Behavioural Study on Multi-Storeyed Buildings with Solid, Coupled and Shear Wall with Openings

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***Abstract*—Finite element modelling is the commonly use method for analyzing different of kinds of civil engineering related problems. The present study considers the behaviour mutli-storey buildings without shear walls and with solid, coupled and shear wall with staggered openings under both static and dynamic loads. Shear walls are vertical members provided in the buildings to resist the lateral loads during the events of earthquake and wind. Functionality is ensured by the provision of openings. Coupled shear walls are shear wall systems with a coupling beam used in medium and high rise structures to resist lateral forces. These dual systems should not collapse or induce severe damage during earthquake events. So coupled shear walls must have high strength, high ductility, high energy absorption capacity and high shear stiffness to reduce deformation in lateral direction. Staggered arrangement of openings in shear walls provides both the architectural and the seismic requirements; capacity of walls with staggered openings to dissipate seismic energy is a function of the vertical positioning of the door openings,. A comparative study is done on multi-storeyed buildings without shear wall and with coupled, solid and staggered opening shear wall using ETABS.**

Keywords—Base Moment; Coupling Beam; Coupling Degree; Diagonal Reinforcement; Staggered Openings.

I. INTRODUCTION

Earthquakes and wind are phenomenon pertaining to nature but induce devastating effect on buildings particularly in high rise buildings. Hence the buildings should be protected from such phenomenon by employment of special structural components. Shear wall systems are reinforced wall systems used as lateral load resisting members in high-rise buildings. Shear walls posses a high in plane stiffness and strength, which can be used to resist large horizontal loads and support gravity loads simultaneously, making them really useful in many structural engineering applications. Their size and location of are extremely critical. A symmetrical location in plan is recommended to reduce the effect of twisting in buildings. The efficiency of the solid shear walls makes their use desirable, but equipping them does not meet functional necessity. In such a scenario the concept of a shear wall with openings or coupled shear walls came into consideration. A coupled shear wall is part of a shear wall system, consisting of coupling beams and wall piers, increasing the functional flexibility of structure. Eventually by coupling individual flexural walls, the overturning moments are resisted partially by an axial compression–tension couple across the wall system than by the individual flexural action of the walls.

Staggered openings are another option for providing functionality. The staggered opening shear walls developed a ductile failure, whereas regular openings walls developed a brittle failure. The staggered opening shear walls are more rigid and demanded much less reinforcement. Thus capacity to dissipate seismic energy is a function of the openings provided. These specially fitted buildings are studied under the effect of linear as well as non linear loading as the earthquake effect mitigation is an important consideration.

II. PREVIOUS STUDIES

The study on shear walls have been done from time immemorial and a number of researches were carried out to rule out non- functionality of shear walls. This element of non functionality was eliminated through implementing the provision of openings by coupled shear walls, regular opening shear walls and staggered openings shear walls. Sharman Reza Chowdhury, M.A. Rahman, M.J. Islam and A.K. Das modeled a nine story frame-shear wall building using ETABS and studied the effects of openings in solid type shear wall of thickness 220mm. Their study revealed that stiffness and seismic response in terms of lateral displacement, storey drift of the structure is affected by the size of openings and location of openings in shear walls. Mosoarca Marius modeled a six story shear wall of thickness 120 mm and loaded them statically with cycles of horizontal loads. He reached the conclusion that, for the same amount of reinforcement and for the same layout, the walls with staggered openings showed a ductile failure, whereas the framed structure with regular openings developed a brittle failure. Yanez F.V., R. Park and T. Paulay studied on seismic behaviour of R.C. walls with square openings of varying size and different arrangement subjected to reversed cyclic loading. He came to the inference that the stiffness of walls is dependent on the size of the openings with less regard to their horizontal location. An extensive research from past shows that the coupled shear walls are the powerful systems and could be reliable and viable in any kind of circumstances by the attachment of a coupling beam.

III. SCOPE AND OBJECTIVE

The main scope is the conduction of a wide spread study on the structural component shear wall provided in a number of multi-storied medium and high raised buildings as specially framed member. The limitations of the solid shear wall are to be studied giving insight into the improvement of functionality aspects of a shear wall. The consideration of static and dynamic load stipulates a refined study covering all the aspects of comparisons. The capacity of coupled shear walls in resisting the deformations and distributing the inelastic deformations is an important scope of the future use of coupled shear walls on an extensive scale. Similarly the effect of staggered openings in shear walls is an area of great research scope as the staggered provision of opening reveals the limited crack propagation and yielding only at a higher seismic load.

The objectives of the study are to assess the various attributes of Shear wall provision within a building. The most suitable alignment preferred for a shear wall based upon the studies. The thickness in which shear wall could be provided. The types of buildings in which shear wall can be provided and how the orientation may differ based upon the type of the building. The changes in various results parameters with varying storey height are studied. The study of solid shear wall through light into its limitations also. Hence as an improvement the provision of openings is dealt with. The reduction of negative aspects by providing coupling shear walls and shear walls with staggered openings as an improvement over regular opening walls is studied.

III. BASIC COMPONENTS DESCRIPTION

A. Solid Shear Walls

Shear wall is a relevant, reliable and effectively used structural component used for resisting lateral load in high rise building. Shear walls posses the ability to resist earthquake as well as gravity loads. Solid shear walls are devoid of openings. Shear walls in a building is a structurally efficient solution to stiffen the building. Shear walls begin at the foundation level and extend till top of building. They are usually provided along length and width of the building. Their location may vary but the most reliable location is at the ends to enable the distribution of moments.

The base moment resistance M_{ws} of the solid shear wall is due to flexural stresses, but axial forces and moments are not resisted by a solid shear wall. The lateral displacement is much less for a solid shear walls. Hence solid shear walls are considered to be stable for high rise buildings.

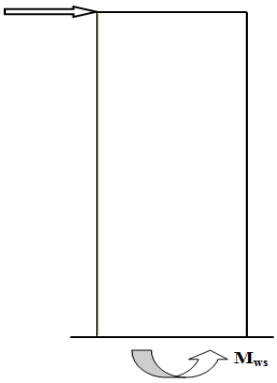

Fig.1 Solid Shear wall

B. Coupled Shear Walls

With progress in technology and more consideration for human comforts, the provision of openings in shear walls came into relevance. This has lead to provisions for providing openings in shear wall for the provision of doors, windows, refrigeration's etc. Like all other structural components provision of openings essentially reduces the stable profile of the component. One way of mitigating this is to provide couples shear walls.

A coupled shear wall is an improvement over shear wall and consists of coupling beams and wall piers. Employment of openings in shear walls improved the functional flexibility in architecture. By introduction of the principle of coupling the lateral loads resisting behaviour changes and overturning moments are resisted partially by an axial compression–tension couple across the wall system than by the individual flexural action of the walls.The high ductility and soaring resistance enables the use of coupled shear walls limiting its deterioration. The reinforcement in coupling beam can be provided in conventional and diagonal manner. The diagonal arrangement of reinforcement is generally preferred over the conventional one as a colossal amount of reinforcement is required in conventionally reinforced coupling beams.

The degree of coupling between the coupling beam and wall piers is a key parameter in the design of coupled shear walls. Coupling should be maintained to be an optimum value else it may force the member to behave as a two isolated walls or single pierced wall. The coupled shear walls should be modelled with almost care as the overall response may get effected due to the shear force acting between the wall piers and coupling beams. Coupling is an effective tool in reduction of the overturning moments and hence is to be employed in buildings with due care. This method of study is effectively used.

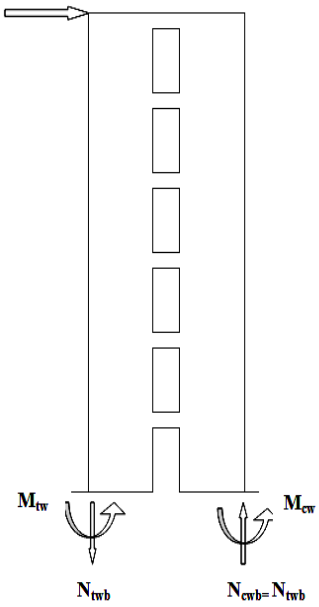

Fig.2 Coupled Shear wall

Fig. 3 Diagonal reinforcement in a coupled shear wall

B. Shear wall with staggered openings

Functionality requirements are satisfied by the provision of openings and these demands for compromise in the stability aspect of shear walls. The openings can be provided in regular manner or in a staggered manner. In regular opening shear wall one opening is vertically above the other which is a drawback with regard to the crack propagation criterion. This disadvantage can be eliminated by providing openings in staggered manner.

Shear wall with staggered openings are preferentially used over the one with regular openings. For the same measure of reinforcement and the shear wall layout, the walls with staggered openings encapsulate a ductile failure, while the ones with regular openings show a brittle failure. This suggests a concluding remark on the selection of shear wall with staggered openings as such shear walls are rigid and requires much less reinforcement. Staggered opening walls yields at higher seismic forces in comparison to regular openings walls. Thus these three reinforced concrete walls provide a good ground for comparative and comprehensive study. The relevance of study lies in deep rooted facts that technological advances have grown to a par extend that even the decrease in the stability of a solid shear wall on account of functional flexibility may be accounted for by choosing variable depths and thickness of the shear walls.

V. METHODS OF ANALYSIS

A. Equivalent Static Method

In most of the low and medium profile buildings, the consideration of nonlinear forces will not be of that significance. Hence such buildings can be effectively and efficiently analyzed by linear equivalent static method. Most of the Indian standard codes provide detailed account on static method of analysis and is hence a reliable method. At the onset of analysis, estimation of base shears load and its distribution on each story calculated by using codal provisions this method is effective were lateral torsion moments are not effective and only the first mode of vibration in each direction is considered.

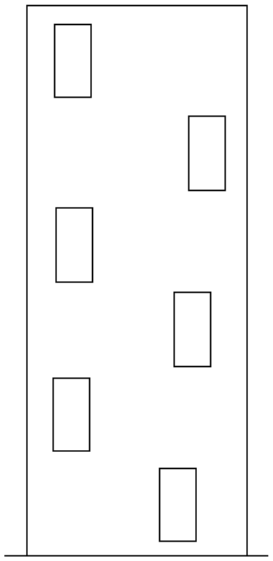

Fig. 4 Shear wall with staggered openings

C. Response Spectrum Method

In case of buildings located in earthquake prone locations and also in the case of tall buildings the influence of earthquake and wind cannot be disregarded. Tall buildings (over 75 m), second and higher modes of vibration will effect such buildings and induce torsion effects. So the evaluation of such buildings using static method will not prove to be a good ground for analysis and hence a much superior method needs to be considered which is based upon the principle of non linearity.

Nonlinear analysis in buildings can be performed by a number of methods such as push over analysis, Time history analysis, response spectrum method. In response spectrum methods analysis, all its specification and formulation and the steps for analysis are specified in IS 1893:2002.Response

spectrum is the graphical representation of the maximum response stimulated by earthquake related ground motions of an idealized single degree freedom system having certain period and damping,. The response can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.

C. Terms Of Result Evaluation

The final result yielded from various modular studies is evalauated with reference to a number of parameters. These may include lateral displacement, roof displacement , time period, storey drift, storey displacement, axial force on columns. The comparison of these parameters relative to different models and also to models at different storey heights we can reach the conclusion regarding the efficiency and rekiability of buildings under the employement of solid shear walls, coupled shear walls and shear walls with openings . This effectively gives an implication of a number of experimental analysis on the shear wall and modifications proposed for them by improving functionality through th provision of coupled shear walls and shear walls with staggered openings.

VI. CONCLUSIONS

A large and extensive study conducted with regard to shear wall and their modification revealed findings which are really useful with regard to future research in the field of study. The experimental study related to improvement of shear wall has begun from 1970's and is still being continued in various parts of the world. This revealed the relevance of the topic with respect to its importance in the practical field as well as in the research field. Earlier the research was in the behavior of buildings with and without shear walls and then research extended on to the most suitable location of shear walls. Many scholars conducted research worldwide relating the location of the shear walls. Based on all those experimental and analytical studies conducted the most appropriate location was at the outer edges of the building parallel to the X and Y direction. In the present project shear wall is proposed to be provided at the outer edges. Buildings with shear walls with regular openings, a brittle failure was observed whereas in case of buildings with shear walls with staggered openings, a ductile failure was analyzed from studies. The lateral displacement, storey drift, time period of shear wall with staggered and coupled shear walls reveals their superiority over solid shear walls. Base shear is comparatively more in case of asymmetric buildings compared to symmetric buildings. In 80% of the literatures collected it was observed that ETABS was the most suitable software for analysis of shear walls The main conclusion of the study is that solid shear walls are the most stable forms of shear walls, if functional flexibility needs to be provided it shall be in the form of coupled shear walls or by the provision of staggered openings.

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