A REVIEW ON DESIGN AND LAYOUT OF SHEAR WALLS IN TALL BUILDING LOCATED IN DIFFERENT SEISMIC ZONES

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Abstract- The shear wall is a structural element which is used to resist earthquake forces. These wall will consumptives shear forces & will prevent changing location-position of construction & consequently destruction. On other hand, shear wall arrangement must be absolutely accurate, if not, we will find negative effect instead.. The bending moment, shear force, torsion, axial force contribution by rest of the structural element and the ultimate design of all the structural components also affected by that. A study has been carried out to determine the optimum Structural configuration of a multistory building by changing the shear wall locations. The different cases of shear wall position for a G+15 storey residential building with keeping zero eccentricity between mass centre and hardness centre have been analyzed and designed as a space frame system by computer application software, subjected to lateral and gravity loading in accordance with IS provisions.

Keywords: Skyscraper, exaggeration, Response spectrum, Shear wall location, different seismic zones.

I. INTRODUCTION

A. WHAT IS A SHEAR WALL BUILDING

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls (Figure 1) 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. Shear walls are usually provided along both length and width of buildings (Figure 1). Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

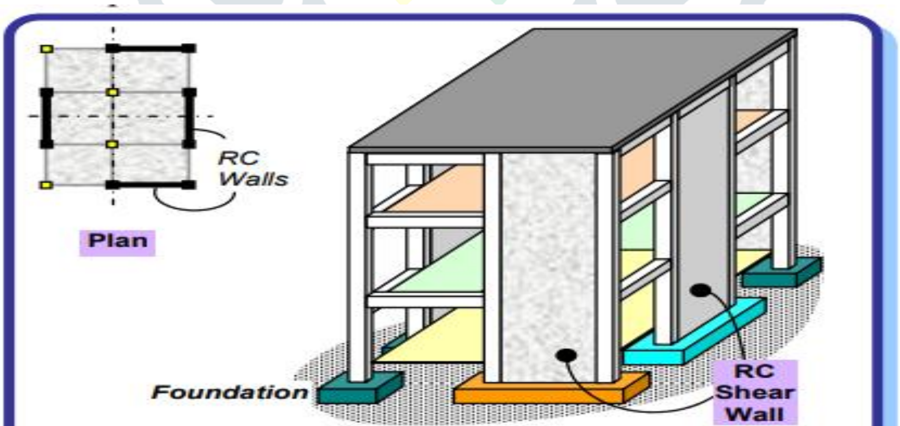

Figure 1: Reinforced concrete shear walls in buildings – *an excellent structural system for earthquake resistance.*

B. ARCHITECTURAL ASPECTS OF SHEAR WALLS

Most RC buildings with shear walls also have columns; these columns primarily carry gravity loads (i.e., those due to self-weight and contents of building). 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. Thus, design of their foundations requires special attention. Shear walls should be provided along preferably both length and width. However, if they are provided along only one direction, a proper grid of beams and columns in the vertical plane (called a moment-resistant frame) must be provided along the other direction to resist strong earthquake effects.

Door or window openings can be provided in shear walls, but their size must be small to ensure least interruption to force flow through walls. Moreover, openings should be symmetrically located. Special design checks are required to ensure that the net crosssectional area of a wall at an opening is sufficient to carry the horizontal earthquake force.Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings (Figure 2). 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.

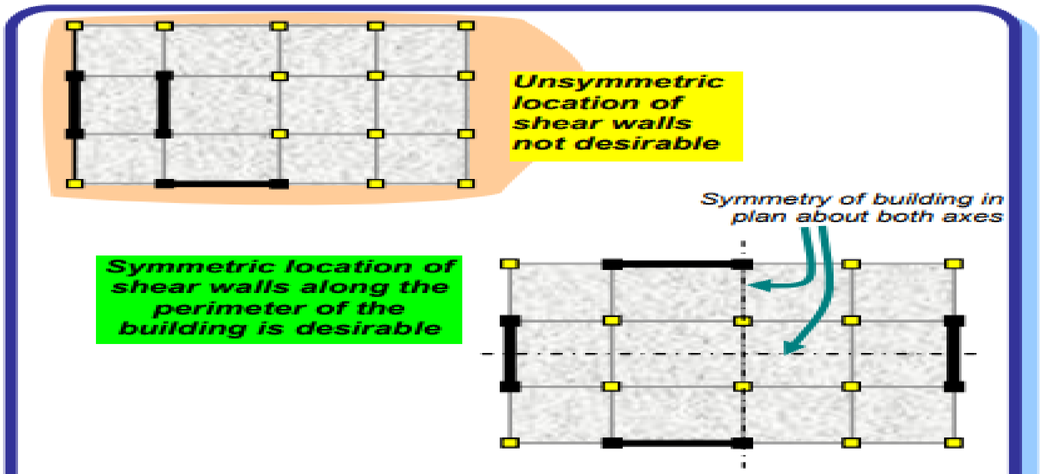

Figure 2: Shear walls must be symmetric in plan layout — *twist in buildings can be avoided.*

II. REVIEWS OF ARTICLES

- **M.S. Medhekar & D.J.L. Kennedy (2000)** The displacement-based seismic design method is applied to the design of a two-storey and an eight-storey building having concentrically braced steel frames as the lateral load resisting system. To the authors' knowledge, this marks the first application of this method to the seismic design of (steel) buildings. Displacement spectra for design are generated numerically from appropriate earthquake accelerograms. The buildings are designed to have both elastic and inelastic responses in the design earthquake. The influence of torsion due to an asymmetric building layout, column shortening, and higher vibration modes, is addressed. Nonlinear static and dynamic time history analyses are used to assess the seismic response. The displacement-based design method is shown to be a viable alternative to the current spectral acceleration-based design approach. 1999 Elsevier Science Ltd. All rights reserved.[1]

- **M. Halis Gunel & H. Emre Ilgin (2006)** In the early structures at the beginning of the 20th century, structural members were assumed to carry primarily the gravity loads. Today, however, by the advances in structural design/systems and high-strength materials, building weight is reduced, and slenderness is increased, which necessitates taking into consideration mainly the lateral loads such as wind and earthquake. Understandably, especially for the tall buildings, as the slenderness, and so the flexibility increases, buildings suffer from the lateral loads resulting from wind and earthquake more and more. As a general rule, when other things being equal, the taller the building, the more necessary it is to identify the proper structural system for resisting the lateral loads. Currently, there are many structural systems that can be used for the lateral resistance of tall buildings. In this context, authors classify these systems based on the basic reaction mechanism/structural behavior for resisting the lateral loads.[2]

- **Han-Seon Lee & Dong-Woo Ko (2007)** Based on the test results, which are analyzed and compared, the following conclusions are drawn. The estimated fundamental periods for other structures than moment frames and bearing wall structures in UBC 97 and AIK 2000 appear to be reasonable. The total amounts of energy absorption by damage are similar regardless of the existence and location of the in filled shear wall. The largest energy absorption is due to overturning, followed by that due to shear deformation. The rigid upper system renders rocking behavior in the lower frame, and thereby, the self weight contributes up to about 23% of the resistance against the total overturning moment.[3]

- **Mosoarca Marius (2013)** The main aims of this study are the following: to present the failure mechanisms recorded after the earthquakes between 2009 and 2011, to explain their failure modes based on the latest recordings of seismic wave characteristics, to present the recordings made at the ground level and on the bearing elements of the constructions and to analyze the advantages of the reinforced concrete structural walls with staggered openings subjected to seismic loads function to the position of the openings.[4]

- **Xiao Lu et al.(2014)** The seismic design of super-tall buildings has become an important research topic in earthquake engineering. Limited research has been conducted on the distribution of plastic energy dissipation among the different components of super-tall buildings when subjected to strong earthquakes. A simplified two dimensional (2D) nonlinear model is developed based on the analysis of Shanghai Tower, an actual super tall building with a total height of 632 m. The accuracy of the simplified model is validated by comparing the results from modal analyses, and static and dynamic time-history analyses of the refined finite element model. Then, the proposed simplified model is used to determine the plastic energy dissipation of different components and the distribution of the total plastic energy dissipation over the height of the Shanghai Tower under different seismic intensities. The analysis indicates that the total plastic energy is mainly concentrated in the upper four Zones of the building and that the outrigger is the major plastic energy dissipation component in the Shanghai Tower.[5]

- **Jian-Guo Nie et al.(2014)** This paper focuses on the effective stiffness of the composite shear walls. Despite many design practices addressing the shear stiffness by employing a stiffness reduction factor, a model named as plane combination truss model (PCTM) for the effective shear stiffness of the composite wall is proposed based on the theory of the fixed angle truss model in this paper. The formula for calculating the effective shear stiffness of the composite shear wall is derived based on this model. The total effective stiffness is obtained by combining the effective shear stiffness and the effective flexural stiffness, in which the flexural stiffness can be obtained by the fibre model. The predictions for the effective stiffness correlate well with the results of a series of tests on composite shear walls.[6]

- **Men Jinjie et al. (2014)** the optimal design techniques and specific explanations are introduced for residential buildings with shear wall structure, especially for that with a rectangular layout. An example of 30 storey building is presented to illustrate the effectiveness of the proposed optimal design process finally , the optimal material consumption is suggested for the residential building with Rc shear wall structure and with rectangular layout. The relation and data suggested can be used for guiding the design of similar Rc shear wall structure.[7]

- **Masoumeh Gholipour & Mohamad Mehdi Alinia (2016)** In this paper, SPSW frames with 4, 7, 10, 13, 16 and 19 story levels are considered with three different panel aspect ratios of 0.83, 1.67 and 2.5; while all models have similar overall plan dimensions. This comparative study is to provide practicing engineers tools to make reasonable decisions on the suitable design bay width for SPSW structures. Results show that the selection of a suitable bay width produces a considerable reduction of VBE sections, especially in high-rise SPSWs. Consequently, the weight of structures becomes minimal; while the capacity of structural members is utilized more efficiently and the SPSWs are provided with less over strength. The maximum increase in the stiffness and load capacity of moment frames due to the employment of infill plates is obtained in the suitable design bay width. The variation of bay width highly affects the deformation mode and the behavior of high rise SPSW frames. It is also found that HBEs yielding has an important effect on the axial force demands in VBEs, especially in SPSWs with large bay widths.[8]

- **R. Tremblay et al. (2016)** Seismic design provisions for buildings in Canada, the United States, Chile and New Zealand are presented for buckling restrained braced frames, with focus on design requirements for seismic stability. P-delta effects are explicitly considered in seismic design in Canada, the U.S. and New Zealand. In Chile, stability effects are limited by means of more stringent drift limits. The provisions are applied to a 9-storey building structure located in areas in each country having similar seismic conditions. For this structure, comparable seismic loads are specified in Canada and Chile, whereas significantly lower seismic effects are prescribed in the U.S. In all countries, use of the dynamic (response spectrum) analysis method resulted in lighter and more flexible structures compared to the equivalent static force procedure. Seismic stability requirements had greater impact on designs in Canada and New Zealand. Frame design in the U.S. was only affected by stability effects when applying the stability requirements from AISC 360-10.[9]

- **David Ugaldea & Diego Lopez-Garciaa (2017)** This observation suggests that there is a large (and unintended) over strength in this type of buildings. In a previous study, the authors showed that some of the traditional sources of over strength mentioned in the literature could explain the lack of damage in low rise buildings but not in taller structures. Motivated by this observation, representative tall buildings were reanalyzed using more realistic models (e.g., flexural capacity of the walls assessed by fiber models) in order to get more insight into their actual seismic capacity. Two actual buildings of 17 and 26 stories that survived with no damage the 2010 Chile earthquake were analyzed by response history analysis. Results show that consideration of wall flanges (usually omitted in practice) cannot explain the lack of damage. On the other hand, it is observed that good performance might be a consequence of possible foundation uplift. Finally, the analyses also suggest that, even when there is no damage, elastic analysis has limitations to reproduce the actual observed behavior.[10]

- **Yu Zhang & Caitlin Mueller (2017)** The work presented in this paper intends to accelerate the process with an optimization system involving a ground structure program formulation, a modified evolutionary algorithm, and innovative computational techniques. Unlike existing work that focuses either exclusively on structural performance or architectural layout, this research integrates both. An efficient computational design methodology for shear wall layout in plan is introduced. The method minimizes structural weight with constraints on torsion, flexural strength, shear strength, drift, and openings and accessibility. It can be applied from the very beginning of floor plan design or after generating an architectural floor plan. This paper demonstrates the potential of this approach through a variety of case studies. Key contributions include a novel application of the ground structure method, a fast and robust modified evolutionary algorithm, and a simplified auto-calculation system for reinforced concrete design.[11]

- **Xu Chen et al. (2018)** this paper proposes a simplified procedure for estimating the nonlinear seismic response of tall piers. The influence of plastic deformation at the base on dynamic properties (natural periods and mode shapes) of a linarized system for the tall piers is first investigated, using a numerical model of the prototype bridge, based on an equivalent linearization technique. Using these results, a simplified procedure is proposed to predict the distribution of seismic shear force and bending moment along the pier height, as well as the curvature ductility ratio at the pier base. The efficiency of the proposed procedure is verified with numerical examples of tall piers subjected to recorded ground motions, through comparing the seismic demands determined by this method with rigorous nonlinear response history analysis. The results show that the proposed method can efficiently estimate the distribution of both shear force and bending moment along the height of the tall pier; the curvature ductility ratio at pier base can be predicted with errors around 10%.[12]

- **Ying Zhou et.al (2018)** In this paper, based on the statistical analysis of 39,744 ground motions, an improved frequency-domain defining parameter, namely βl, is firstly proposed to identify long-period ground motions without the necessity of seismological information. Then, based on the definition, long-period ground motions are selected for the time history analysis of a super-tall building structure. The structural responses are obtained under three scenarios: the original ground motion record, the ground motions scaled to minor earthquakes and major earthquakes. To assess the validity of the proposed parameter βl in identifying long-period ground motions, correlation between the structural response and the defining parameter is obtained.[13]

- **Seyed Rohollah Hoseini Vaeza & Hamidreza Shahmoradi Qomia (2018)** The objective function of the algorithm minimizes the cost of the wall, which depends on the reinforcement details (rebar diameter and layout) and the wall dimensions (the cost of concrete and form working). This objective function consists of the boundary element dimensions and the reinforcement layout variables (cross-sectional area and spacing of rebars). Shear wall design requirements and restrictions are formulated as constraints in accordance with ACI318-11 provisions for special ductility. After obtaining optimal wall design for seismic loads, design details such as wall dimensions and reinforcement details are determined accordingly. The optimization is performed by the use of several metaheuristic algorithms, including PSO, FA, WOA, and CSA. The comparison of the results of continuous and discrete optimization methods show that the shear wall designs obtained by the continuous approach are less expensive and closer to the global optimum.[14]

- **Shoma Kitayama & Michael C. Constantinou (2018)** The study concludes that seismically isolated buildings designed by the minimum criteria of ASCE/SEI 7 of either 2010 or 2016 may have unacceptable probability of collapse in the Risk-Targeted Maximum Considered Earthquake (MCER). The probability of collapse in the MCER becomes acceptable when they are designed with enhanced criteria of RI=1.0 and with isolators having a displacement capacity at initiation of stiffening equal to 1.5 times the demand in the MCER. It is also observed that designs that meet the minimum criteria of ASCE/SEI 7 of either 2010 or 2016 and without any displacement restrainer have unacceptably high probabilities of collapse.[15]

- **D. Vassallo et.al (2018)** This paper presents the design and construction of a six-storey residential cross-laminated timber (CLT) building in Florence, Italy. The different phases of the design process are described in detail, together with the production, transportation and on-site construction. Special emphasis is given to the seismic design, where a recently developed proposal for the revision of the Euro code 8 has been applied, demonstrating its feasibility. Some design and construction issues are also addressed, including the connection of hold-down anchors to the concrete foundation. This connection represents the weakest link of the traditional commercial connectors used for CLT buildings, especially concerning the seismic design.[16]

- **Muhammad Mostafijur Rahman et al.(2018)** Three geometrically similar commercial reinforced concrete buildings in high seismic regions of Bangladesh, India, and U.S. were designed and detailed per the respective codes. Three-dimensional nonlinear dynamic analyses of the designed structures were conducted. Each structure was subjected to a pair of orthogonally applied artificial ground motions compatible with the design response spectrum for each building code. The structural performance of each building was compared in terms of roof displacements, inter-story drifts, loadcarrying capacity of beams and columns, and overall energy dissipation characteristics. The comparisons allowed an in-depth evaluation of the differences in the seismic performance of buildings designed according to ASCE 7-10, BNBC-1993, and IS-1893 codes. The Indian code performed better when subjected to the ground motion that is intended to represent the Indian design response spectrum.[17]

- **M. Follesa et al. (2018)** This paper presents the results of the ongoing work on the revision of the provisions for the seismic design of timber buildings in Europe included within Chapter 8 of Eurocode 8. The most recent research results and technical developments regarding both wood-based materials and structural systems have been implemented into the proposed new version together with the application of the capacity design to each structural system. The main objectives are to update the few and incomplete provisions included in the current version to the current state-of-the-art and to correct some misleading rules. This manuscript represents the authors' point of view on the basis of a scientific research background and the design common practice regarding different key aspects in the seismic design of timber structures.[18]

III. CONCLUSION

The review of earlier studies related to Study design and layout of shear walls in tall building located in different seismic zones reveals, high-performing shear wall layout designs for tall buildings that can respond to both structural and architectural design goals. The method is compatible with a large variety of buildings, from low-rise to high-rise, from wide to tall (aspect ratio), from to residential and commercial. Furthermore, it can be incorporated flexibly either before or after the design of architectural floor plan, sparking new inspiration or conforming to an agreed upon system. Integrating structural performance and architectural design. Previous studied also shows that proposes general solutions for unaddressed problems. With respect to structural performance, a simplified auto-calculation system for reinforced concrete design has been established and applied in this research, which saves computational time and memory for the optimization process, and addresses the blank in the design codes regarding irregularly configured shear wall. Lastly, this paper aims to fill the gap between engineers and architects, and reduce the trial-and-error design process for buildings so that better and more integrated solutions can be found. Thus, future improvements include the spatial arrangement and connectivity to consider human usability and convenience, exploration in three dimensions to widen the application of this research, and analysis and improvement on the evaluation criteria to make this algorithm more general, comprehensible, and compatible.

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