Shear Wall and Frame Interaction Terminology

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Abstract

Shear wall is 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 load and support gravity load. The objective of the present study is to study the behavior of building frame in the lateral load analysis of shear wall-frame structures; a fundamental goal is to model the shear wall assemblies using a realistic and feasible method.

Keywords- Shear wall, Frame, lateral loading, tall building wall, Stiffness

I. INTRODUCTION

A. Frame and Shear Wall Interaction

Shear walls and frames in combination normally provide the required stiffness and strength to withstand lateral loads effectively in high rise buildings. In certain cases the walls are much stiffer than the frames and thus take most of the lateral load. For this reason, the participation of the frame in resisting lateral load is often ignored. This may not always be a conservative procedure. With the construction of increasing tall building allowing for the effect of frames and walls becomes more important. When the building is very tall, the shear wall flexural deformation become very pronounced and hence induces deformation in the frame which must be allowed for in the analysis.

The composite action of the combined structure causes the frame to restrain the shear wall in upper storeys and the shear wall to restrain the frame in the lower storeys, hence the reducing the free deflection and improving the overall efficiency of the structural system. Fig. 2.4(a) shows the shear mode deflection of a frame which can be defined as a system of interconnected vertical columns and horizontal elements. Fig. 2.4(b) shows the predominantly bending mode deformation of a shear wall or simple cantilever the behavior of stair walls, elevator shafts and walls normally conform to this mode. Fig. 2.4(c) shows the interaction forces between a frame and a shear wall.

The modes of deformation are not always easy to categories, for example a row or rows of opening in a shear wall may be change deflection the characteristics from a bending to shear mode and conversely an in filled frame will tend to deform in a bending mode.

If the height to depth ratio of shear wall is low, for example less than one, the shear deformation can be more important than the bending deformation.[4]

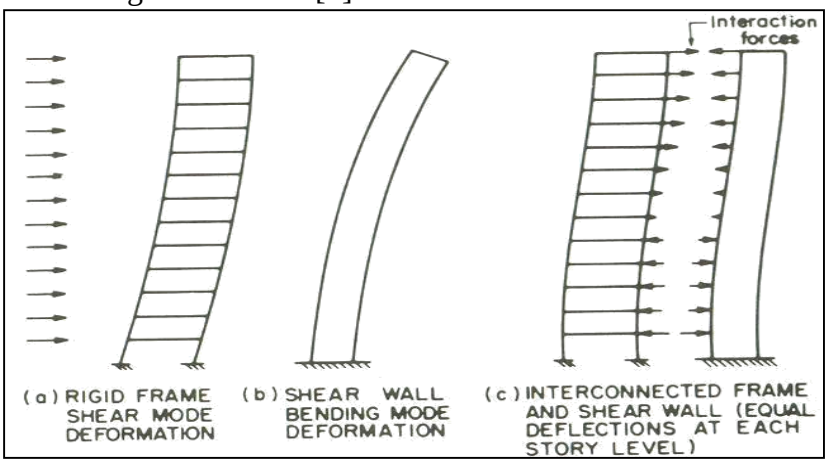

Fig. 1.1: Deformation Mode

Fig. 1.1 shows the geometry of a frame before lateral load is applied while Fig.1.2 shows the displaced position of the frame due to lateral loading. The columns and girder, or the columns and floor slabs in the case of a flat slab structure, combined to resist the load by bending and take the displaced profile.

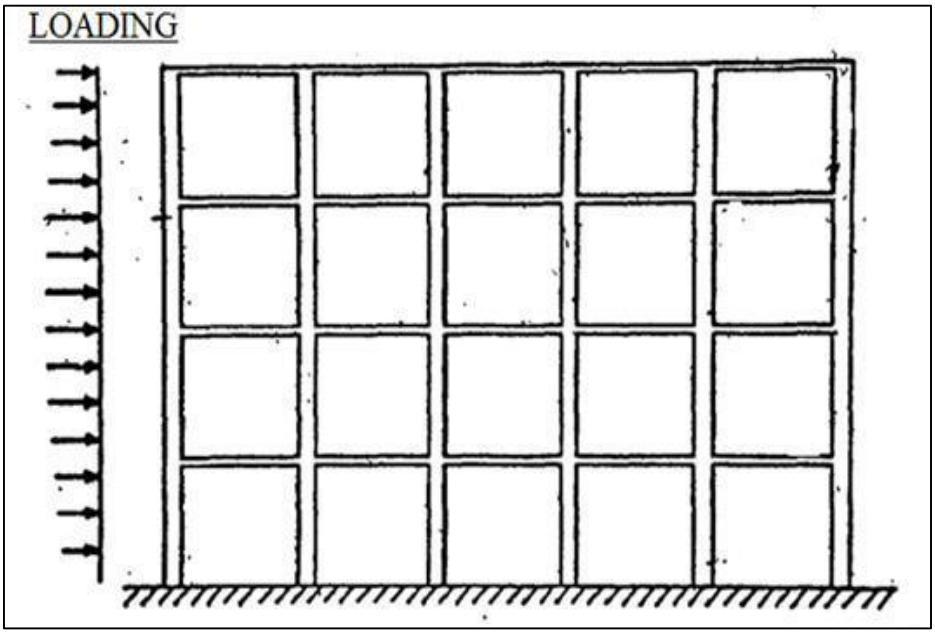

Fig. 1.2: Building Subjected To Lateral Load

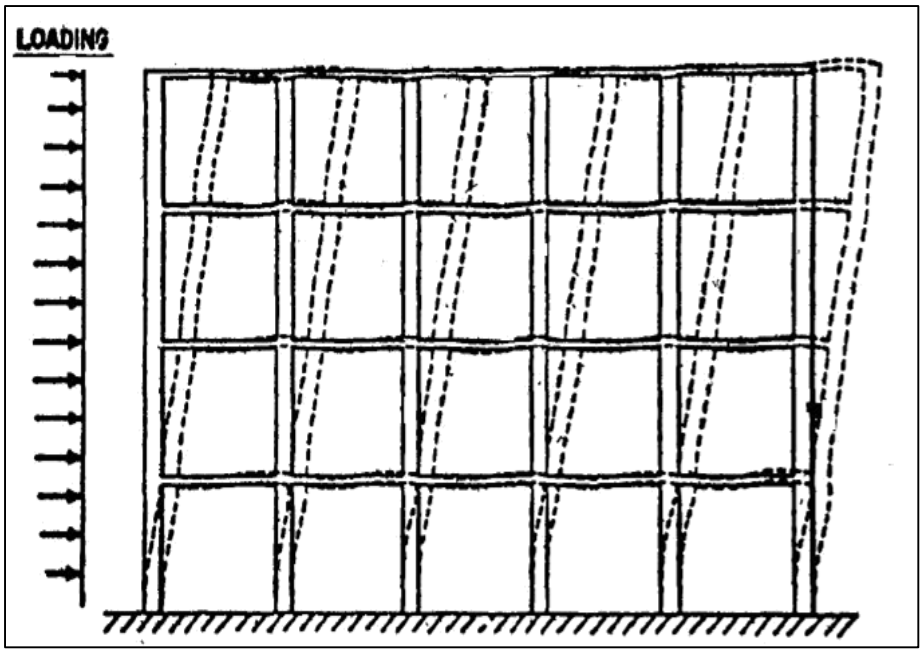

Fig. 1.3: Frame Action of Building Subjected To Lateral Load

B. Terminology of Related to Shear Wall

Some commonly used term related to shear wall analysis and design are described below.

1) Dual System

Building with dual system consist of shear walls and moment resisting frame is designed to resist the total designed lateral force in proportion to their relative stiffness

2) Coupled Shear Wall

The coupled shear wall system consists of two or more shear walls, in the same plane, connected at each floor level by short beam like members. The shear wall shall be connected by ductile coupling beam. If the earthquake induced shear stress in the coupling beam exceeds.

3) Shear Wall-Frame Interaction

When the tall building has both shear wall and frame to resist lateral load and shear wall deflect in bending mode under horizontal load and frame under horizontal load deflect in shear mode. Due to the infinity rigidity of the floor diaphragm, the main function of this structure increases the rigidity for lateral load resistance. Shear wall and frames have the same deflection each floor level, modifies the final behavior of these element know as shear wall-frame interaction. [1, 7]

4) Shear Centre of Shear Wall

Shear center may be defined as the point through which the plane of loading must pass to eliminate torsion. The rigidity Rx, Ry, Rxy, Ryx of a shear wall is assumed to act through its shear center.

5) Rigidity of Shear Wall

Rigidity of a wall element in a given direction (R_x or R_y) is defined as a force per unit deflection in the given direction.

C. Range of Applicability

The shear wall structure is more suitable in buildings where permanent partitions and the lack of flexibility for future modifications may be tolerated.

Its major advantage lies in its higher resistance and speed of construction and low content of reinforcing steel. Shear wall structure are well suited for construction in earthquake areas while cost varies from city to city. Shear wall buildings usually become economical where lateral forces affect the adversely design. Buildings up to 70 stories have been built using shear walls. [1]

D. Coupled Shear Wall System

Many high rise building are constructed, especially in Asian region, using the box system which consists only of reinforced concrete walls and slab. In box system structure have opening for the door, windows and duct spaces for functional reasons. The number of location and size of opening affect the behavior of structure and stresses in the shear wall. So that finite element meshing model is given good accuracy with opening of shear wall, but if entire apartment building structure is subdivided into a finer mesh with large numbers of element, it should be requirement a significant amount of time and memory. The number, location and size of the opening seriously affect the efficiency and accuracy of this method. Generally, plane stress element and beam element are used to model the shear wall core and frames respectively in the analysis of this kind of building. A plane stress element should have degrees of freedom to represent the connection of shear wall core and frames. Otherwise, the bending moment at the end of a beam cannot be transfer to the shear wall. Computational Walls with openings present a complex problem to the analyst. Opening normally occurs in vertical rows throughout the height of wall and the connection between the wall segments is provided by either connecting beams or floor slabs, or a combination of both. The terms “coupled shear walls”, “pierced shear walls”, and “shear wall with openings” are commonly used to describe such units shown in Fig. 1.4

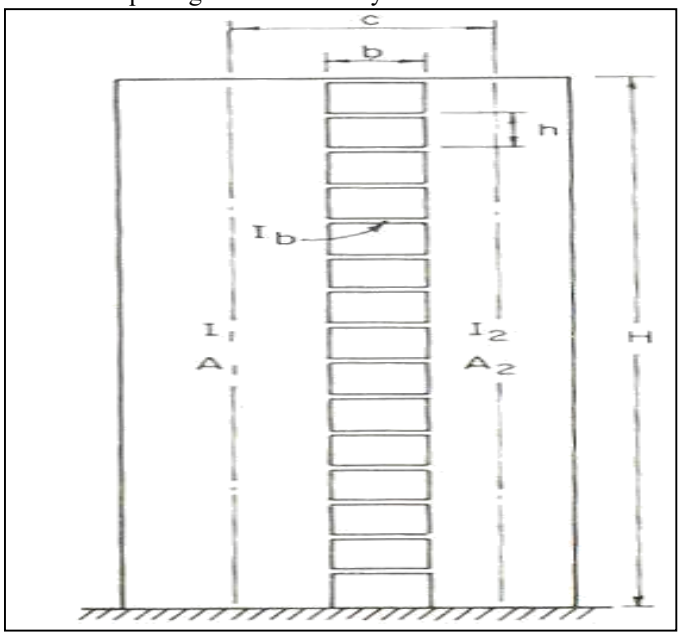

Fig. 1.4: Coupled Shear Walls

If the openings are very small, their effect on the overall state of stress in a shear wall is minor. Large openings have a more pronounced effect and, if large enough, result in a system in which typical frame action predominates. The degree of coupling between two walls separated by a row of opening has been conveniently express in terms of a geometrical parameter α (having a unit 1/length) , which gives a measure of the relative stiffness of the connecting beams with respect to that of walls. The parameter α is appears on the basic differential equation of the so called continuum approach. When the dimensionless parameter αH (H being the total height of wall) exceed 13, the wall may be analyzed as a single homogeneous cantilever. When $\alpha H < 0.8$, the all may be treated as two separate cantilevers. For intermediate values of αH (i.e. $0.8<\alpha H>13$), the stiffness of the connecting beam should be considered. This system can be used for building up to 50 stories. [1, 6]

E. Modeling of Shear Wall

Tolga et al. (2009) proposed two different three dimensional shear wall models based on the conventional equivalent frame model for open and closed section. In the model suggested for open section shear walls, each planar wall in the assembly is replaced by column having in the same mechanical properties of the walls as in the equivalent frame method. Rigid beam at floor level are rigidly connected to each other at the corners but torsional moment were released at these joints to avoid errors in analysis as system become over stiff. The problem with closed section shears walls modeled by conventional equivalent frame method is that the torsional stiffness of the model becomes less. This problem is solved by modifying torsional constant of the shear wall. The results of the proposed models agreed well with results in the literature

Arnott (2005), modeled shear wall like a beam as well as by meshing of 1,9,36 and 81 shells. Results showed no significant difference with increase in meshing and same answer was obtained. Conclusion was that when considering global effects such a building sway the beam element model gives the same result as meshed shell models. The results for the shell models vary slightly as the meshing is increased. Results given by modeling of the “9 shell” conform to a widely held view that shear walls can be adequately modeled with shell size at 1/3 and 1/4 of floor to floor height. The beam model also produces more readily usable design information; axial forces, shear forces and bending moments for the panel as a whole are readily available. When shells are used all sorts of contour diagrams are available, but to know the design forces applicable to an entire wall panel at some stage of design or checking then the shell nodal results need to be re-integrated along desired cut lines.

F. Stability of Tall Building with Shear Wall Structures

Li et al. (2001) modeled tall buildings with shear-wall structures and with narrow rectangular plane configuration as flexural-shear plates for buckling analysis. The governing differential equation for buckling of a flexural-shear plate with varying cross-section was established. Using appropriate transformations, the equation was reduced to an analytically solvable equation by selecting suitable expressions, such as power functions and exponential functions, for the distribution of stiffness along the height of the plate, flexural shear plate for buckling analysis. This problem has not previously been investigated in the past and thus, the solution of this problem has not been proposed yet in the literature.

Al-Mosawi et al. (1999) studied of optimum design of single core shear wall. In this paper coupled shear wall systems and wall-frame structures were considered with rectangular cross section only. Authors didn’t find any earlier research work carried out on the optimum design of single core shear wall structures. The algorithm developed in this study obtained the optimum cross sectional dimensions as well as area of reinforcement for single core lipped channel shape shear walls. It treated the width, depth, length of lips, the thickness of wall and area of reinforcement as design variables. It considers the displacement limitations in the design problem and employs limit state theory to formulate the mathematical model. The optimum design algorithm developed in this study for reinforced concrete thin wall open section is general. It is based on limit state theory and considered displacement limitation in addition to strain constraints in concrete and yielding constraints in rebar.

II. CONCLUSIONS

The number of location and size of opening affect the behavior of structure and stresses in the shear wall. So that finite element meshing model is given good accuracy with opening of shear wall, but if entire apartment building structure is subdivided into a finer mesh with large numbers of element, it should be requirement a significant amount of time and memory. The number, location and size of the opening seriously affect the efficiency and accuracy of this method. Torsion re-distribute the member force and in same members are made critical where as other are suffer. The comparison of results to the traditional shear paneled structure shows that the staggered shear panel structure has higher lateral stiffness. Its displacement ductility and energy dissipation capacity is little lower than the traditional shear panels structures.

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