SIMULATION OF BRICK MASONRY WALL BEHAVIOUR UNDER CYCLIC LATERAL LOADING USING FINITE ELEMENT METHOD

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ABSTRACT

This report presents the results of lateral strength and behaviours of masonry wall by using Finite Element Method. The study focused on comparison of lateral forces that caused the initial crack and ultimate crack between laboratory experiments done by previous researchers and the results from Finite Element Method. There were three masonry models based on the laboratory experiments done by previous researchers. Previous researcher constructed and tested three full scale wall specimens by using lading equipment in laboratory. AutoFEM Finite Element Analysis software was used to carry out the analysis. Solid element was used to model the wall in accordance with the dimensions of wall specimen by previous researcher. Static vertical forces and cyclic lateral forces were applied onto the model for analysis purpose. Results from the study suggested that internal crack of masonry happened at a lower applied lateral forces than the results from laboratory experiments. Results also showed lower lateral displacement values compared to results of laboratory experiments. The finding showed that internal stress of masonry was possibly to be identified when it was subjected to lateral forces.

ABSTRAK

Laporan ini membentangkan kekuatan dinding batu bata dan tindak balas dinding batu bata terhadap daya mendatar dengan menggunakan Finite Element Method. Kajian ini menumpu kepada perbandingan daya mendatar yang menyebabkan retakan awal dan retakan mutlak di antara ujikaji makmal yang dilakukan oleh penyelidik sebelum ini dan hasil daripada Finite Element Method. Analisis Finite Element telah dijalankan ke atas tiga model seperti kerja yang dijalankan oleh penyelidik sebelum ini. Penyelidik sebelum ini telah menjalankan ujikaji makmal terhdap tiga dinding batu batu yang dibina ikut skala sebenar dengan menggunakan perlalatan makmal. Perisian komputer AutoFEM telah digunakan untuk menjalankan analisis Finite Element. Unsur pepejal telah digunakan untuk model Finite Element dimana dimensinya serupa dimensi dinding batu bata yang dibina oleh penyelidik sebelum ini Hasil daripada kajian ini mencadangkan bahawa retakan dalaman batu berlaku apabila daya mendatar yang lebih rendah dikenakan terhadap dinding batu bata berbanding kepada keputusan yang diperolehi daripada ujikaji makmal. Keputusan juga menunjukkan bahawa nilai-nilai anjakan ke arah sisi yang lebih rendah berbanding dengan keputusan uji kaji makmal. Daripada keputusan yang diperolehi daripada kajian ini, ia menunjukkan bahawa tekanan dalaman batu adalah mungkin untuk dikenal pasti apabila daya mendatar dikenakan.

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F_a	-	Vertical stress
$H_{cracked}$	-	Lateral force at initial crack
f_{tu}	-	Tensile stress
H_{ult}	-	Peak lateral force
f_{vu}	-	Shear stress
σ	-	Stress
τ	-	Force
ε	-	Strain
γ	-	Shear strain
E	-	Elastic Modulus
v,u	-	Displacement

CHAPTER 1

INTRODUCTION

1.0 Introduction

Masonry wall is the common element in either reinforced concrete structures or steel structures for compartment and partition purpose. Most of the time in modern construction design, masonry walls are not designed to be a structural member to the building frame. This is also an argument among engineers where there are difficulties in determining the structural capacity of masonry walls. However, there is a case where there are two structurally similar buildings, one without internal non-structural masonry wall totally collapsed; while another one with internal masonry walls survives from being collapsed over an earthquakes attack but it experience moderate damages. From the view of just observation, masonry wall does have its effects on the seismic resistance of building frame. Masonry must be confined by cast in-situ reinforced concrete columns and beams with reinforced bars connecting these RC structures and masonry wall for dowel action in order for the system to work. This will form a diaphragm strong enough to resist a certain magnitude of moment and shear caused by lateral load before it fails. Masonry wall sustains damages in the form of cracks as mortar breaks at low level of load compared to brick units. There are many factors that could affect the structural capacity of masonry wall, for examples tie columns, tie beams, mortar, quality of brick used, etc. Nonetheless, understanding the behavior of masonry wall under lateral loads is very important in order to determine the structurally capacity of masonry wall. Therefore, experimental modeling has been carried out by researchers to capture the behavior of masonry wall.

1.1 Problem Statement

There has been a doubt on determining the capacity of load resistance of masonry wall by using computer analysis software. Conducting laboratory experimental test to determine the load resistance capacity of masonry wall is not practical in terms of cost, time and scale for each and every different condition. The efficiency and effectiveness of a project during design and construction stages depend on time and cost. Therefore, it is important to develop and method of modelling masonry wall in computer analysis software in order to proof that analysing the load resistance of masonry using computer software will produce the same result as laboratory experimental tests.

1.2 Objectives

i. To model the behaviours including lateral strength against cracking and displacement of masonry wall under cyclic lateral loadings.

ii. To compare the results between Finite Element Analysis and laboratory experiments.

iii. To determine the internal stress of masonry and deformation shape reacting to cyclic lateral loadings.

1.3 Scope of Work

This paper involves developing unreinforced masonry models using Finite Element Analysis computer software. Software “AutoFEM” has been chosen to analyse the model. The results of Finite Element Method analysis were studied and discussed as well as comparison had been carried out between Finite Element Method analysis and laboratory experimental exercise by previous researchers. Besides, the internal stress of masonry and deformation shapes reacting to the externally applied loads shall be study and discussed.

1.4 Limitation of Study

The limitation of the study includes the result of cracking of wall specimens are not shown in the AutoFEM software. Instead, it shows the percentage of damage experienced by the wall specimens. On top of that, it also shows the utilization of safety factor of the element strength. Therefore, the crack is interpreted from the results of safety factor utilization where the element undergoes failure, in the case is the crack, when the utilization ratio is more than one.

On the other hand, Finite Element mesh generation in AutoFEM software is limited to tetrahedral type. Although tetrahedral is the most suitable type of mesh for solid element, it limits the trial of different type of mesh generation in order to compare would the mesh type cause any difference to the result of the analysis.

Another limitation of AutoFEM is that the displacement of wall specimens and the damage of wall specimens within the cycles of loading applied could not be determined. The software shows the displacement and the damage of wall at the end of the cycles of loading. Therefore, the results of displacement and the damage of wall by the software are considered in the comparison of results between Finite Element Method and laboratory experiments.

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