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Self Compacting Concrete Shear Walls using Solid65 Element

Atared S. Kawoosh
Department of Civil Engineering, College of Engineering, University of Thiqar, Thiqar, Iraq

Abstract: The main objective of this paper is to study the structural behavior of self-compacting concrete shear wall. The study an analysis of two SCC shear walls has been conducted to the tested specimens by using a three dimensional nonlinear finite element method by ANSYS software.

In the present work is able to simulate the behavior of SCC shear walls without openings. The numerical ultimate loads are slightly lesser than those obtained from experimental work. The ratio of numerical ultimate load to experimental ultimate load is between 0.9 and 0.99. The adopted finite element analysis showed a good agreement with experimental results. The crack patterns obtained from the finite element models are comparable with the crack patterns observed in the experimental work and was very well in agreement.

Keywords: Shear walls, Solid 65 element.

1. INTRODUCTION

Shear walls are popular structural systems to resist lateral forces and axial loads acting on buildings such as earthquakes, wind or blast. Shear walls are more preferable in high rise buildings and office towers. They are vertical elements of the horizontal force resisting system and constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls should be designed and constructed properly to have a good strength and stiffness to resist the horizontal forces. The best location of its in buildings can be achieved when the shear wall located at the periphery of the building . The walls on each side might be single or may be a coupled to each other [1]. In 2012, Zhu T. et.al [2] suggested a new composite structure system to proportion the desired building heat preservation and energy conservation. Depend on the low reversed cyclic loading test, the non-linear finite element method (FEM) analysis sample of composite shear wall was established by ANSYS so as to study stress variation characteristics, failure process and crack status under the action for the horizontal loading. The results of ANSYS finite element analysis showed good agreement with the results of test. In 2013, Gopalarathnam M. and Kumar M. [3] studied the material nonlinear dynamic response for the shear wall, without and with openings for various damping ratios and subjected to El Centro earthquake. For dynamic analysis, constant acceleration Newmark β method for the direct time integration was used. From the study, it was observed that the existence of opening results in stresses on the shear wall and critical displacements and also results in stress condensation near the opening tip. Hence, the existence of damping was investigated to be vital for large opening under critical dynamic loading condition. In 2008, Aihara C.H et al. [4] studied the influence of aggregate grading on the properties of SCC mixtures using aggregates derived from basalt rock which is native to and readily available on the Island of Oahu. They found the slump flow, T500, VSI values change with the change in grading. In 2009, NCHRP-R628 [5] reported that, HRWRA demand decreases with the increase in W/C and binder content, surface settlement of SCC increases with the increase W/C ratio and thixotropy of the SCC decreases with the increase in binder content and W/C ratio. Better slump flow retention can be obtained with SCC made with a lower W/C ratio because of the higher HRWRA demand.

2. Modeling of Shear wall using Solid 65 Element

ANSYS16.1 program have the ability to model various types of material properties. Three dimensional brick element SOLID65 was utilized to model the concrete without or with reinforcing rebar. This element is defined by eight nodes having three degree of freedom at each node: translation in the x, y and z direction. Most of the formulations of concrete material models are either plasticity-based or elasticity-based models. The most important aspect of this element is the treatment of nonlinear material properties. This element is capable of cracking (in three orthogonal directions), crushing and plastic deformation. The rebar is capable of taking compression and tension [6]. The geometry, node location and the coordinate system for SOLID 65element are show in the Figure (1).

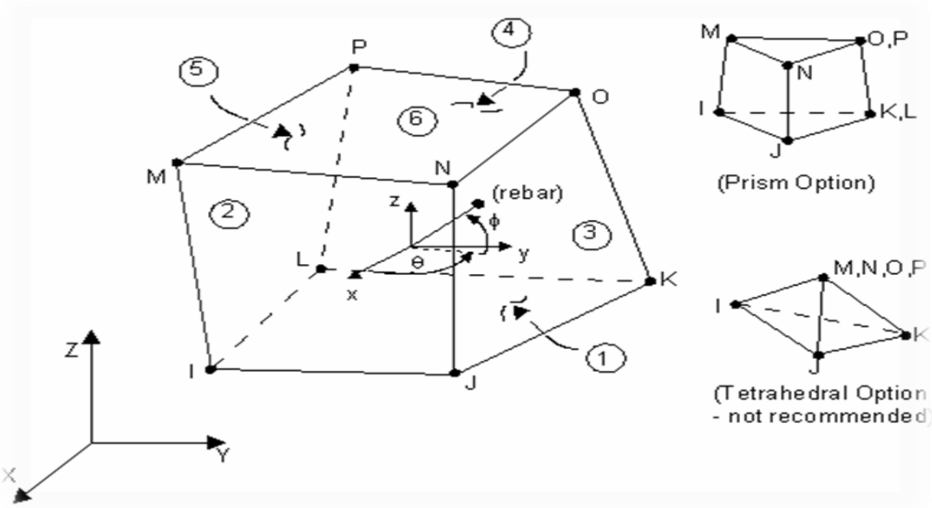

Figure (1) Brick Element with 8 Nodes (SOLID65 in ANSYS-16.1)

2.1 Solid 65 Input Data

The element is defined by eight nodes and the isotropic material properties. The element has one solid material and up to three rebar materials. Command is used to input the concrete material properties while link 8 is used to represent the main reinforcement so, the volume ratio which is defined as the rebar volume divided by the total element volume is equal to zero .

Typical shear transfers coefficient ranges from 0.0 to 1.0, with 0.0 representing a smooth crack (complete loss of shear transfer) and 1.0 representing a rough crack (no loss of shear transfer). These specifications may be made for both the closed and open crack. Used in this study the shear transfer coefficients: Open shear transfer coefficient $\beta t = 0.2$, closed shear transfer coefficient $\beta c = 0.8$.

3. Analysis Result and Discussion

A non-linear finite element analysis has been carried out to obtain the numerical results of shear wall specimens. The analysis was performed by using ANSYS computer program (Version 16.1), models of shear walls specimens prepared and analyze.

This verification of tested specimens was done in order to check the validity and accuracy of the finite element procedure. The numerical results obtained by using finite element method were compared with the experimental results through the ultimate loads and load-displacement relation.

3.1 Failure Load

Table (1) explain the experimental and numerical failure load of solid specimens. It is clear that the finite element results are very well in agreements with experimental results. The results show that for SHW1 and SHW2, numerical failure load reach 92% and 90% of experimental failure load, respectively.

Table 1: Experimental and numerical results' failure load

Group No.	Specimen Symbol	Numerical Failure loads (kN)	Experimental Failure loads (kN)	P(Num.) /P(Exp.)
1	SHW1	635.5	692	0.92
	SHW2	737.28	820	0.9

3.2 Load – displacement

Figure (2) and (3) show the load-displacement relationship for both numerical and experimental results. Numerical results gave a very good agreement with experimental results. The numerical displacement was greater than the experimental displacement. While the ultimate load of the finite element model is smaller than the experimental ultimate load.

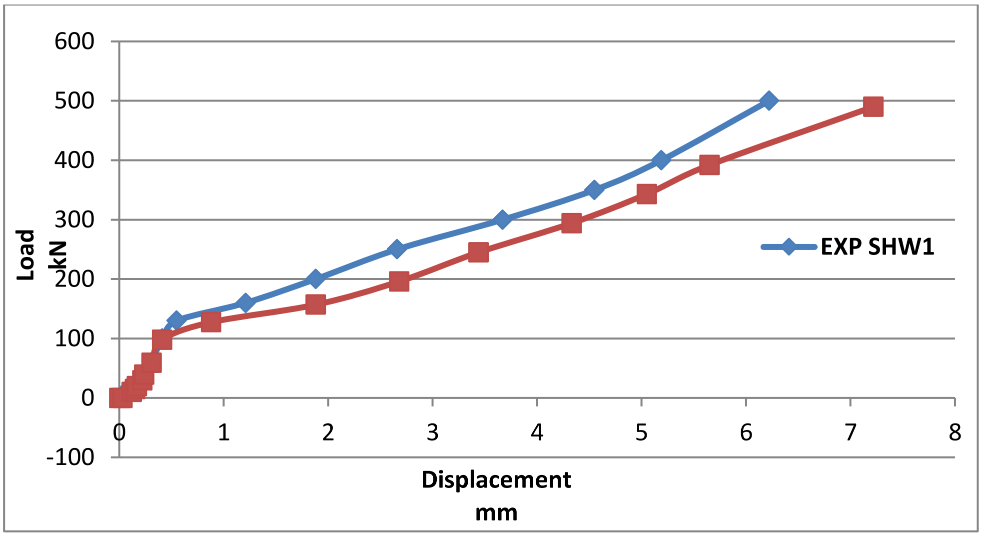

Figure (2) Numerical and experimental load-displacement relationship of model SHW1

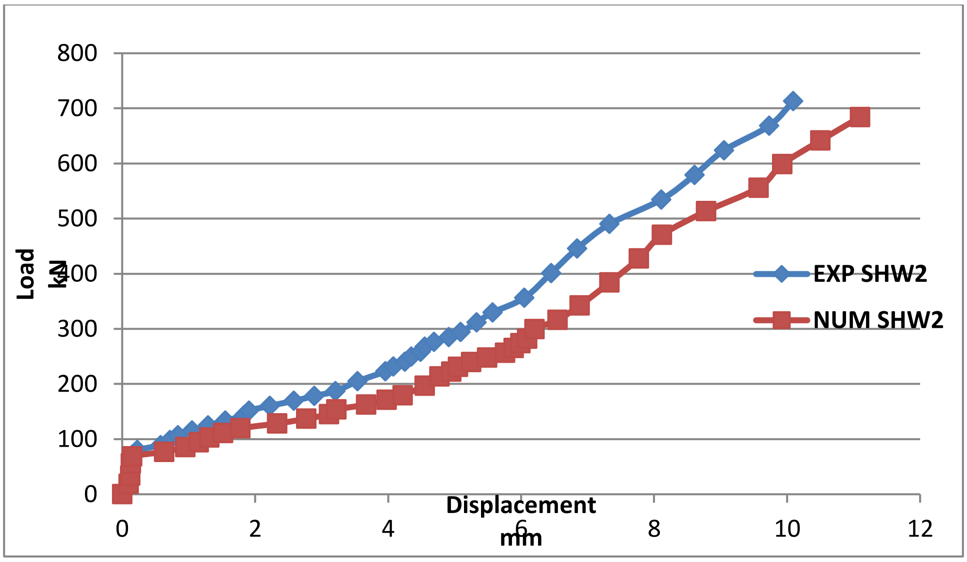

Figure (3) Numerical and experimental load-displacement relationship of model SHW2

3.3 Concrete Strain Distribution

Figure (4) show the numerical strain distribution of SCC shear wall model. From these figure it can be observed that the maximum strain occurs along the load path where the diagonal crack had occurred. This is observed in solid models.

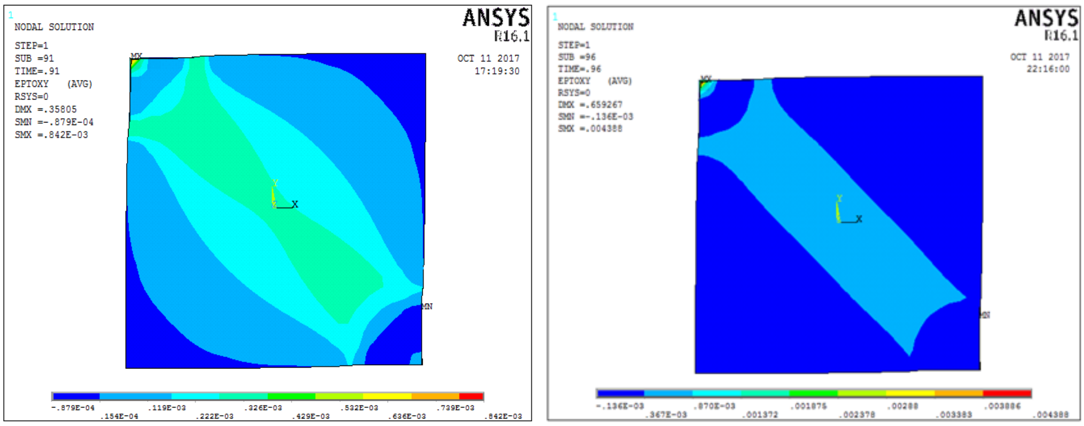

Figure (4) Concrete strain for shear wall without openings (SHW1) and (SHW2)

4. Conclusions

1. Increasing the thickness of shear wall means an increase in the strength to sustain the applied loads. For the solid specimens, when increasing thickness from 100mm to 150mm the ultimate load increased by 18%.
2. The finite element model used in the present work is able to simulate the behavior of axially loaded reinforced concrete shear walls without openings. The numerical ultimate loads are slightly lesser than those obtained from experimental work. The ratio of numerical ultimate load to experimental ultimate load ranged between 0.9 and 0.99.
3. In general, the behavior of the finite element models represented by the load-displacement curves shows a good agreement with the corresponding experimental curves.

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