

EARTHQUAKE VULNERABILITY ASSESSMENT OF
THE BUILDINGS FOR DENSELY DISTRIBUTED
RESIDENTIAL AREAS IN DHAKA CITY

BY

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ABSTRACT

Earthquake is one of the most extreme hazards that can neither be predicted nor be controlled out of all the natural hazard reported. It has a major ability to degrade an urban socio-economics structure with geological components. For this reason, the main objective of this thesis is to assess the seismic vulnerability including ground factors, building's physical conditions and socioeconomic aspects, so that earthquake-prone buildings can be identified in terms of minimal loss of life and damage. Most of the present earthquake-vulnerability evaluation processes focus on structural loss evaluation without focusing on socio-economic features. In this research, a combined strategy for vulnerability evaluation has been developed for earthquake-prone areas in Dhaka District of Bangladesh. In order to fulfil the objective, seismic vulnerability of Reinforced Cement Concrete (RCC) structures has been evaluated in the study area using the Turkish method as proposed by the Turkey government and Japan International Cooperation Agency (JICA). 240 different reinforced concrete residential buildings within three selected wards of Dhaka city were assessed using a developed checklist. The physical vulnerability was estimated by walk-down procedure (site visit) of Turkish method to calculate the E.R.S (Earthquake Risk Score) value of each building, while the economic and social components with various indicators were determined through statistical studies which is a simple coding system to collect the data provided in the questionnaires. After that, calculated the proportion of respondents answering for each category of each question by SPSS software. This scoring was then calculated using a simple additive weighting (SAW) method to determine the most fragile area within the selected territory based on the social and economic status. The results revealed that only 10 out of 240 structures were considered as high risk, whereas 84 structures were of moderate risk. So, more methodical evaluations were suggested for such structures before confirming the building have an earthquake risk. On the other hand, ward no. 51 was the most vulnerable area against earthquakes according to social vulnerability, whereas ward no. 46 was more susceptible to earthquake due to economic vulnerability. However, this research has only been conducted in three Dhaka city zones. Similar work can be carried out in other parts of the town that belongs to vulnerable areas of the earthquake. Also, the assessment result of vulnerability features to develop the vulnerability index would therefore provide an excellent basis for the theoretical research.

خلاصة البحث

الزلازل هو أحد أكثر الكوارث خطورة والتي لا يمكن التنبؤ بها أو السيطرة عليها من بين جميع الكوارث الطبيعية المبلغ عنها. ولديها قدرة كبيرة على تدهور البنية الاجتماعية والاقتصادية الحضرية مع المكونات الجيولوجية. لهذا السبب، فإن الهدف الرئيس من هذه الأطروحة هو تقييم الضعف الزلزالي بما في ذلك العوامل الأرضية والظروف المادية للمبنى والجوانب الاجتماعية والاقتصادية، حيث يمكن تحديد المباني المعرضة للزلازل من حيث الحد الأدنى من الخسائر في النفوس والأضرار. تركز معظم عمليات تقييم التعرض للزلازل الحالية على تقييم الخسائر الهيكلية دون التركيز على السمات الاجتماعية والاقتصادية. في هذا البحث، تم تطوير إستراتيجية مشتركة لتقييم الضعف للمناطق المعرضة للزلازل في منطقة دكا في بنغلاديش. من أجل تحقيق الهدف، تم تقييم الضعف الزلزالي لهياكل الخرسانة المسلحة (RCC) في منطقة الدراسة باستخدام الطريقة التركيبية على النحو الذي اقترحه الحكومة التركيبية والوكالة اليابانية للتعاون الدولي (JICA) كما تم تقييم 240 مبنى سكني مختلف من الخرسانة المسلحة ضمن ثلاثة أجنحة مختارة في مدينة دكا باستخدام قائمة مراجعة مطورة. وتم تقدير الضعف المادي من خلال إجراء السير (زيارة الموقع) بالطريقة التركيبية لحساب قيمة ERS (درجة مخاطر الزلازل) لكل مبنى، بينما تم تحديد المكونات الاقتصادية والاجتماعية بمؤشرات مختلفة من خلال الدراسات الإحصائية وهي عبارة عن نظام ترميز بسيط لجمع البيانات الواردة في الاستبيانات. بعد ذلك، تم حساب نسبة المجيبين عن كل فئة لكل سؤال بواسطة برنامج SPSS ثم تم حساب هذا التقييم باستخدام طريقة ترجيح المواد المضافة البسيطة (SAW) لتحديد المنطقة الأكثر هشاشة داخل المنطقة المختارة بناءً على الحالة الاجتماعية والاقتصادية. لقد أظهرت النتائج أن 10 فقط من أصل 240 مبنى تم اعتبارها عالية الخطورة، في حين أن 84 مبنى كانت ذات مخاطر متوسطة. لذلك، تم اقتراح تقييمات أكثر منهجية لمثل هذه الهياكل قبل التأكد من أن المبنى معرض لخطر الزلازل. من ناحية أخرى، كان الجناح برقم 51 كانت المنطقة الأكثر عرضة للزلازل حسب الضعف الاجتماعي، بينما الجناح برقم 46 كان أكثر عرضة للزلازل بسبب الضعف الاقتصادي. ومع ذلك، تم إجراء هذا البحث فقط في ثلاث مناطق في مدينة دكا. ويمكن القيام بأعمال مماثلة في أجزاء أخرى من المدينة التي تنتمي إلى المناطق المعرضة للزلازل. كما أن نتيجة تقييم سمات الضعف لتطوير مؤشر الضعف ستوفر بالتالي أساساً ممتازاً للبحث النظري.

APPROVAL PAGE

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DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF ABBREVIATIONS

ADPC	Asian Development Preparedness Center
BNBC	Bangladesh National Building Code
B.S.	Base Score
CDMP	Comprehensive Disaster Management Programme
DCC	Dhaka City Corporation
DEM	Digital Elevation Model
EMI	Earthquake and Megacities Initiative, Inc.
E.R.S	Earthquake Risk Score
FEMA	Infinite Impulse Response
GDP	Global Gross Domestic Product
GFDRR	The Global Facility for Disaster Reduction and Recovery
M	Magnitude
MMI	Modified Mercalli Intensity
MoFDM	Ministry of Food and Disaster Management
NOAA	The National Oceanic Atmospheric Administration
PGA	Peak Ground Acceleration
PGV	Peak Ground Velocity
R.C.C	Reinforced Cement Concrete
RCF	Reinforced Concrete Frame Building
SAW	Simple Additive Weighting Method
S.R.V	Score Reduction Values
Si	Score of Indicator

UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNISDR	United Nations International Strategy for Disaster Reduction
URM	Unreinforced Masonry Building
USGS	United States Geological Survey
V.P.M	Vulnerability Parameter Multiply
W	Weight

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Earthquakes are natural catastrophe under which disasters are mainly caused by demolition or collapse of man-made structure and which can be violent enough to kill thousands of people. It is one kind of applied force which is affected directly to the building as whole partially and indirectly.

Earthquake destruction depends on many variables such as Intensity, vibration period, the strength and speed of the energy, frequency, geological and soil condition, construction system also known as factors. It is estimated that 500, 000 or so detectable earthquakes that occur worldwide each year, more than 150,000 temblors strong enough to be felt by humans and about 700 shocks have this capability to cause damage when centered in a populated area (FEMA, 2010). Although most of these destructive potential earthquakes are moderate in size and centre in unpopulated areas far from civilization, a severe earthquake infrequently strikes a community that is not prepared adequately and thousands of lives and billions of economic investment are lost.

For example, Haiti (North America) was struck with an earthquake of 7.0M magnitude on January10, 2010, rendering around 1.5 million people homeless and killing more than 230,000 people (2010 Haiti earthquake, n.d.)These numbers were far more than the casualties caused by the earthquake of same magnitude in San Francisco,1989 (63 died and 3,757 injured) (1989 Loma Prieta earthquake, n.d.). The reasons beyond such surprising difference were densely distribution of buildings and

other auxiliary structures. Most of the buildings did not built according to the standards and those were desperately destroyable in the grip of a strong earthquake. In this study, a vulnerability assessment process will categorize for earthquake hazard in densely disseminated residential location. The proposed evaluation model of vulnerability includes structural condition of houses, ground features, social (demographic) and economical phases of the settlement etc. The proposed methodology will have implemented for Dhaka, which is one of the metropolitans of Bangladesh. The purpose of the thesis is to calculate the building's vulnerability so that earthquake-prone buildings can be identified and plans to increase awareness among the users can be easily organized. The results of the vulnerability analysis can also be useful in developing an urban community earthquake awareness and mitigation approach.

1.2 BACKGROUND OF THIS STUDY

1.2.1 Earthquake Overview

An Earthquake is the series of vibrations caused by the arise of seismic waves which is spread out from rapid movements in rift, known as active fault in the Earth's crust. When some form of stored energy in the earth crust is suddenly release it causes seismic waves (Guney, 2015), usually when masses of rock push into each other or pull apart suddenly fracture and slip (Figure 1-1).

From the fault location, different types of waves and velocities travel different paths in all direction before reaching a building's site and exposing the local ground to various motions. A tectonic earthquake begins most often along geologic faults,

narrow zones where movement of the opposing blocks of rock past one another (Bachmann, 2002).

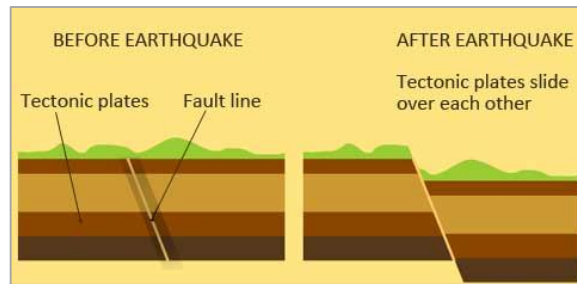


Figure 1-1: Earthquake Occurrence (Introduction to Earthquakes & Tsunamis, 2010)

Before getting into a site, different types of rupture propagation and velocities travels various routes and placed the local ground in danger by several motions. The earth surface shakes quickly both horizontally and vertically in all directions. The amplitude of the earthquake shaking is dependent on many variables, including size, distance from the epicentre, focus depth, topography and local circumstances.

Seismic waves classify into two general categories: body and surface waves. Body waves, including P and S waves, travel through inner earth (Figure 1-2). P waves look like sound waves for that they can compress and expand element as they pass. S waves act like water waves, so they move material up and down (Earthquake, n.d.).

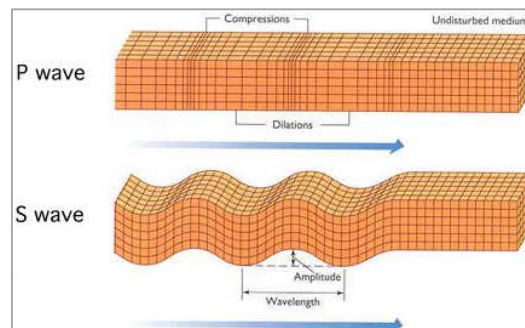


Figure 1-2: P Wave and S Wave (P Wave, n.d.)