Experiemental Investigation and Analysis on Shear Walls

Rama Krishna Kolli, Lingeshwaran Nagarathinam

Abstract: During earthquakes large amount of buildings are getting collapsed due to the cause of lateral forces and increasing of load carrying capacity in structural element and it's caused by winds, earthquake, and uneven settlement of loads. Least damage and wellbeing healthy level of a structure is the necessary requirement of tall buildings. For reducing the effect of damage on all tall structures, it may consist of base isolation techniques &shear walls etc. For enhancing the structural performance and to limit the damage of a building shear walls are used. On tall buildings to prevent earthquake loads Reinforced Concrete walls used as supporting elements. Reinforced Concrete structures are mainly implemented in engineering practices in different situations and various applications.

Many researchers addressing on performance of a shear walls with boundary conditions based on different types of reinforcement alignment. This paper deals with the Load Vs deflection curve, crack pattern, mode of failure of shear wall without boundary elements and three specimens of 200mm thick are casted with different reinforcement alignment types are examined and analysis of shear walls by using STAAD Pro, comparing the results of both experimental and analyze the shear walls to further crack deflections patterns

Index Terms: reinforced concrete walls, boundary elements, reinforcement types, STAAD Pro.

I. INTRODUCTION

Reinforced concrete wall is designed as a compression member. Reinforced concrete wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. These are the vertical elements of the horizontal force resisting systems and resist the loads due to cantilever action. These RC walls are used in case where beam is not provided and load from slab is heavy or when masonry wall thickness is restricted and in this the Load from slab is transferred as axial load to wall.

There are still limitations to fully reproduce the actual seismic behavior of structures. For addressing the design of buildings in an efficient way there are some simplifications which are using currently. These simplifications become even more relevant because of their many possible cross-sections (e.g., T, L, or C shapes).

Major research efforts have focused on doing their work on reinforced concrete shear walls having boundary elements with normal conventional and diagonal reinforcement. For identifying the seismic response of shear walls having without boundary elements and changing the alignment of reinforcement types is a topic of current research. [1] Presented a modelling on analysis of light weight concrete shear walls and in this analysis were carried out for light weight concrete shear walls by keeping the reinforcement in four different ways. The ANSYS 8.0 was used to do the numerical study on light weight reinforced concrete shear walls, and from that numerical results were compared with the experimental results and they said that diagonal web reinforcement was effective in transferring shear force to foundation. [2] presented an experimental study on seismic restoring performance of reinforced concrete shear walls, Based on that study by increasing and decreasing the axial compression ratio and shear span ratio, Quasi static test was done for nine reinforced concrete shear walls and they concluded that bearing capacity of shear wall will increase by increasing the axial compression ratio to some extent. [3] Presented behaviour of reinforced concrete shear wall buildings subjected to large earthquakes and in this analysis were carried out on two buildings of 17 and 26 stories which were survived from 2010 Chile earthquake and states that buildings constructed in Chile until 2010 are constructed without boundary elements and these techniques gives a good performance in 1985 Valparaiso earthquake (Mw 8.0) and states that boundary elements are not mandatory. [4] presented a seismic behavior of high strength concrete slender wall under high axial load, In this the comparison between two specimens of concrete strength of 80Mpa and 40Mpa are tested under high axial load and concluded that under same axial load 80Mpa concrete showed large deformation capacity than 40Mpa concrete and also said that design of HSC slender walls is possible with flexure type failure mode under high axial load. [5] presented a global perspective on minimum wall thickness requirements of shear wall, In this a comparison between minimum wall thickness requirements for load bearing reinforced concrete shear wall system was done based on two code books of IS456:2000 and IS13920:2016 and concluded that ratio of height to thickness shall not exceed 30 as per IS456 and thickness of any part of the wall section shall not be less than 150mm.

II. OBJECTIVE

1. Comparison between conventional type and diagonal type reinforced shear wall.
2. Stress development due to application of loads on walls by axial and horizontal.
3. To identify Crack pattern in walls.
4. Development of deflection due to application of walls.

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III. EXPERIMENTAL PROGRAM

In this present study, three reinforced concrete walls with length and height of 1.2m×0.8m and with thickness of 200mm was considered and the analysis of the wall was done manually using direct design method. A moment calculated using this method of analysis was used to design the wall as per the Indian code, IS 456: 2000 [5] and IS 13920:2016 [6].

A total of three reinforced concrete walls were cast and were tested on the loading frame. The main aim of this study was to study the performance and behavior of reinforced concrete walls both without the provision of boundary elements. The details of the cross-section and reinforcement of the three wall specimens are listed below.

A. WALL DETAILS

The three walls were given codes WS (Wall specimen) 1 to 3. WS1 was the wall specimen casted with normal conventional reinforcement.WS2 and WS3 were the remaining two wall specimens provided with diagonal reinforcement. The cross-sectional details of the three wall specimens are described in table 1.

Table I: Dimensions of wall specimens

Specimen	Length (mm)	Height (mm)	Thickness (mm)
WS 1 WS 2 WS 3	800	1200	200

B. SHEAR REINFORCEMENT

Total three Wall specimens were provided with shear reinforcement in the form of shear stirrups.

For wall WS1, shear reinforcement was provided in the form of shear stirrups. Shear stirrup is one of the most commonly used types of shear reinforcement. In this study, two legged stirrups were used to connect the vertical reinforcement bars. 8mm diameter bars of Fe500 grade steel is bent into required lengths and are placed around the wall connecting the vertical reinforcement bars. For walls WS2 and WS3, diagonal type reinforcement is provided. These diagonal reinforcements are connected with the shear reinforcements both at top and bottom of the wall specimens.12mm dia bars of Fe500 grade steel is used as diagonal type reinforcement in both of the wall specimens.

C. REINFORCEMENT DETAILS

The horizontal reinforcement for all three wall specimens was the same. In this the horizontal reinforcement is known as shear reinforcement. This shear reinforcement is provided in the form of shear stirrups. But, for the walls WS2 and WS3, additional reinforcement was provided. This additional reinforcement was provided in diagonal direction the detailing of reinforcement for the wall is shown in table 2 and table 3 respectively. Figure 1 shows the reinforcement details of wall WS1, which has no diagonal reinforcement in it. Figure 2&3 shows the reinforcement details of wall WS2&WS3 which has diagonal reinforcement in it.

Table II: Detailing of wall reinforcement

specimen	Longitudinal reinforcement	Shear reinforcement	Diagonal reinforcement
	top & bottom	top & bottom	top & bottom
WS1	5No-12mm	7No-8mm	
WS2	5No-12mm	7No-8mm	2No-12mm
WS3	5No-12mm	7No-8mm	2No-12mm

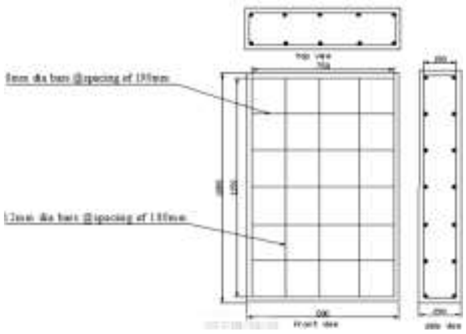

Fig. 1: Reinforcement detailing of wall specimen 1

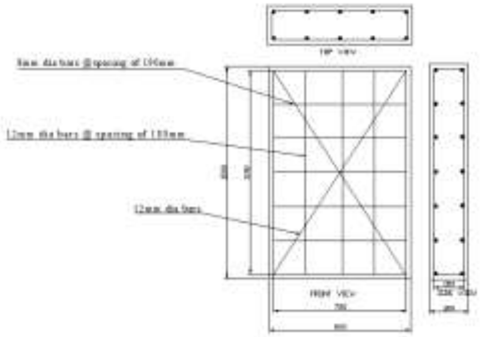

Fig. 2: Reinforcement detailing of wall specimen 2

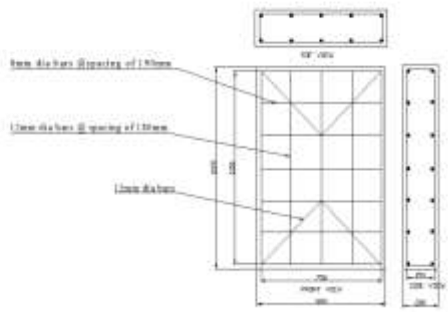

Fig. 3: Reinforcement detailing of wall specimen 3

D. CONCRETE

Concrete used for the three wall specimens was designed according to IS 10262: 2009[4]. Ready-mix concrete of grade M30 with a mix design- 1:1.5:2.8 was used. The concrete was compacted by vibrators and after casting, the three cured were cured for 28 days. Three concrete cubes of size 150mmx150mmx150mm were cast using the same sample and the cubes were tested on the same day as that of the wall specimens. The 28 days compressive strength obtained for the concrete mix design is shown in Table 3.

Table III: Compressive strength of concrete cubes

SPECIMEN	WS1	WS2	WS3
Load (KN)	730	725	730
Load (KN)	750	705	710
Load (KN)	770	730	725
Compressive strength(N/mm^2)	33.33	32	32.07

E. TEST SETUP

The setup was carried out with 200 tones loading frame and loading jack was fixed on the top of the wall. Load cell was fixed to the tip of the jack by nut bolt system. Testing of RC walls was carried out under Point Load on the wall. Before testing, the specimens were painted with lime white wash to identify the crack pattern due to the applied loadings. The load verses deflection curves were plotted according to the load values given by the loading frame. The load was applied with uniform increment up to the failure. The load applied on the wall specimens was measured using a compression loading cell. LVDT (Linear Variable Differential Transducer).The dial gauge readings were taken to calculate the deflection of the wall at each increment. Deflections caused by these loadings were tabulated at each increment of loading. Crack patterns were developed due to loading, and finally failure load was recorded.

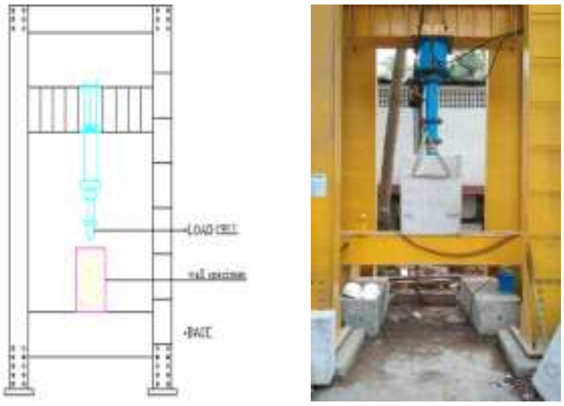

Fig 4: loading frame Experimental set up

IV. ANALYSIS

In this Analysis for shear walls is done by using STAAD. Pro software. This software is used for structural modeling and analysis. Result obtained from analysis is collected in terms of stresses in shear wall panels. Also, maximum nodal displacement, maximum shear force, maximum bending moment, maximum axial force, maximum storey drift are noted for the wall elements.

The three shear wall panels (WS1, WS2, WS3) with different types of reinforcement alignments with fixed supports were designed by using STAAD Pro software is shown in Fig 5.

Procedure for analysis of shear wall in STAAD Pro

1. In space, add beam option is chosen for creating a wall using nodal points.
2. After creating a model, wall properties and wall thickness is assigned.
3. Support conditions are given to the wall as per requirement.
4. Load combination is chosen as per IS 456-2000.
5. Assigning dead load and live load on reinforced concrete wall.
6. Create a shear wall panel and assign all the properties of that shear wall.
7. Run analysis and results will obtain.

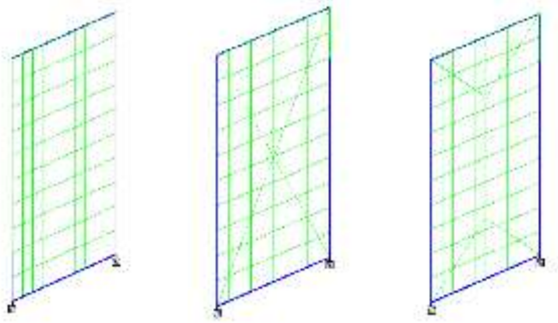

Fig. 5: wall specimens WS1,WS2,WS3

V. RESULTS AND DISCUSSION

EXPERIEMENTAL RESULTS

A. CRACK PATTERN

The total three wall specimens WS1, W2, WS3 contained shear reinforcement. The specimen WS1 which was a control specimen failed at a load of 1005kN.In this wall spalling of concrete is observed due to application of high amount of load. The crack pattern of the specimen is shown in figure 5.

Specimens WS2 and WS3 contained shear reinforcement and diagonal reinforcement in it. Crack pattern for both the walls was different to that of wall WS1, because in this an extra reinforcement was added by changing its alignment type in both WS2&WS3. A frustum pyramid type crack was formed on the face of the wall of WS2.the crack pattern for the all three specimens WS1, WS2 and WS3 is shown in figure 5.

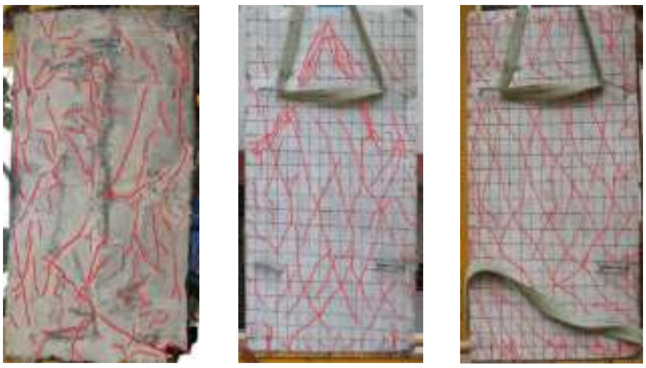

Fig. 6: crack pattern for walls WS1,WS2,WS3

B. LOAD VS DEFLECTION

The specimen WS1 failed at a load of 1005kN with a deflection of 2.92mm and spalling of concrete failure is observed in it. WS2 had a cracking load of 900kN and had a maximum load carrying capacity of 1227kN with a deflection of 3.6mm. WS3 had a cracking load of 980kN and had a load carrying capacity of 1275kN with a deflection of 2.96mm. The load Vs deflection graph for the three wall specimens is shown in Figure 6.

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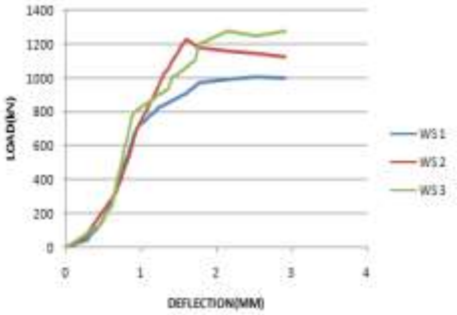

Fig. 7: load vs deflection curve for walls WS1,WS2,WS3

ANALYTICAL RESULTS

Table 4 shows the maximum values of three broadly classified stresses. Stress contour for shear wall are shown in figures. All three stress contours shows the concentration of stresses in shear wall.

Table IV: stresses in shear wall (N/mm^2) for point load.

S.No	Stresses	WS1	WS2	WS3
1	Max. absolute	4.74	5.8	6.03
2	Max.Von mises	53.1	64.84	67.38
3	Max. Tresca	54.70	66.93	69.58

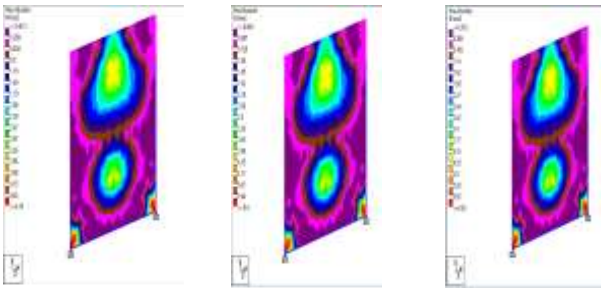

Fig. 9: Max absolute stress contours for shear wall with point load

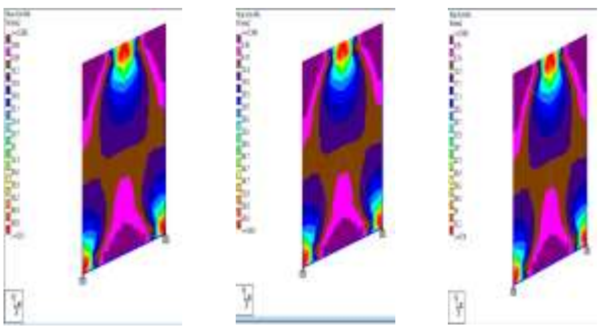

Fig. 10: Max von mises stress contours for shear walls with point load

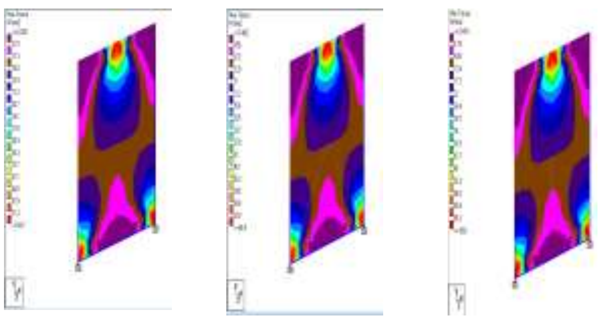

Fig 11: Max Tresca stress contours for shear walls with point load

Table V: stresses in shear wall (N/mm2) for lateral load

S.No	Stresses	WS1	WS2	WS3
1	Max. absolute	109.6	133.4	138.9
2	Max.Von mises	212.1	258.9	269.3
3	Max. Tresca	218.6	266.7	277.4

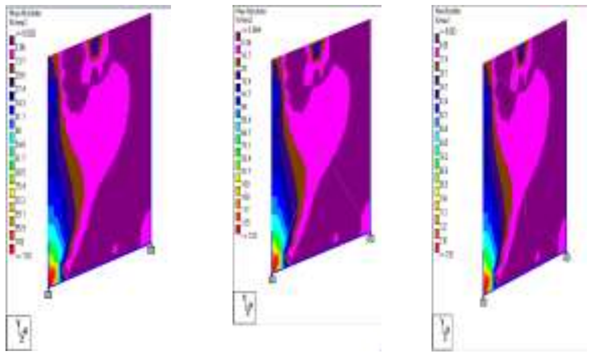

Fig. 12: Max absolute stress contour for shear walls with both lateral and point load

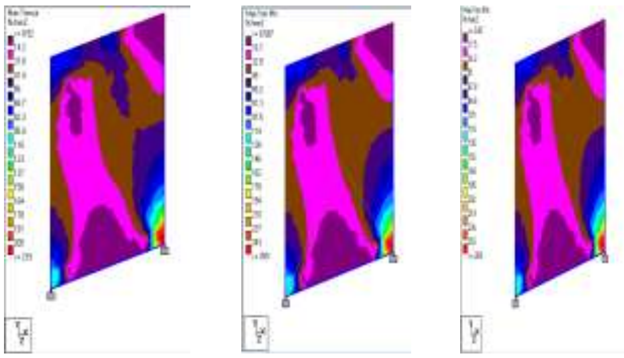

Fig. 13: Max von mises stress contour for shear walls with both lateral and point load

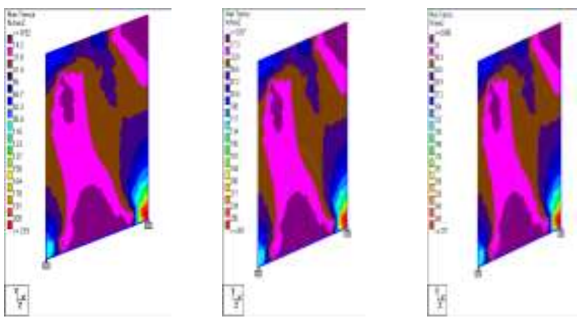

Fig. 14: max Tresca stress contours for shear walls with both lateral and point load

VI. CONCLUSION

A brief introduction about shear wall is presented in this paper, for checking the load carrying capacity of shear walls by changing the reinforcement types without having boundary elements. In addition, three walls were cast, where two specimens are equipped with diagonal reinforcement and one specimen with conventional reinforcement and they are tested. The objective of this experiment was to study and evaluate the load vs. deflection curve for all these three types. The conclusions drawn from the experimental program and analysis are listed below.

1. The load carrying capacity of shear wall specimens with diagonal reinforcement is found to be greater than that of wall specimen with conventional reinforcement.
2. By adding extra reinforcement in the form of diagonal type, load carrying capacity of walls increasing gradually but along with that stresses are also increasing.
3. For finding the place where stresses are increasing in the specimen, analysis was done by using the software.
4. From that software analysis results, we can clearly say that the stresses were increasing mostly at the supports.
5. For reducing the increase of stresses in walls, reinforcement ratio in walls has to be increased or boundary elements have to be installed in it.
6. In this work, without having boundary elements in the wall specimens, all the three types of walls were ready to resist both lateral and point load, but stresses were developing at the places were boundary elements are not installed for reducing that problem we have to add the boundary elements or special confining reinforcement to that wall specimens.

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