarajul Fikri Bin Mohamed[3] --- Mahmood Tahir[4] --- Muhd Zaimi Abd Majid[5] --- Chau-Khun Ma[6] --- Yousef Karimi Vahed[7]
[1,2,3]*Department of Quantity Surveying, Faculty of Built Environment, UniversitiTeknologi Malaysia (UTM), Skudai, Johor Bahru, Malaysia*
[4,5]*Universiti Teknologi Malaysia Construction Research Centre (UTM-CRC), Faculty of Civil Engineering, UniversitiTeknologi Malaysia (UTM), Skudai, Johor Bahru, Malaysia*
[6,7]*Department of Structure and Materials, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor Bahru, Malaysia*

ABSTRACT
Natural disasters such as flood which are related to weather, occurring in a lot of places in the world. Environment deterioration and human life damage are the recorded results of floods. Between years 2006 till 2008 due to heavy monsoon rainfalls, a number of floods have generated along Malaysia's in different parts of the country. The critical zones in term of flood damage are located in the east coast of peninsular Malaysia in the states of Kelantan, Terengganu and Pahang. Manek Urai, as a rural area due to its type of buildings was one of the most vulnerable areas during Kelantan flood in 2014. As a proven fact, the victims need to be informed about housing options at the first one week after disaster. The evaluation of building damage must be conducted quickly and exactly. It is a clear fact that building damage survey using proper damage chart is more effective. This paper presents the results of site investigation according to the damage chart for damage assessment, and classifies photographic data of Manek Urai area, based on the damage chart. In addition, the damage chart of timber structures affected by liquefaction is localized.

Keywords: Building damage, Flood, Kelantan, Matek urai, Disaster, Liquefaction, Damage survey.

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Contribution/ Originality
This study is one of very few studies which have investigated the level of structural damage in flood affected area (Manek Urai, Malaysia) and evaluate the effect of using proper and localized building damage chart in order to increase the accuracy of disaster management.

1. INTRODUCTION
Estimation of Initial Damage, Evaluation of Building Safety and Assessment of Damage are time series damage assessment steps which are needed in disaster management for buildings. As

† *Corresponding author*

more description, Estimation of Initial Damage is to apply the Disaster Relief Law, Evaluation of Building Safety is the damage assessment that determines the buildings safety and Assessment of Damage is the assessment to issue the Certification of Victims. As a very critical victim's need it is good to mentioned, victims needs the information about housing options at the first one week after the disaster. Therefore, Evaluation of Building Safety, which was the first damage assessment for the individual houses, should be conducted in first few days after disaster. A lot of researchers have done studies in terms of the improving the building component performances in order to introduce solutions to have more resistance structures as well as reducing the probable damage under any kind of disasters such as earthquake, strong winds and flood (Azimi *et al.*, 2015; Alhajri *et al.*, 2016; Azimi *et al.*, 2016; Chau-Khun *et al.*, 2016).

The assessment of building damage must be conducted both quickly and exactly. It is a proven fact that building damage survey using the damage chart is more effective than conventional methods. Survey results comparison and examination are the applied approaches in previous researches related the building damage survey. In order to classification of building damages, Okada and Takai in 1998 tried to do grouping of building collapse patterns and proposed building damage survey method according to a building damage chart (Okada and Takai, 1998; Azimi *et al.*, 2015; Ma *et al.*, 2016). However, there are few researches for proving the damage chart effect. In 1999, Murao and Yamazaki performed a research on building damage surveying and they concluded that the building damage survey needs the criterion with uniformity and objectivity, and proposed a building damage survey sheet (Murao and Yamazaki, 1999; Tatsuki and Hayashi, 1999).

Based on soil condition and the structure the building damage can be classified in to four types groups named; No Liquefaction – Engineered Structure, No Liquefaction – Non-Engineered Structure, Liquefaction – Engineered Structure and Liquefaction – Non-Engineered Structure. According to literature, the damage chart for No Liquefaction – Engineered Structure and No Liquefaction – Non-Engineered Structure is already available. The chart for wooden structures, an unreinforced masonry structure and reinforced concrete structure of no liquefaction soil is prepared by Okada and Takai. There is no complete damage chart for Liquefaction – Engineered or Non-Engineered Structure.

In this paper the application of the damage chart for damage assessment using photographic data linked to the GIS database is evaluated for Manek Urai, Kelantan area, and improves the damage map of the mentioned flood affected area.

2. BUILDING DAMAGE SURVEY USING DAMAGE CHART

Classification of building damage pattern using building damage photographs taken from Manek Urai after the great Kelantan flood disaster, and proposed the damage chart was done by a surveying team from Universiti Teknologi Malaysia, Faculty of Built Environment. This damage chart classifies the damage, and includes figures of the damage patterns. The definition of this damage chart is illustrated in Figure 1.

Furthermore, the Built Environment Database of Manek Urai, Kelantan is constructed after The Great Flood Disaster using GIS. Built Environment database includes the following data such as urbanization area data, real estate tax roll data before the flood, data from the investigation of damaged buildings, human casualty data, and photographs of the damaged buildings. Totally about 1,980 photographs have been taken as well as recording a video of whole the research area. All the information including photographs which supported by video are classified using the damage chart.

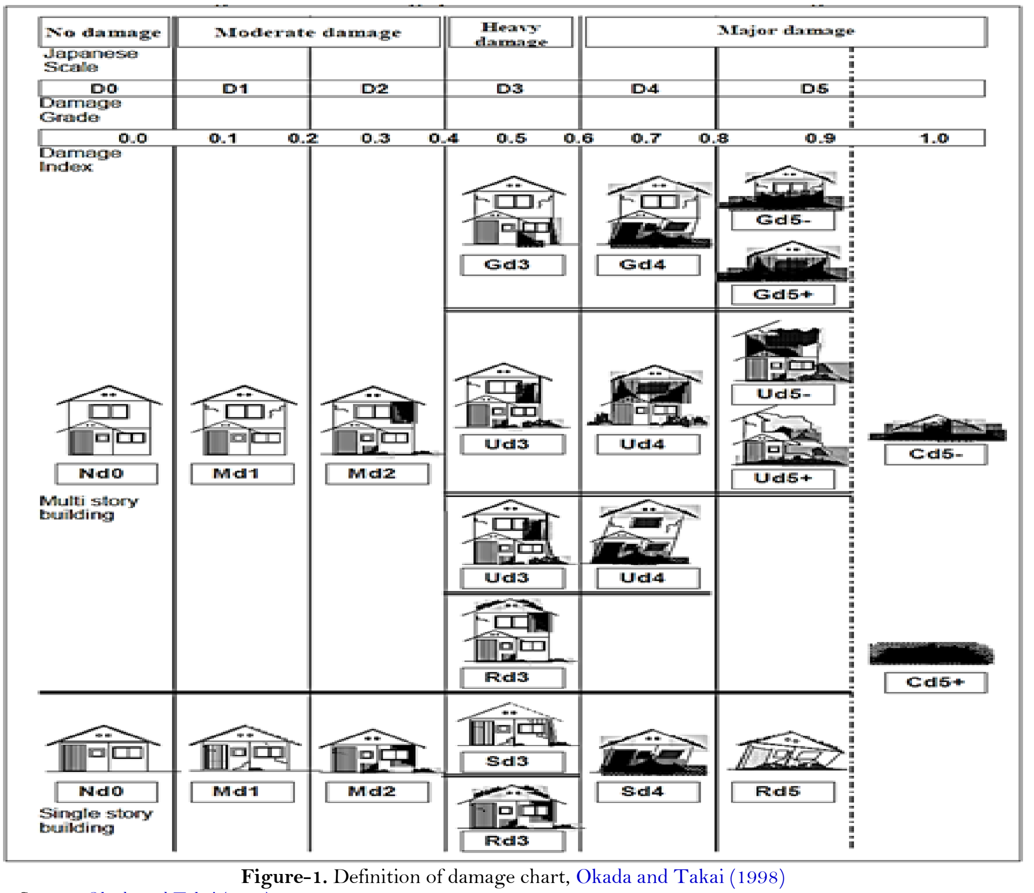

Figure-1. Definition of damage chart, Okada and Takai (1998)

Source: Okada and Takai (1998)

In Manek Urai area, the Department of Quantity Surveying of University Teknologi Malaysia (QS-UTM) conducted survey for academic interest. The photographic data of the Built Environment Database is classified based on the damage chart made by Okada and Takai, in order to inspect the building damage pattern in Manek Urai, Kelantan. The survey by QS-UTM determined four grades of damage:

1- No Damage,
2- Rank A (Slight Damage),
3- Rank B (Half Collapse) and
4- Rank C (Total Collapse).

3. DAMAGE CHART FOR BUILDINGS AFFECTED BY LIQUEFACTION

The introduced damage chart by Okada and Takai is limited to the classification of the superstructure of wooden structures, and only the simplified versions for an unreinforced masonry structure and reinforced concrete structure are shown. Therefore, the damage chart must be supplemented with the collapse patterns of non-wooden structure and those due to liquefaction. Thereupon, for the purpose of clarifying the damage patterns due to liquefaction, the survey and building damage survey is considered regarding Manek Urai area, in Kelantan State, which suffered severe damage due to liquefaction (e.g. (Hamada *et al.*, 1997; Kurazono *et al.*, 1997)).

The ground is an accumulation of loose alluvial deposit from the surface of the ground to a depth of about 8m. The location of the Manek Urai area in Kelantan State is shown in Figure 2. The underground water level is very high, with G.L.-0.5m on average. Under these conditions, by the 2014 Kelantan Flood, sand boiling and subsidence of the ground occurred throughout this area. Wooden structures constituted about 47.6% of all structures. Moreover most of the structures were old wooden structures that were built in very past in this area. Even though the building damage pattern was mainly subsidence and inclination, structural damage such as total collapse or damage to walls and roofs also occurred.

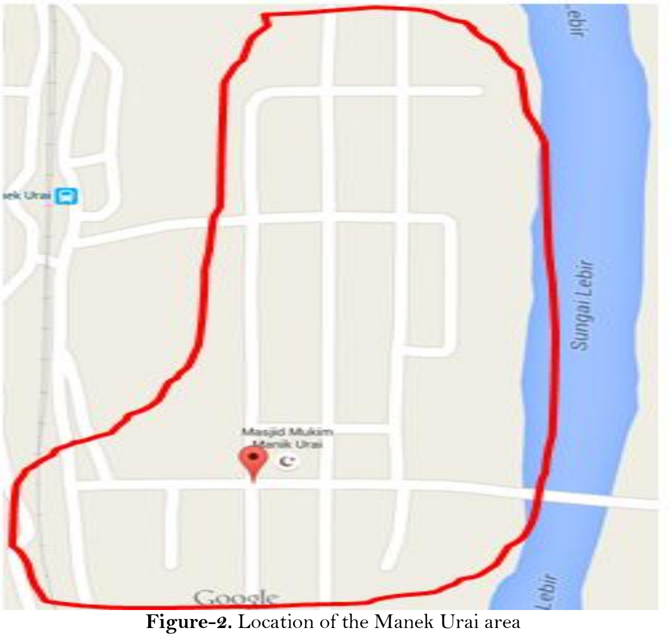

Figure-2. Location of the Manek Urai area

Based on damage survey with consideration of liquefaction in the Manek Urai area, damage chart has been developed for wooden structures as shown in Figure 3. Collapse of a Building due to liquefaction can be categorized into the two patterns, inclination and subsidence. The damage by itself is classified into three levels according to the angle of inclination and amount of subsidence. Level 1 corresponds to no damage where neither subsidence nor inclination of the building can be observed by visual inspection from the outside. In Level 2, some amount of subsidence or inclination can be confirmed. In Level 3, severe subsidence or inclination can be confirmed.

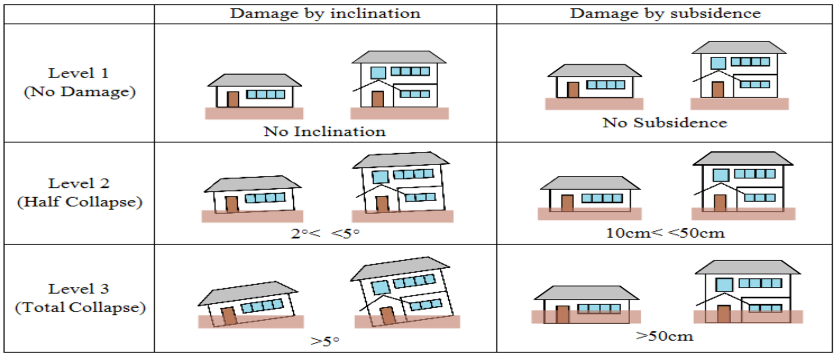

Figure-3. Damage chart for wooden structures affected by liquefaction

4. RESULTS OF THE CLASSIFICATION STUDY

The building damage patterns classifications in the study area using the damage chart is shown in Figure 4. Consequently, the proportion of total collapse is high at 50.3%. These photographs are including all buildings. However, it can be considered that damaged buildings were the main objects of the photographs. The numbers of the buildings in the study area are given in Table 2. Total of 376 buildings and their positions were confirmed from 1980 photographs. The damage chart made by Okada and Takai was for wooden structures and in Manek Uai, Kelantan area the majority of the structures are wooden, therefore, we investigated building damage to 179 wooden structures and classified the damage pattern of these buildings.

Table-1. buildings in the study area

Total number of surveyed buildings		376	
Total number of photographs		1980	
Number of the studied buildings	Wooden structures	179	47.6%
	Concrete structures	88	23.4%
	Masonry structures	109	28.9%
Survey by Universiti Teknologi Malaysia, Department of Quantity Surveying, (QS-UTM)	No Damage	73	19.4%
	Slight Damage	29	7.7%
	Half Collapse	85	22.6%
	Total Collapse	189	50.3%

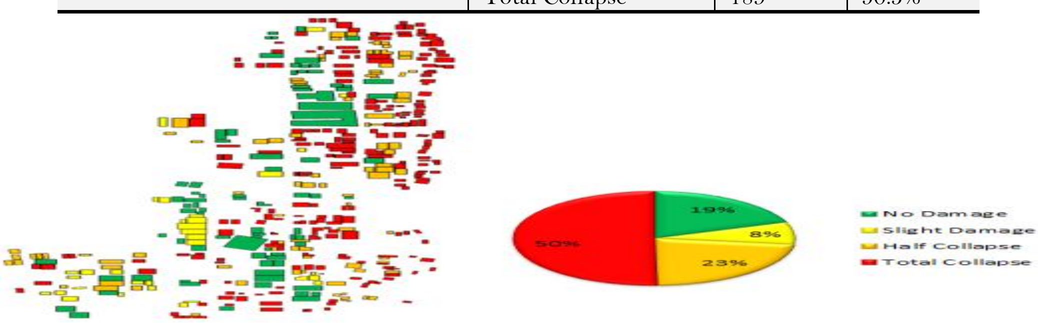

Figure-4. Distribution of total collapse rate in Manek Urai area and target area of the classification study

5. CONCLUSIONS

In this study, evaluation of the effectiveness of the damage chart for damage assessment is aimed and the damage survey is carried out by using the damage chart and photographs from the database of Manek Urai, Kelantan State. As a result, even if there was a little information in the photograph, it was possible to classify the damage pattern and evaluate the building damage based on the damage chart. Also, the survey of damaged buildings due to liquefaction is conducted. The damage patterns in liquefaction area were inclination or subsidence. In liquefaction area, it was important to observe these damage patterns for building damage survey. And a damage chart for wooden structures affected by liquefaction is developed.

REFFERENCES

Alhajri, T.M., M.M. Tahir, M. Azimi, J. Mirza, M.M. Lawan, K.K. Alenezi and M.B. Ragaee, 2016. Behavior of pre-cast U-shaped composite beam integrating cold-formed steel with ferro-cement slab. Journal of Thin-Walled Structures, 102: 18–29. DOI 10.1016/j.tws.2016.01.014.

Azimi, M., B. Asma, M.T. Mahmood, B.M.S. Abdul Rahman and M. Chau-Khun, 2016. Evaluation of new spiral shear reinforcement pattern for reinforced concrete joints subjected to cyclic loading. Journal of Advances in Structural Engineering, 19(5): 730-745. DOI 10.1177/1369433216630371.

Azimi, M., B.A. Azlan, M.T. Mahmood, B.M. Abdul Rahman and M.B.S.A.R. Sk, 2015. Seismic performance of ductility classes medium RC beam-column connections with continuous rectangular spiral transverse reinforcements. Lat. Am. J. Solids Struct, 12(4): 787–807.

Azimi, M., M. Ponraj, A. Bagherpourhamedani, M.T. Mahmood, S.A.R. Sk Muiz and P.P. Ong, 2015. Shear capacity evaluation of reinforced concrete beams: Finite element simulation. Jurnal Teknologi, 77(16): 59–66.

Chau-Khun, M., Z.A. Abdullah, O. Wahid, L. Maybelle, J. Siow-Wei and A. Mohammadamin, 2016. Flexural capacity enhancement of rectangular high-strength concrete columns confined with post-tensioned steel straps: Experimental investigation and analytical modelling. Journal of Structural Concrete: 1-25. DOI 10.1002/suco.201500123.

Hamada, T., S. Suwa, Y. Iwasaki, M. Kurazono and K. Tsuda, 1997. Structure damage by liquefaction at Tukiji area in Amagasaki city (Part2). Proceedings of Japan Association for Quaternary Research. pp: 222-223.

Kurazono, M., K. Tsuda, Y. Iwasaki, S. Suwa and T. Hamada, 1997. Structure damage by liquefaction at Tukiji area in Amagasaki city (Part1). Proceedings of Japan Association for Quaternary Research. pp: 220-221.

Ma, C., A. Awang, R. Garcia, W. Omar, K. Pilakoutas and M. Azimi, 2016. Nominal curvature design of circular HSC columns confined with post-tensioned steel straps. Journal of Structures, 7: 25-32. DOI 10.1016/j.istruc.2016.04.002.

Murao, O. and F. Yamazaki, 1999. A comparision damage evaluation by local governments after the hyogoken-nanbu earthquake. Jounal of Architecture, Planning and Environmental Engineering AIJ, 515: 187-194.

Okada, S. and N. Takai, 1998. Earthquake field investigation method using damage patterns of buildings: Part1 classifications of structual types and damage patterns of buildings. Summaries of Technical Papers of Annual Meeting AIJ. pp: 81-82.

Tatsuki, S. and H. Hayashi, 1999. Determinants of the changes of residence and life reconstruction among the 1995 Kobe earthquake victims. 24th Annual Hazards Research and Applications Workshop.