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A Study on Construction of RC Shear Walls for Multi-Storied Residential Building

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Abstract: ***Shear wall systems are one of the most commonly used lateral load resisting systems in high-rise buildings. Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. There are lots of literatures available to design and analyze the shear wall. However, the decision about the location of shear wall in multistory building is not much discussed in any literatures. In this paper, therefore, main focus is to determine the solution for shear wall location in multistory building. A RCC building of six story placed in Hyderabad subjected to earthquake loading in zone-II is considered. An earthquake load is calculated by seismic coefficient method using IS 1893 (PART-1):2002. A study has been carried out to determine the strength of RC shear wall of a multistoried building by changing shear wall location. Three different cases of shear wall position for a 6 storey building have been analyzed. Incorporation of shear wall has become inevitable in multi-store building to resist lateral forces.***

I. INTRODUCTION

Reinforced concrete (RC) building often has vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm or as high as 400mm in high rise buildings. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote, “We cannot afford build concrete buildings meant to resist severe earthquakes without shear walls” as said by Mark Fintel, a noted consulting engineer in USA. RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building such a layout increases resistance of the building to twisting. In reinforced concrete framed structures of wind forces increase in significance as the structure increases in height. Codes of practice impose limits on horizontal movement or sway.

II. LITERATURE REVIEW

Anushuman.S, Dipendu Bhunia, Bhavin Ramjiyani[1] have worked on Shear wall systems are one of the most commonly used lateral-load resisting systems in high-rise buildings. Shear walls have very high in-plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. It has been also observed that the both bending moment and shear force in the 1^{st} and 12^{th} frame were reduced after providing the shear wall in any of the 6^{th} & 7^{th} frames and 1^{st} & 12^{th} frames in the shorter direction. It has been observed that the in inelastic analysis performance point was small andwithin the elastic limit.

Misam Abidi, Mangulkar Madhuri.N[2] have found that Severe structural damage suffered by several modern buildings during recent earthquakes illustrates the importance of avoiding sudden changes in lateral stiffness and strength. From their analysis use of shear wall is a good way to provide more level of ductility and getting more stable behavior and appear to be a novel approach to reduce of soft story in seismic response in the other hand, vulnerability level of existing high rise building can be increased by adding different arrangement of shear wall on building and it will help for retrofitting of structure to resist the major portion of lateral induced by an earthquake.

Ashish S. Agarwal, S.D.Charkha[3] have investigate that Shear wall systems are one of the most commonly used lateral load resisting in high rise building. Shear wall has high in plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. Incorporation of shear wall has become inevitable in multi-storey building to resist

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lateral forces. It is very necessary to determine effective, efficient and ideal location of shear wall.From preliminary investigation reveals that the significant effects on deflection in orthogonal direction by the shifting the shear wall location, placing shear wall away from centre of gravity resulted in increase in most of the member forces. It may be observed from that displacement of the building floor at storey 25 has been reduced due to presence of shear wall placed at centre from placing of shear wall in y direction the displacement reduces but it displacement not reduces in X direction. When the lift core placed eccentric position it develops displacement in both directions with application of seismic force in Y direction. That the column which placed at the edge of the building is heavily axially loaded due to seismic forces, location of shear wall effects on static and dynamic axial load on the column. The displacement of building is uni-directional and uniform for all the grids in the case of Zero eccentricity for seismic loading. With the increase in eccentricity, the building shows the non-uniform movement of right and left edges of roof due to torsion and induces excessive moment and forces in member.

III. CONSTRUCTION OF SHEAR WALLS

SHEAR WALL: It consists of reinforced concrete walls and reinforced concrete slabs. Wall thickness varies from 140mm to 500mm depending on the number of stories, building age, and thermal insulation requirements. In general, these walls are continuous throughout the building height; however, some walls are disconnected at the street front or basement level to allow for commercial or parking spaces. Usually the wall layout is symmetrical with respect to at least one axis of symmetry in the plan.

Figure 1 R.C Shear wall

Excavation: After the initial surveying and soil test, excavation of land carried out. If the land site is very hard with rocks and boulders, excavation is carried out using heavy earthquakes, cranes and diggers, and in some cases if the land is very hard, blasting of site by using small amount of dynamics is preferred. Generally blasting of site is done during early mornings.

Figure 2 Excavation using heavy earth movers

Once the excavation is completely done the excavated material is not wasted. It should be generally reused in the same construction work so that construction work is reduced. On the other side, if the land is very loose and site is being excavated very easily then earth movers of normal size are used.

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Figure 3. Drilling

Once the excavation is completed marking of land for footings is carried out.

A. Foundation and Footings

Generally shear walls are opted for tall buildings which are more than 15 floors so that they can resist lateral load most effectively.Therefore for this type of buildings we need strong foundation, so that it can resist high loads due to self weight as well as lateral loads. Hence combined footings and isolated footings are generally preferred.

Figure 4. Footings laid for construction

These footings are tied together by using the beams so that the moment during lateral load is completely arrested. In accordance with footing neck columns are raised these neck columns once related to the ground surface are tied together with plinth beam.
Shear Walls: Shear walls are generally casted monolithically, in this type of construction the beams and columns are placed inside the walls so that you can never find beams inside any floor in this type of construction. Schedule of reinforcements: After the horizontal reinforcement is placed in accordance with the design, vertical reinforcement is placed.

Figure 5. Horizontal reinforcement of shear wall

As per the design the reinforcement of size 10mm spacing 30mm is placed in the middle of the wall of length 0.8 = 0.8 x 25 = 200m and the design reinforcement of 20mm dia 20 bars are placed in the remaining 0.2 space. The horizontal bars on the vertical reinforcement are placed f diameter 10mm spacing 300mm distance.

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Figure 6. Vertical Reinforcement of shear wall

This reinforcement in the horizontal direction is usually tied as double strand single tie with GI wire, this process can also be done by using rehar machine. Normally cover either cement or most preferably PVC cover is tied to the vertical reinforcement so that once from works place it maintains a specific cover distance. Once the reinforcement is completely placed then comes the part of the MIVAN form work.

MIVAN form work: MIVAN is an upcoming technology which has empowered and motivated the mass construction projects throughout the world. Good quality construction should not reduce the project speed nor should it be uneconomical. Construction is done through MIVAN technology keeping a motto in mind that "Cost is long forgotten, but the quality is remembered forever." Mivan is an aluminium formwork system developed by a European construction company. In 1990, the Mivan Company Ltd. From Malaysia started manufacturing these formwork systems. Today, more than 30,000sqm of formwork from Mivan Co. Ltd. is used across the world. There are a number of buildings in Mumbai that are being constructed with the help of the Mivan system, that the proven economical as well as satisfactory for the overall Indian construction environment. One of the architectural examples is XRBIA which uses MIVAN system to achieve its dream of "A House for Every Indian".

Figure 7. MIVAN formwork

MIVAN technology is suitable for constructing large number of houses in a short part of time using room size forms to construct walls and slabs in one continuous pour on concrete. In this system of formwork construction, cast-in-situ concrete wall and flow cast monolithic provides the structural system in one continuous pour. To facilitate fast construction, early removal of forms can be achieved by hot air curing / curing compounds. Large room sized forms for walls and slabs are erected at size. These strong and study forms are fabricated with accuracy and are easy handle. The concrete is produced in RMC batching plants under strict quality control and convey it to site transit mixers. The frames for windows, doors and ducts for services are placed in the form before concreting. Staircase flights, panels, chajjas and jails etc. and other pre-fabricated items are also integrated into the structures. This

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proves to be a major advantage as compared to other modern construction techniques. High quality Mivan Formwork panels ensure consistency of dimensions. On the removal of the formwork mould a high quality concrete finish is produced to accurate tolerances and vertically. The high tolerance of the finish means that, no further plastering is required.

Figure 2 Alluminium panels of MIVAN formwork

B. Wall Ties

Wall ties are thin plates of dimensions 20cm x 4.5cm x 0.3cm with three holes of diameter 12mm on either side. Wall ties are generally used to tie the form work. Wall ties are so placed from inside the form work. Formwork when once placed is tied together with the wall ties filled with grease and plastic cover is winded over the central portion of the wall tie. Once this arrangement is made the holes of wall tie and the holes of form work are made to coincide and filled using pins and wedges

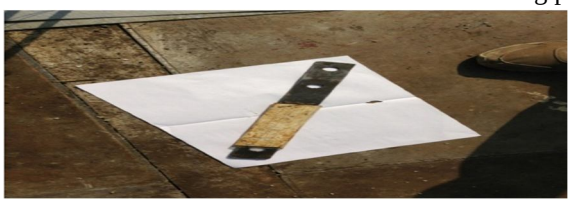

Figure 3 Wall ties

C. Pins and Wedges

Pins actually resemble the rivets its top diameter of head is 12mm and its tail is about (6-8) mm with a rectangular hole in it 2mm thickness.

Figure 10. Pins and Wedges

Wedge is of thin iron sheet mostly resembles the front view of frustum of cone. Once the completely placed with wall ties coinciding the holes pin is placed and wedges are drilled with the help of a wooden hammer. Wall ties with grease and yellow cover finds its importance after concreting. This eases the work of removal of wall ties. Once the concreting is done and cured wall ties are

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carefully removed by pulling them out. They cover which is placed on the central portion of the wall tie remain inside the wall and the gap which remains is filled with cement mortar.

D. Electrical boards and Plumbing lines

The shear walls in a building itself acts like column with no flexibility to drill and hence it becomes very important to place electrical lines and plumbing or sewer lines.

Figure 4 Electrical lines in slab

The electrical lines in slabs and wall also have a design.

Figure 5 Gaps left for plumbing lines

The plumber and sewer lines are left with gap to place into the wall exactly.

Concreting: Once the complete arrangement of the formwork i.e., wall ties, pins and wedges with electrical lines are placed completely up to an accuracy of 1mm, precisions done so that no concrete will leak out of the form work. The cement generally used in this is a grade of concrete is; the size of aggregate should be 10mm or 12mm. so that it moves easily inside the wall. Sand here used may be either robust sand or sea sand or sea sand. Admixtures generally used are of self compacting nature. Rebuild and Gilinium are two admixtures which are used most effectively in the shear walls construction. These admixtures are generally mixed using a design mix in a transit mixer. Once the mixing is done accurately for specified time, this mixture of concrete is pumped using pipes. Once the form is arranged accurately concrete pouring is done using the hydraulic pumps. As the concrete used in this type is of self compacting nature, there is no need for additional compaction, but still pin vibrations are generally used to place in the wall and vibrate the concrete. After the wall form is completely filled with concrete with proper compaction it is left for one complete day to set in its position.

Curing: After one day of curing of the wall, removal of form is done. Removal of form is done very carefully.

Figure 6 Shear wall after removal of formwork

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Firstly the wedge is taken out by using a hammer and then pin is also removed. Now started from top and one side form is carefully removed. Now started from top and one side removed carefully removed. The form removal is cleaned immediately, to remove the concrete on it, so that it can be reused effectively. Once the form completely removed a smooth finish of wall is obtained which does not require plastering. The wall which is now finished with the removal of form is cured with regular water i.e., water which we use for drinking purpose. Curing of walls is done for 3-7 days continuously and for better curing and to reduce heat of hydration a white coating with lime powder is also preferred. Curing can also be done by covering walls with plastic covers ad watering them so that it reduces the heat of hydration. As it becomes difficult to make form work through staircase for constructing the next floor, these holes are drilled in the slab of size a little more than the standard form work.

Figure 7 Holes drilled in the slab

Hence these holes play the key role in transfer of mivan form work.

Electrical and Plumbing lines after concreting: After the walls are completely built they are checked for electrical and plumbing connections. As electrical lines are pre-established with design pattern in the slab as well in the wall only thing needed is to arrange them with proper connection.

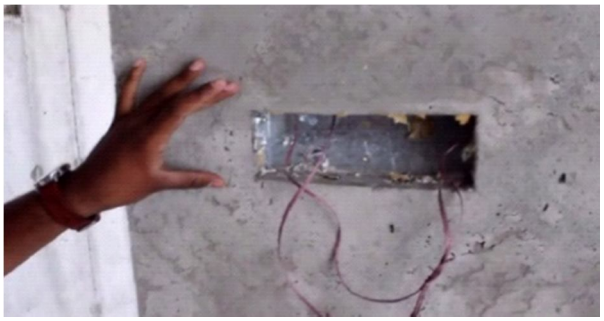

Figure 85. Electrical spaces left in wall]

When it comes to the server lines holes or empty gaps are left over. And in these empty spaces the sewer pipes are placed exactly to match the empty spaces.

Figure 9 Gaps left for sewer pipes

In this way electrical and plumbing lines are placed.
Painting and Finishing Works: As the wall which is obtained is perfectly plain with exact finishes there is no need for and plastering work.

Figure 10 Painting and finishing works

It is said that finishing on shear wall is so perfect that plumb line drawn from the tap storey meets the bottom storey exactly without any deflection or deviation. Generally for shear wall two coats of white wash and paint color of your choice on it is enough special architectural features on the shear wall building like fall ceiling can be done. Hence the construction of shear wall is completed which are resistant to lateral loads, quick in construction, aesthetic in view, these walls are generally built for tall structures hence they give lots of solace from pollution and noise as well.

IV. CONCLUSIONS

From the above study the following conclusions are drawn

A. The system, designed and detailed properly is very ductile and has relatively large energy dissipation capability. As a result, steel shear walls can be very efficient and economical lateral load resisting systems.

B. The steel shear wall system has relatively high initial stiffness, thus very effective in limiting the drift.

C. Compared to reinforced concrete shear walls, the steel shear wall is much lighter which can result in less weight to be carried by the columns and foundations as well as less seismic load due to reduced mass of the structure.

D. By using shop-welded, field-bolted steel shear walls, one can speed-up the erection process and reduce the cost of construction, field inspection and quality control resulting in making these systems even more efficient.

E. Due to relatively small thickness of steel plate shear walls compared to reinforced concrete shear walls, from architectural point of view, steel plate shear walls occupy much less space than the equivalent reinforced concrete shear walls. In high-rises, if reinforced concrete shear walls are used, the walls in lower floors become very thick and occupy large area of the floor plan.

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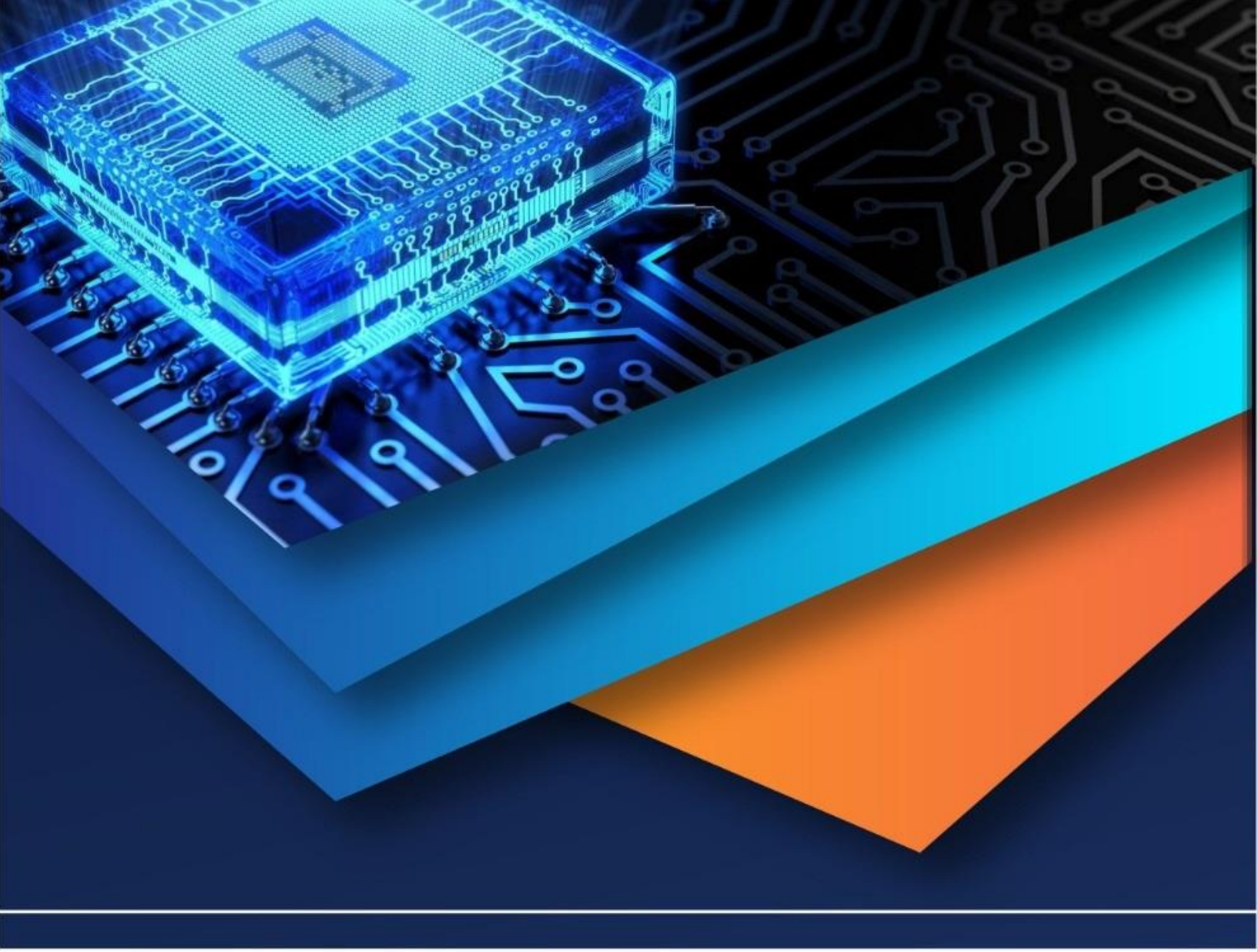
[7] Bangladesh mostly focused on the design of shear walls with openings on seismic response using E- Tabs
[8] I.S 456:2000 As per clause 32, design for wall describes, design of horizontal shear in clause 32.4 given details of how shear wall have to be constructed.
[9] I.S:1893 Criteria of Earth Quake resistant Buildings Part (3) page 23, clause 4.2 gives the estimation of earth quake loads.
[10] In IS: 13920:1993 it gives the ductile detailing of shear wall as per clause 9, where 9.1 gives general requirements.



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