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Study of Infill walls on the Strength and Displacement of Multi-Story Buildings-A Review

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Abstract*- This paper presents a review of the experimental efforts also as modeling approaches to review estimate typical variations in magnification factor of a mid rise open ground storey building accounting for the variability of compressive strength and modulus of elasticity of infill walls with various infill arrangements so that it can help designers facing trouble with heavy designs for a structure of mid-size, with the given material properties, geometry and loadings in particular. The paper investigates Equivalent static analysis (ESA) and Response spectrum analysis (RSA) is considered for the comparative study. The building will be analyzed for two different cases: i) considering infill mass but without considering infill stiffness. ii) Considering both infill mass and infill stiffness. From the study Expected outcome have found that building with soft storey will exhibit poor performance during a strong shaking. But the open ground storey is an important functional requirement of almost all the urban multi-storey buildings and hence cannot be eliminated. Alternative measures need to be adopted for this specific situation. The under-lying principle of any solution to this problem is in i) increasing the stiffness of the ground storey; ii) provide adequate lateral strength in the ground storey. The possible schemes to avoid the vulnerability of open ground storey buildings under earthquake forces can be by providing stiff columns in open ground storey buildings or by providing adjacent infill walls at each corner of soft ground storey buildings.

Keywords - Infills, OSG building, Equivalent static analysis (ESA), Response spectrum analysis (RSA).

I. INTRODUCTION

Reinforced concrete frame buildings have become common form of construction with masonry infills in urban and semi urban areas in the world. The term infilled frame denotes a composite structure formed by the combination of a moment resisting plane frame and infill walls. The infill masonry may be of brick, concrete blocks, or stones. Ideally in present time the reinforced concrete frame is filled with bricks as non-structural wall for partition of rooms because of its advantages such as durability, thermal insulation, cost and simple construction technique. There is significant advantage of this type of buildings functionally but from seismic performance point of view such buildings are considered to have increased vulnerability. In the current practice of structural design in India infill walls are considered as non-structural elements and their strength and stiffness contribution are neglected. The effect of infill panels on the response of reinforced concrete frames subjected to seismic action is widely recognized and has been subject of numerous experimental and analytical investigations over last five decades. Covers a huge analysis area since every a part of the system has its own technical complexity. The open ground storey framed building behaves differently as compared to a bare framed building (without any infill) or a fully infilled framed building under lateral load. A bare frame is much less stiffer than a fully infilled frame; it resists the applied lateral load through frame action and shows well-distributed plastic hinges at failure. When this frame is fully infilled, truss action is introduced thus changing the lateral load transfer mechanism. A fully infilled frame shows lesser inter-storey drift, although it attracts higher base shear (due to increased stiffness). A fully infilled frame yields lesser force in the frame elements and dissipates greater energy through infill walls. The structural implications like strength and stiffness of infill walls in infilled frame buildings are ignored in the structural modelling in conventional design practice. The design in such cases will generally be conservative in the case of fully infilled framed building. But things will be not be the same for an open ground storey framed building. Open ground storey building is slightly stiffer than the bare frame, has larger drift (especially in the ground storey), and fails due to soft storey-mechanism at the ground floor as shown in Fig. 1.1. Therefore, it may not be conservative to ignore strength and stiffness of infill wall while designing open ground storey buildings. Performance of buildings in the past earthquakes clearly shows that the presence of infill walls has significant structural implications on them. Therefore, we cannot simply neglect the structural contribution of infill walls particularly in seismic regions where, the frame–infill interaction may cause significant changes in both stiffness and strength of the frame. Inclusion of stiffness and strength of infill walls in the open ground storey building frames decreases the fundamental time period compared to a bare frame and consequently increases the base shear demand and the design forces in the ground storey beams and columns. This increased design forces in the ground storey beams and columns of the open ground storey buildings are not captured in the conventional bare frame analysis. An appropriate way to analyse the open ground storey buildings is to model the strength and stiffness of infill walls. Unfortunately, no guidelines are given in IS 1893: 2002 (Part-1) [1] for modelling the infill walls. As an alternative a bare frame analysis is generally used that ignores the strength and stiffness of the infill walls. The aim of this study is to check the applicability of the multiplication factor of 2.5 in the ground storey beams and columns for the model considered in particular, when it is to be designed as open ground storey framed building taking into account the effect of stiffness of the walls also and to study the effect of infill strength and stiffness in the seismic analysis of a mid rise open ground storey building.

Fig. 1.1: examples of failure of buildings with soft storey at ground floor

II. OVERVIEW OF WORK

Non-linear dynamic (NDA) analysis is considered to be the most accurate but at the same time it is most rigorous among all methods. The magnification factors for the ground storey columns in open ground storey (OGS) buildings should ideally be based on the findings of nonlinear analysis. However as mentioned above this method is computationally difficult and needs considerable research. Therefore for the present study Equivalent static analysis (ESA) and Response spectrum analysis (RSA) is considered for the comparative study. The building will be analyzed for two different cases

i) Considering infill mass but without considering infill stiffness.

ii) Considering both infill mass and infill stiffness.

Infill thickness, strength, modulus of elasticity and openings are analysed by two methods mentioned above. The modelling and analysis for the study is done with the aid of commercial software ETABS v 9.7.1[2] in compliance with the codes IS 456-2000[3] and IS 1893-2002.

Masonry infill walls are widely used as partitions all over the world. Evidences are that continuous infill masonry walls can reduce the vulnerability of the reinforced concrete structure. Often masonry walls are not considered in the design process because they are supposed to act as non-structural members or elements. Separately the infill walls are stiff and brittle but the frame is relatively flexible and ductile. The composite action of beam-column and infill walls provides additional strength and stiffness.

Different types of analytical models based on the physical understanding of the overall behaviour of an infill panels were developed over the years to simulate the behaviour of in filled frames. The elastic analysis based (Smith and Carter, 1969)[4], the plastic analysis based (Liauw and Kwan, 1983)[5], and the ultimate load based (Saneinejad and Hobbs, 1995)[6] approaches are among them. This methods aim at calculating the geometric properties and strength of an equivalent strut. The single strut model is the most widely used as it is simple and evidently most suitable for large structures. The frames with unreinforced masonry walls can be modelled as equivalent braced frames with infill walls replaced by equivalent diagonal strut. The Fig. 1.2 shows the equivalent diagonal strut model for the infilled frame –

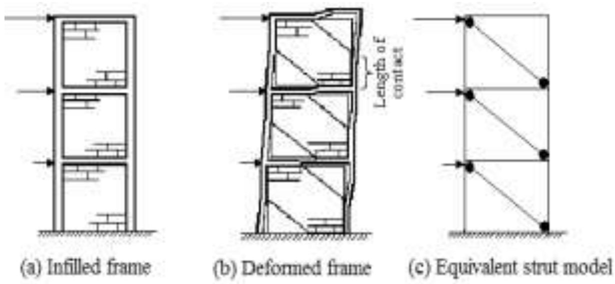

Fig. 1.2: Typical behaviour of infilled frame

III. LITERATURE REVIEW

In existing systems, third party auditor demanding local copy of user outsourced data. So this will increase the possibility of the following research papers are consulted for obtaining an in-depth understanding of various aspects of the project:

Asokan (2006) studied how the presence of masonry infill walls in the frames of a building changes the lateral stiffness and strength of the structure. This research proposed a plastic hinge model for infill wall to be used in nonlinear performance based analysis of a building and concludes that the ultimate load (UL) approach along with the proposed hinge property provides a better estimate of the inelastic drift of the building[7].D Menon et. al. (2008) concluded that the MF increases with the height of the building, primarily due to the higher shift in the time period. Also when large openings are present and thickness of infills is less, there is a reduction in MF. The study proposed a multiplication factor ranging from 1.04 to 2.39 as the number of storey increases from four to seven[8]. J. Dorji and D.P. Thambiratnam(2009) concluded that the strength of infill in terms of its Young's Modulus (E) has a significant influence on the global performance of the structure. The stresses in the infill wall decrease with increase in (E) values due to increase in stiffness of the model. The stresses varies with building heights for a given E and seismic hazard[9] Sattar and Abbie (2010) in their study concluded that the pushover analysis showed an increase in initial stiffness, strength, and energy dissipation of the infilled frame, compared to the bare frame, despite the wall's brittle failure modes. Likewise, dynamic analysis results indicated that fully-infilled frame has the lowest collapse risk and the bare frames were found to be the most vulnerable to earthquake-induced collapse. The better collapse performance of fully-infilled frames was associated with the larger strength and energy dissipation of the system, associated with the added walls[10]. Dukuze (2000) investigated the failure modes of infilled structure on single storey specimens with and without opening. In general, three types of failures were observed under an in plane load such as sliding of bed joints, tensile cracking of infill and local crushing of compressive corners at the loaded corner. The specimen with opening at the centre of panel had suffered shear cracks at the point of contact and severe damages on the lintel beam. The contact length between the infill panel and frame had increased by increasing the stiffness of the confining frame. However, when the aspect ratio (H/L) was increased, the crack pattern spread throughout the panel and the column fails in shear and bending. The failure of fully infilled specimen was dominated with the diagonal cracking along with shear slip along mortar joints. Although, failure occurred at the loaded corners in most cases, the specimen which had strong column, failure occurred mostly near the beam in the loaded corner and conversely failure concentrate near the loaded region of column when their beam is stronger than the column[11]. Kaushik (2006) conducted a comparative study of the seismic codes especially on the design of infilled framed structures. The study revealed that the most of the modern seismic codes lack the important information required for the design of such buildings. Moreover, the relevant clauses of codes are not consistent and vary from country to country. Such variations were attributed to the absence of adequate research information on important structural parameters as determination of natural period of vibration of infilled structures, soft storey phenomenon associated with the presence of infill, exclusion of strength and stiffness of infill and considerations of openings. The main reason of not considering the beneficial effects of the infill is due to variation in material property as well as brittle nature of failure[12]. Fardis (1996) investigated the seismic response of an infilled frame which had weak frames with strong infill material. It was found that the strong infill which was considered as non structural is responsible for earthquake resistance of weak reinforced concrete frames. However, since the behaviour of infill is unpredictable, with the likelihood of failing in brittle manner, it was recommended to treat infill as non-structural component by isolating it from frames. On the contrary, since infill is extensively used, it would be cost effective if positive effects of infill is utilized.[13]. Dominguez (2000) studied the effects of non-structural component on the fundamental period of buildings. The model consists of five storeys, ten storeys and fifteen storeys with diagonal struts as the infill (non-structural component). It was reported that the presence of infill decreases the fundamental period of the structure. When the models was provided with 100mm thick infill, the fundamental period was decreased by 46%, 40% and 34% for five storey, ten storeys and fifteen storeys. When the infill thickness was 200mm, the fundamental period was 53%, 44% and 36% respectively. The trend of decrease in period with increase in thickness is decreasing with the increase in height. However, the effect of thickness is not significant. The effect of masonry strength was reported to be insignificant on the fundamental period of the structure as the difference between 2 models which had 8.6MPa and 15.2MPa was 10.4%. The significant difference was observed by increasing the number of bays. When the number of bays was increased to 2, the difference in fundamental period was 15%[14].

IV. NEED FOR THE PROPOSED WORK

The presence of infill walls in upper storeys of open ground storey (OGS) buildings accounts for the following issues:

i) Increases the lateral stiffness of the building frame.

ii) Decreases the natural period of vibration.

iii) Increases the base shear.

iv) Increases the shear forces and bending moments in the ground storey columns.

V. OBJECTIVE OF THE WORK

The salient objectives of the study have been identified as follows:

i) To study the effect of infill strength and stiffness in the seismic analysis of open ground storey (OGS) buildings.

ii) To check the applicability of the multiplication factor of 2.5 as given in the Indian Standard IS 1893:2002 for design of mid rise open ground storey building.

iii) To assess the effect of varying the infill arrangements on the analysis results by taking various combinations of infill thickness, strength, modulus of elasticity and openings.

Through this study it is clear that building with soft storey exhibits poor performance during a strong shaking. But the open ground storey is an important functional requirement of almost all the urban multi-storey buildings and hence cannot be eliminated. So some alternative measures need to be adopted for this specific situation. The under-lying principle of any solution to infills problem is in i) increasing the stiffness of the ground storey; ii) provide adequate lateral strength in the ground storey. The possible schemes to avoid the vulnerability of open ground storey buildings under earthquake forces can be providing stiff columns in open ground storey buildings or by providing adjacent infill walls at each corner of soft ground storey buildings.

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