Structural Analysis of Unbonded Post-Tensioned Shear Wall

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Abstract- *The project examines the significance of utilising a shear wall as a key structural element. The goal of the current paperwork is to review numerous studies on improving shear walls and their response to lateral stresses, wind load and seismic forces. Shear walls respond as a progressive ductile failure and avoid brittle shear failure. In this paper, a building was designed without the shear wall, with a shear wall and with a prestressed shear wall using ETabs. All these 3 types of buildings are compared based on displacement, story drift and % steel requirement. The results show a significant decrement regarding considered parameters. The steel requirement is decreased from 0.42% to 0.26% for prestressed shear walls.*

Keywords: *Shear wall, prestressed, unbonded post-tensioned, precast, seismic analysis, lateral loading.*

- **INTRODUCTION:**

In multi-story buildings, shear walls are more effective in resisting lateral loads. Shear walls consisting of steel and reinforced concrete are kept at key locations of multi-story buildings that are constructed with consideration for wind and seismic pressure. Significant research was conducted on several shear wall-related topics, including shear walls can be used in the construction of any kind of tall building that is susceptible to lateral forces like earthquakes and wind. Shear walls can be used to retrofit existing constructions as well as to resist lateral loads. Researchers' cyclic stress experiments reveal that internal shear walls are more effective than external shear walls . If shear walls are sufficiently strong, they will transmit these horizontal forces to the component below them in the load path. These additional elements in the load path could be additional floors, slabs, foundation walls, or shear walls. Shear walls also offer lateral stiffness to avoid excessive lateral movement of the roof or floor above. Shear walls that are sufficiently rigid will stop floor and roof framing members from slipping from their supports. Additionally, sufficiently rigid structures typically sustain less non-structural damage. The overall stiffness is greater than the sum of the individual stiffness when two or more shear walls are joined by a system of beams or slabs.

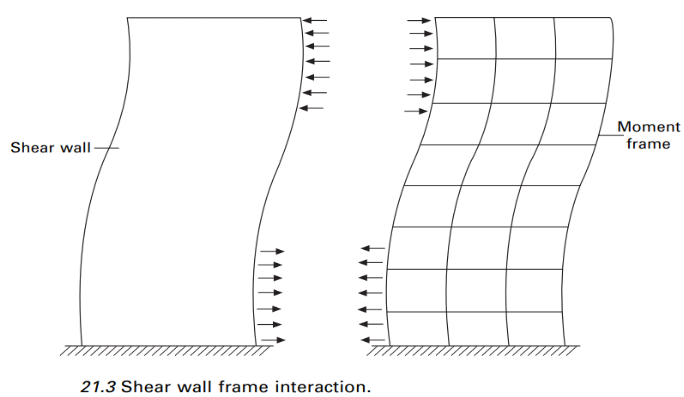

Fig 1. Shear wall interaction

Openings typically appear in vertical rows along the height of the wall, and connecting beams hold the cross-sections of the walls together. Coupled shear walls are the name given to such shear walls . The load-deformation behaviour of prestressed concrete wall panels was investigated experimentally. Three main variables—the type of wall panel, slenderness ratio, and intensity of the load—were used in the study. The types of wall panels examined included ribbed and flat walls. With an increase in wall width for flat wall panels, both the ultimate load and deflectional stiffness dramatically rise . Precast shear wall panels come with a variety of bottom face joints (horizontal and vertical) and side face joints. Since shear forces in the wall transfer to the structure through these horizontal joints on the bottom face, the bottom face is where the most stress is generated. Analysis of the various bottom face joints of precast shear wall panels is crucial. It is crucial to analyse the combined behaviour of earthquake-related in-plane and out-of-plane forces. Different kinds of horizontal connections' geometries result in various kinds of shear resistance for identical grout characteristics. At the same degree of load, the shear capacity of the multiple-key connection is larger than that of the simple surface connection . The use of rectangular precast panels stacked along horizontal joints and unbonded post-tensioning (PT) strands inserted into ungrouted ducts to connect the panels to the foundation is proposed as a precast post-tensioned concrete wall system with added friction- and yielding-based energy dissipation. Specially created yielding-based and friction-based energy dissipation components are externally connected at the base of the wall using thru-bolts, enabling the replacement of these components after a significant earthquake, allowing the wall to regain the majority of its original lateral strength, stiffness, and energy-dissipating capacity .

- **METHODOLOGY:**

Flexural behaviour, as opposed to shear sliding at the base, should dictate the lateral load behaviour of a well-constructed UPT wall. Instead of concrete failure, or behaviour caused by under-reinforcement, the flexural strength should be regulated by PT steel yielding. The limit states describe the lateral load behaviour of UPT walls under the assumption that under reinforced flexural behaviour controls .

- **Detailing of Specimen:**

In order to analyse the shear wall, Etab software was used. The modelling was done for G+10 floors. The modelled building was executed at Mumbai, Maharashtra. Whereas same loading conditions were considered. The loading contemplates dead load, live load, wind load and earthquake load. The comparison was done between the building with no shear wall, the building with RC shear wall and last the building was having a prestressed shear wall. So, after the modelling was done, the analysis was done on the basis of displacement of building, story drift and % steel requirement.

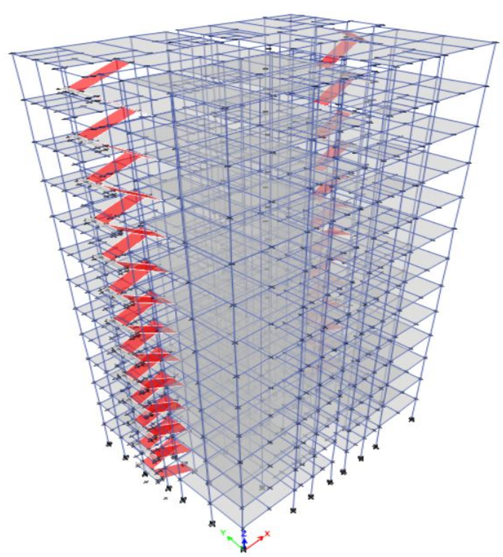

Fig 2. Building model without shear wall using ETab

- **Analytical Analysis**

Firstly, the load calculation is done, i.e. gravity load, live load, seismic forces and wind load ie lateral forces. The location considered for seismic zone is Mumbai. Further, the normal RC shear wall is designed. And for prestressed shear wall, the basic consideration was the wall lied into precast unbonded post-tensioned shear wall category. Therefore, the prestressed wall was designed for thermal bowing, in which potential thermal bow is 0.5 and residual bow is 0.28. Further slenderness effect was also calculated for that second order P- analysis was done by hand calculation as well as through Etab software, to avoid stability failure. After that from the calculated stresses, required number of strands was calculated

- **RESULT AND DISCUSSION:**

The modelled building had the shear wall in x and y direction; therefore, it resists drift n displacement in both the directions.

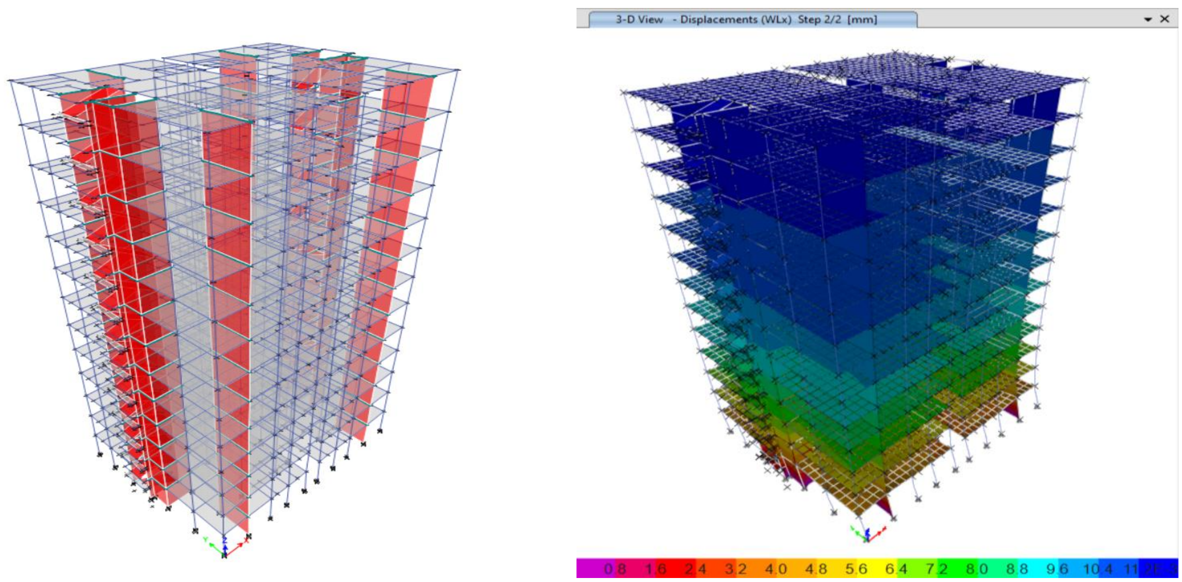

Fig 3. Undeformed and deformed shape of building model created using ETabs

The above figure shows the building model in which unbonded post tensioned shear wall are designed. Whereas the next figure shows the displacement of building in finite element analysis after the load was applied. Therefore, the deformed building figure shows that maximum displacement at the top most floor of building and goes gradually decreasing along the lower floors.

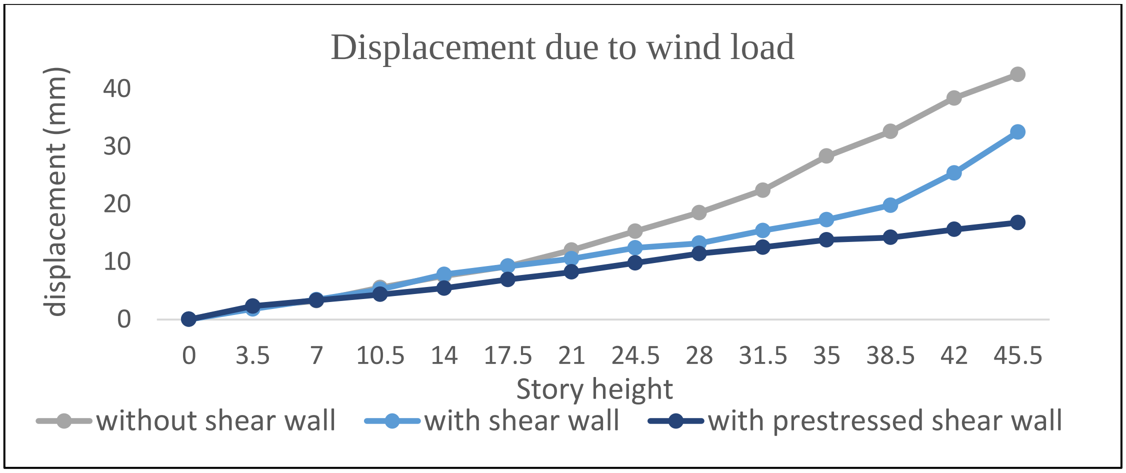

Fig 4. A Comparative Analysis of shear wall based on displacement varying with the story height

The plotted graph shows the increment of displacement as the elevation increases. The building without SW shows a displacement of 42.5mm. Whereas the building with SW shows a displacement of 32.5mm and the prestressed shear wall is displaced by 16.78mm. Displacement check is H/500 = 45.5/500 = 91mm.

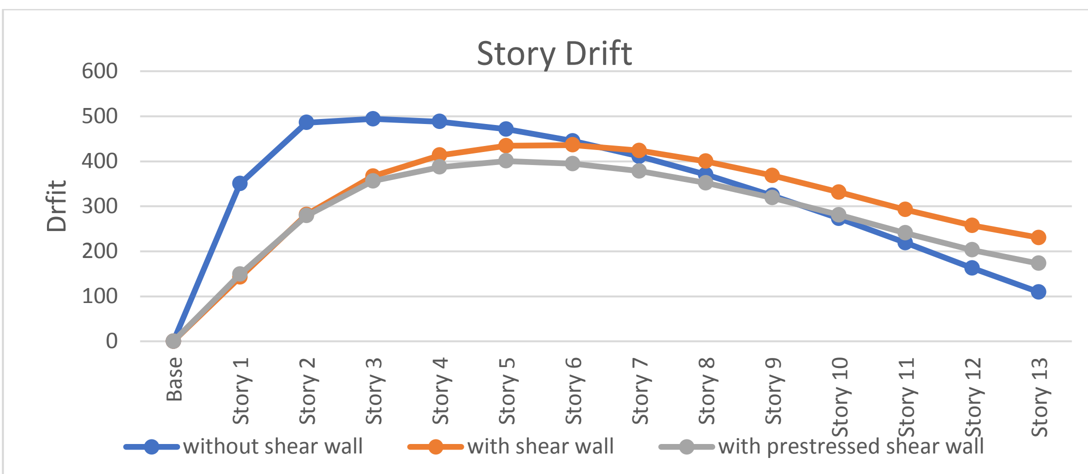

Fig 5. A Comparative Analysis of shear wall based on story drift varying along with the story height

The plotted graph shows the decrement of story drift towards the lower story. The building without SW shows a drift of 494.2 Whereas the building with SW shows a maximum drift of 436.4 and the prestressed shear wall building was drifted by 400.6. As a consequence, the using PT shear wall does not allow a building to displace from its original place even after its impacted by various types of loading. Thus, PT shear wall aids in resisting sturdy loading conditions.

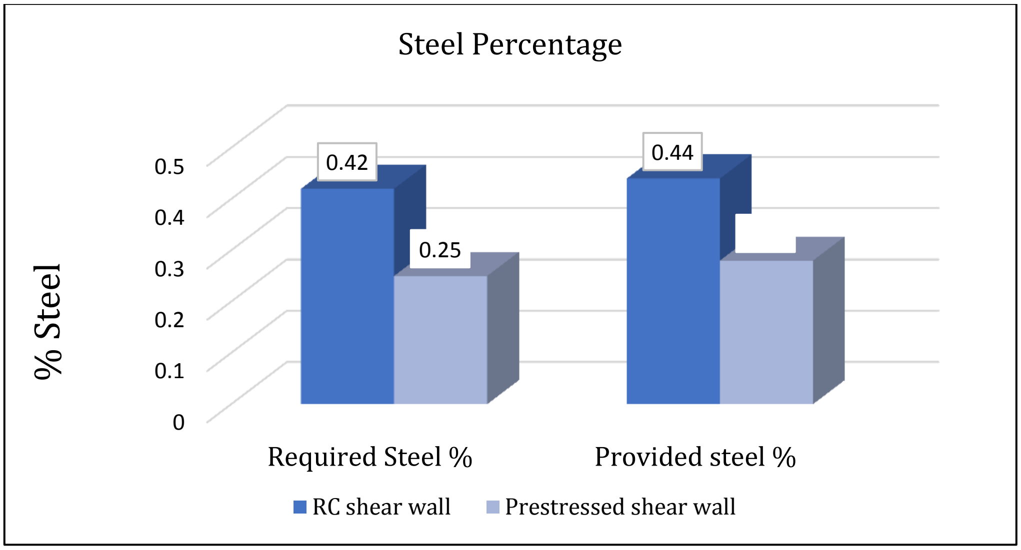

Fig 6. A Comparative Analysis of shear wall based on steel requirement and steel provide

The building without a shear wall requires a % steel of 0.42%. Whereas the building without a shear wall requires a % steel of 0.25%. The difference between the requirement is 0.17%. This shows that 37% of steel is been reduced, due to the application of a prestressed shear walls.

- **CONCLUSION:**

- There are various benefits of integrating PT tendons into traditional shear walls, such as increased stiffness, strength, stability, damage control and reduced lateral displacement. The lateral load capacity and effective stiffness are found observed to be increased in the post-tensioned shear wall system as the PT stress level increases.
- Unbonded post-tensioned precast walls can soften and undergo lateral drift with little damage.
- The overall reinforcement area can be reduced by using unbonded post-tensioned reinforcement and wall ductility is observed to be enhanced.
- The failure mode of the hybrid shear wall with PT tendons is primarily controlled by the yielding of the PT strands. The absence of PT force can result in inadequate restoring, leading to excessive uplift, horizontal slip, and degradation of lateral strength and stiffness.
- The modal displacement is decreased when the shear wall is used, whereas it shows a significant decrement when prestressed shear wall is used.
- Even there is noteworthy decrement of the steel requirement, in this case the steel requirement is decreased by 40%, consequently, it aids in cost efficiency.

- **FUTURE SCOPE:**

Further, the design can be done for vertical prestressing as well as for the combination of horizontal and vertical prestressing. The variation loading can be done using seismic forces. Even the analysis can be based on nonlinear analysis

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