Numerical Analysis of Non-Linear RCCShear Wall Using Abaqus Software

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Abstract-Earthquakes are one of nature's greatest hazards on our planet and have taken aheavy toll on human life and property since ancient times. Since antiquity, earthquakeshave been one of nature's greatest threats to human life and property on our planet. They are also one of the most common natural disasters. People are not killed by earthquakes;instead, dangerous structures are to blame for the widespread destruction. Structures collapse when they are unable to withstand seismic forces. In addition to the significantloss of human life, it becomes difficult to dispose of the debris left behind when buildings fall, and the construction of new buildings also pollutes the environment. Themost efficient way to lessen earthquake damage is to plan and construct structures thatare earthquake-resistant from the start. Shear walls resist lateral and horizontal pressures, and dynamic loads have an impact on all structures. Our goal is to prevent structural deformation brought on by dynamic loading. A building's reinforced concreteshear walls may be able to withstand lateral loads from wind or earthquakes. Using Abaqus software, this study examines the non-linear behaviour of reinforced concrete Shear wall under monotonic loading.

Keywords: Shear wall, Abaqus, Non-linear, monotonic lading.

INTRODUCTION

According to Fintel (1991), a renowned consulting engineer in the United States, "We cannot afford to design concrete buildings built to endure severe earthquakes without shear walls." Building structures with shear walls are referred to as structural walls are made to withstand lateral forces thatan earthquake, wind, or other lateral force can cause in the wall's plane. Because these walls act more like flexural members at large aspect ratios, the term "shear wall" (SW) is somewhat misleading. They are typically present in tall structures and have been discovered to be of great assistance in preventing the complete collapse of structures under seismic stresses. While planning shear walls, one shall try to reduce the bending stresses due to lateral loads on columns by transferringthe lateral loads to shear walls of large stiffness.

Shear walls can be either (1) coupled shear walls (2) simple rectangular versions with or without boundary features. (3) Nonrectangular T, C and (4) Box type. A simple rectangular shear wall that is being actedupon are susceptible to axial, bending, and shear forces as a result of in-plane vertical loads and horizontal shear along its length. Walls that are rectangular andhave boundary elements tend to be stronger and more ductile. These walls should be designed in such a way that they never fail in shear but only by yielding of steel in bending, becauseshear failure is brittle and sudden. Due to this shear wall's rigidity, one of its drawbacks is that during an earthquake,it attracts and consumes a lot of energy by cracking, which is challenging to fix.Coupled shear walls have the ability to correct this flaw. The resultant wall willbe more rigid if two structural walls areconnected by relatively short spandrel beams, and the structure can release the majority of the energy without causing any structural damage to the primarywalls by yielding the coupling beams. These connecting beams are simpler to replace than the walls. Elevators andother service spaces in some buildings may be arranged in a vertical core known as a box type shear wall, which may act as the primary structural component.

BEHAVIOUR OF SHEAR WALL

The following generic descriptions apply to the failure modes of the walls: Flexure failure (often seen in slender shear walls) is characterised by vertical steel yielding, steel fracture, and crushing of the surrounding material Concrete first, then buckles in steel. Shear failure, which is typically seen in squat shear walls, can result in either diagonal crushing (between tension cracks) or diagonal tension (steel yielding and fracture at crack Sliding shear failure is another prominent mode of failure that can be seen in slender walls. When horizontal fissures are widened by the cyclic moment following flexural yielding, slide failure can occasionally occur. These opening fractures experience in sliding shear lose the ability totransfer shear strength across horizontalcracks.

Squat and slender walls are the two main categories for shear walls based on behaviour. A squat wall (low-rise or short shear wall) is one in whichshear regulates deflection and strength. A slender (high rise) wall or tall shear wall) is one in which flexure regulates deflection and strength. In general, the walls with an aspect ratio (height towidth ratio) less than unity are squatshear wall, while ratios more than 2 aredefined as slender walls. The failure is governed by both flexure and shear in intermediate walls, which have an aspect ratio in transition between 1 and 2.

LITERATURE ON SHEAR WALL

G.V. Rama Rao (2016) Studieson ductility of shear walls. Ductility of shear wall is influenced by several factors like aspect ratio, axial load on shear wall, percentage of vertical reinforcement and percentage reinforcement in boundary element. A parametric study had been carried out on the nonlinear ductile behaviour of shearwall using ABAQUS finite element software. Concrete Damaged Plasticity (CDP) model is used to represent the nonlinearity. The validity of the model is checked with the experimental results. A comprehensive study is made on codal provisions for shear wall and suitable recommendations are made to improve the ductility of shear wall. From the parametric study, it concludedthat, to ensure ductile response under strong seismic shaking, the design of shear wall section needs to ensure the axial load to be not more than about 30% of the ultimate axial compression capacity.

G.V. Rama Rao, N. Gopala Krishnan (2016)Studies on Nonlinear Behaviour of Shear Walls of Medium Aspect Ratio under Monotonic and Cyclic Loading. Shear walls are the ideal choice to resistlateral loads in multistore RC buildings. Nonlinear performance of medium aspect ratio shear wall specimens are studied on three identical shear wall specimens through application of monotonic and cyclic loading. In order to study the effect of axial load on the flexural behaviour and ductility of shear wall, a parametric study is conducted using a layer-based approach, which is used to generate the analytical pushovercurve for the shear wall and validated with the experimentally evaluatedpushover curve of the tested shear wall.A comparison is made between monotonic and cyclic load behaviour. Stiffness and strength degradation and pinching parameters are evaluated fromcyclic tests. Plastic rotation limits and ductility capacities under monotonic and cyclic loading conditions are compared with recommended values.

CODAL PROVISIONS

In India, codal provisions for shear wall are discussed in Indian standard code IS13920:2016, which deals with the ductile detailing of reinforced concrete structures subjected to seismic forces with several improvements in the design of shearwalls. IS 13920: 1993 is silent about classification of wall as squat or slender based on aspect ratio. The revised IS 13920:2016 is classified shear wall according to aspect ratio i.e. ratio ofheight of the wall (*hw*) to horizontal length (*Lw*). If $hw/Lw < 1$,squat walls; $1 \leq hw/Lw \leq 2$ intermediate walls and $hw/Lw > 2$ are termed as slender walls. The minimum thickness of any part of the wall shall preferably, not be less than150 mm.

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NUMERICAL INVESTIGATIONOF SHEAR WALL

Reinforced concrete shear wallabsorbs and dissipates considerable energy during an earthquake by concrete cracking and yielding of steel. All this phenomena occurred in inelastic range. Hence it is mandatory to study the behaviour of structures in inelastic range also. Nonlinear models for shear walls need improvement and refinements based on inputs from actual tests. The finite element analysis of shear wall using ABAQUS software is presented. The shear wall, having dimensions of 3 m in height, 1.56 m in width and 0.2 m in thickness is considered for validating the procedure. The shear wall is axially loaded with a super-imposed vertical load of 140 kN. The shear wall has 16 - 10 mm diameter bars which are placed as longitudinal vertical reinforcement in two layers witha non-uniform spacing in plan. At both ends of shear wall, 3 bars in each layer are kept with a spacing of 150 mm c/c and remaining bars are spaced at distance of 300 mm c/c. Four vertical bars at the both ends are provided with special confining reinforcement in the form of hoops. This is towardssimulating a concealed boundary element. 10 mm diameter bars are placed as horizontal reinforcement withspacing of 300 mm c/c at two layers. The grade of concrete is M30 and the grade of steel reinforcement is Fe415.

Height	3000mm
Width	1560mm
Thickness	200mm
Slab	2500x2500x500mm
Raft	2500x2500x400mm
Clear Cover	30mm

Table 1- Dimensions of shear wall

ABAQUS RESULTS

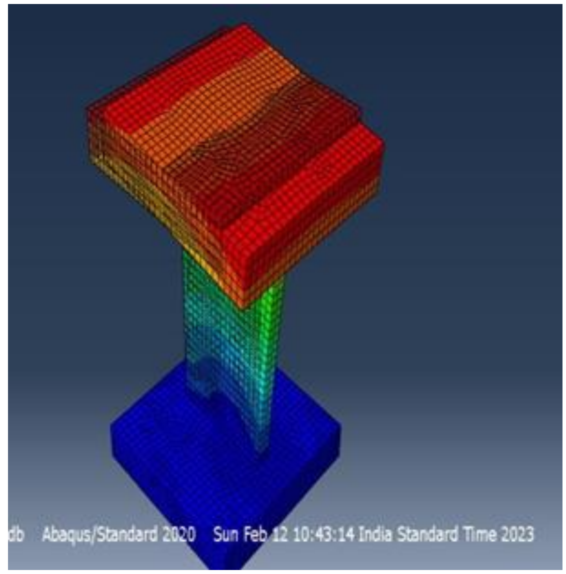

Fig 1- Deformed shape

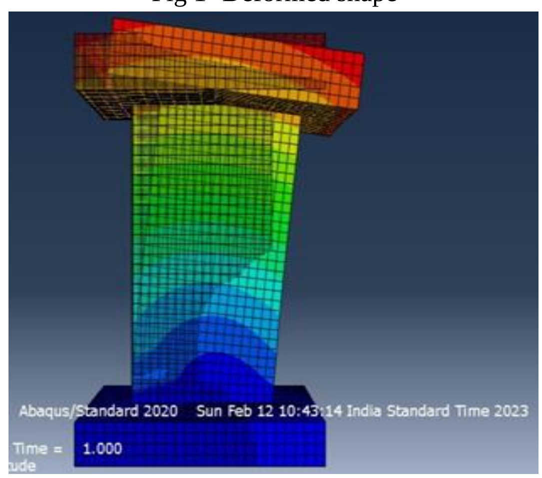

Fig 2 – Contour on Displacement in3D view

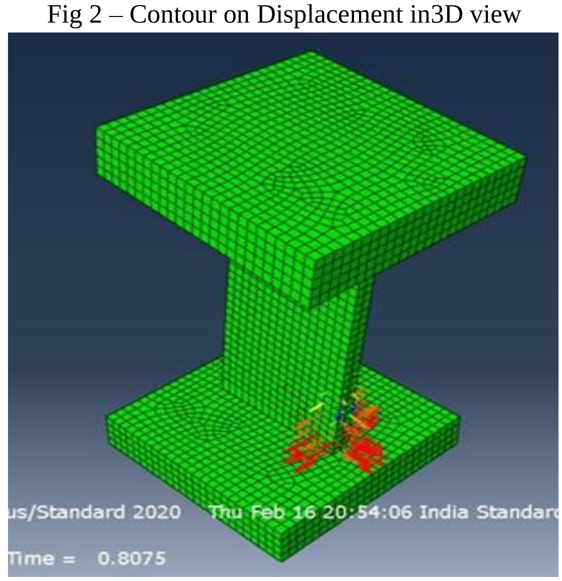

Fig 3 – Contour on Displacement inFrontview

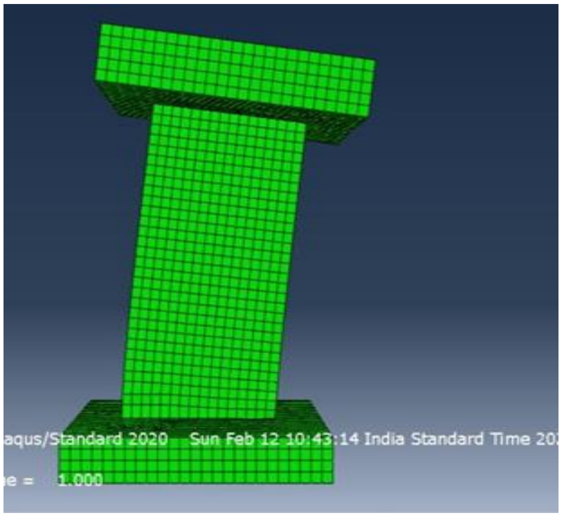

Fig 4 – Principal stresses

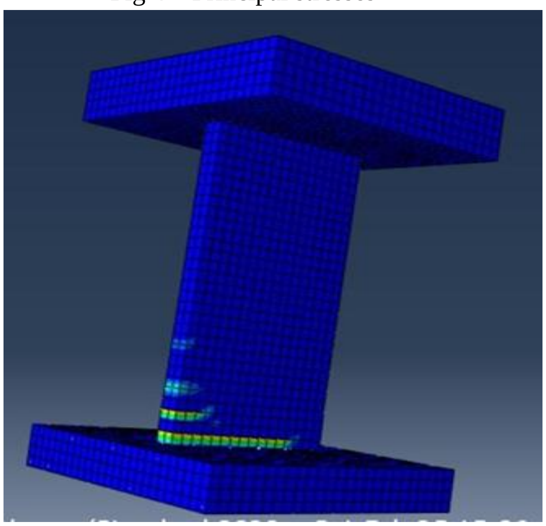

Fig 5 –Tension crack pattern

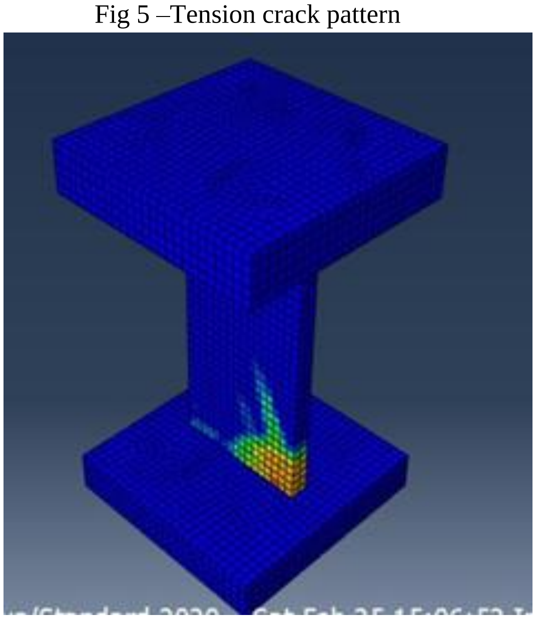

Fig 6 – Compression crack pattern

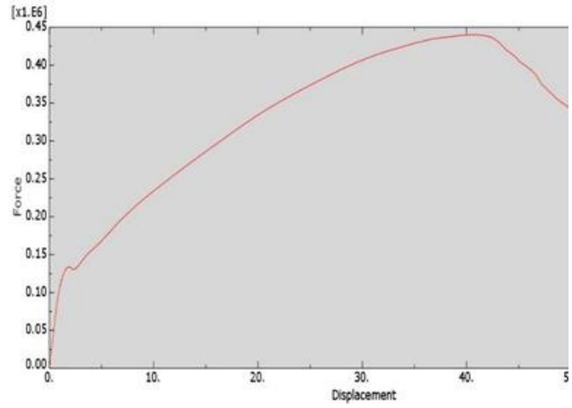

Fig 7 – Load Vs Displacement

CONCLUSION

1. The Plastic hinge is formed at the baseof the shear wall i.e. at the junction of raft and shear wall.
2. The Tension crack pattern is observedat the side of lateral loading (left). On the base of the shear wall i.e. above the foundation the crack is developed with the magnitude of 1.348Mpa.
3. The Compression crack pattern isobserved at the other side of the shear wall (right). On the base of the Shear wall i.e. above the foundation the crack is developed with the magnitude of 1.196Mpa.
4. The Principal stresses were observedat the base of the shear wall with the magnitude of $2.837XE^{-01}$Mpa.
5. The maximum load carrying capacityof the shear wall is about 430kN and maximum lateral displacement is 45mm.

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