SEISMIC IMPACT ANALYSIS IN MULTI-STOREY BUILDING USING INFILL - A REVIEW

Pallavi Rahangdale
M.Tech Scholar
Department of Civil Engineering

Dr. Pradeep Kumar TV
Associate Professor
Department of Civil Engineering

IES Institute of Technology and Management
Bhopal, MP

Abstract

This paper presents a analysis of the experimental efforts also as modelling methods to review estimate typical variations in amplification factor of a mid-rise open ground storey building accounting for the changeability 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 relative study. The building will be examined for two different cases: i) considering infill mass but without considering infill stiffness. ii) Considering both infill mass and infill stiffness. From the study anticipated outcome have found that building with soft storey will display poor performance during a strong shaking. But then again the open ground storey is an important functional constraint of almost all the urban multi-storey buildings and henceforth cannot be eliminated. Alternative measures need to be adopted for this specific situation. The core 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 evade the vulnerability of open ground storey buildings under shaking forces can be by providing stiff columns in open ground storey buildings or by providing neighbouring infill walls at each corner of soft ground storey buildings.

Keywords— Infill's, OSG building, Equivalent static analysis (ESA), Response spectrum analysis (RSA).

I. INTRODUCTION

Reinforced concrete frame buildings became common form of construction with masonry infill's in urban and semi urban areas around globe. The term in-filled frame denotes a composite structure formed by the combination of a moment resisting plane frame and infill walls. The infill masonry could be of brick, concrete blocks, or stones. Preferably in present time the reinforced concrete frame is jam-packed with bricks as non-structural wall for divider of rooms because of its advantages such as resilience, thermal insulation, cost and simple construction practice. There is noteworthy advantage of such type of buildings functionally but from seismic performance point of view these buildings are deliberated to have increased vulnerability. In the existing practice of structural design in India infill walls are supposed of as non-structural elements and their strength and stiffness contribution are ignored. The impact of infill panels on the response of reinforced concrete frames subjected to seismic action is widely known 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 level framed building behaves differently as paralleled to a bare framed building (without any infill) or a fully infilled framed building in lateral load. A bare frame is much less stiffer compared to 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 entirely infilled, truss action is introduced thus shifting the lateral load transfer mechanism. A fully infilled frame displays reduced inter-storey drift, though it attracts greater base shear (due to increased stiffness). A fully infilled frame produces lesser force in the frame elements and disintegrates greater energy through infill walls. The structural repercussions like strength and stiffness of infill walls in infilled frame buildings are overlooked in the structural modelling in orthodox design practice. The design in such cases will commonly be conservative in the event of fully infilled framed buildings. On the other hand things will be not be the similar for an open ground storey framed building. Open ground storey building is slightly stiffer than the bare frame, has greater drift (especially in the ground floor), and fails due to soft storey-mechanism at the ground floor as shown in Fig. 1.1. Therefore, it may possibly not be conservative to ignore strength and stiffness of infill wall however 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 show significant changes in both strength and stiffness of the frame. Presence of stiffness and strength of infill walls in the open ground storey building frames cuts the fundamental time period compared to a bare frame and subsequently increases the base shear demand and the design forces in the ground floor beams and columns. This increased design forces in the ground floor beams and columns of the open ground storey buildings are not captured in conventional bare frame analysis. A fitting way to examine 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) for modelling the infill walls. As an alternative a bare frame analysis is generally utilized that ignores the strength and stiffness of the infill walls. The objective of this study is to find the applicability of the multiplication factor of 2.5 in the ground storey beams and columns for the model deliberated in specific, 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 midrise open ground storey building.

II. OVERVIEW OF WORK

Non-linear dynamic (NDA) analysis is said to be the most precise but at the same time it is most demanding among all methods. The magnification factors for ground storey pillars in open ground storey (OGS) buildings should preferably be based on the findings of nonlinear analysis. However as mentioned above this method is computationally difficult and needs considerable research.
Therefore the present study Equivalent static analysis (ESA) and Response spectrum analysis (RSA) is used for the relative study. The building will be analysed for two different circumstances

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 examined by two approaches mentioned above. The modelling and analysis for the study is done with the assistance of viable software ETABS v 9.7.1 in compliance with the codes IS 456-2000 and IS 1893-2002.

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

Masonry infill walls are commonly used as partitions all over the world. Proofs shows that unremitting infill masonry walls can decrease the vulnerability of reinforced concrete construction. Often masonry walls are not taken under consideration in the design process because they are supposed to act as non-structural members or elements. Separately the infill walls are stiff and brittle however the frame is relatively flexible and ductile. The compound action of beam-column and infill walls offers added strength and stiffness.
Various types of analytical models constructed on the physical understanding of the complete behaviour of an infill panels were developed over the years to mimic the performance of in filled frames. The elastic analysis based (Smith and Carter, 1969), the plastic analysis based (Liauw and Kwan, 1983), and the ultimate load based (Saneinejad and Hobbs, 1995) 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 are often 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.

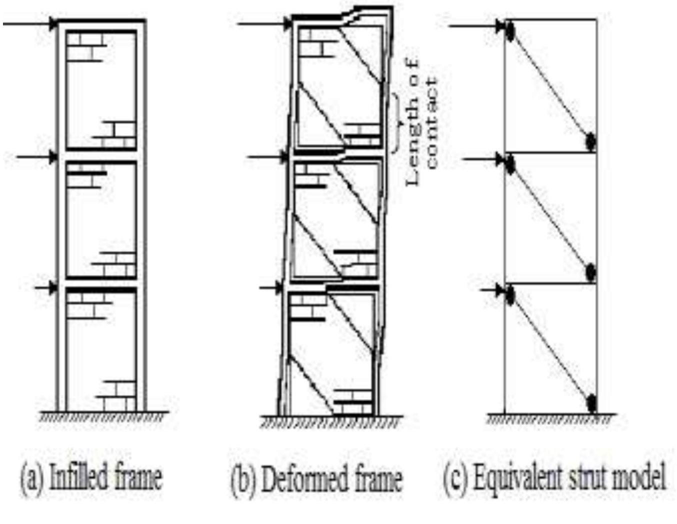

Fig. 1.2: Typical behaviour of infilled frame

III. LITERATURE REVIEW

In present 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 existence of masonry infill walls in the frames of a building changes the lateral stiffness and strength of the building. This research offered a plastic hinge model for infill wall to be used in nonlinear performance grounded analysis of a building and determines that the ultimate load (UL) methodology along with the proposed hinge property delivers a better approximation of the inelastic drift of the building.D Menon et. al. (2008) concluded that the MF increases with height of the building, primarily due to 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. 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 drops with increase in (E) values due to rise in stiffness of the model. The stress differs with building heights for a given E and seismic hazard. Sattar and Abbie (2010) in their study determined that the pushover analysis showed an upsurge in strength, initial stiffness, and energy dissipation of the infilled frames, compared to the bare frames, despite the wall's brittle failure modes. Likewise, dynamic analysis results indicated that fully-infilled frame has the lowest collapse risk and the bare frame were found to be the most vulnerable to earthquake-induced collapses. The better breakdown performance of fully-infilled frames was allied with the larger strength and energy intemperance of the system, accompanied with the added walls. 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 core of panel had suffered shear fissures at the point of contact and unadorned damages on the lintel beam. The contact length between the infill panel and frame had increased by increasing the stiffness of the confining frame. Nonetheless, when the aspect ratio (H/L) was increased, the crack pattern spread all over the panel and the column fails in shear and bending. The failure of fully infilled specimen was subjugated with the diagonal cracking alongside shear slip along mortar joints.

Even though, failure occurred at the loaded corners in most circumstances, the specimen which had strong column, failure occurred mostly near the beam in the burdened corner and conversely failure concentrate near the loaded region of column when their beam is stronger than the column. Kaushik (2006) conducted a comparative study of seismic codes specifically 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 variants were attributed to the non-appearance of acceptable research information on important structural parameters as determination of natural period of vibration of infilled structures, soft storey phenomenon concomitant with the presence of infill, exclusion of strength and stiffness of infill and considerations of openings. The main cause of not considering the advantageous effects of the infill is due to variation in substantial property as well as brittle nature of failure. Fardis (1996) investigated the seismic responses of infilled frames which had weak frames with strong infill material. It was established that the strong infill which was thought as non-structural is responsible for earthquake resistance of weak reinforced concrete frames. Since the behaviour of infill is irregular, with the possibility of failing in brittle manner, it was endorsed to treat infill as non-structural constituent by isolating it from frames. On the contrary, since infill is broadly used, it would be cost effective if constructive effects of infill is consumed. Dominguez (2000) studied the effects of a non-structural component on the fundamental period of buildings. The model comprises of five storeys, ten storeys and fifteen storeys with oblique struts as the infill (non-structural component). It was reported that the manifestation of infill decreases the essential 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 thickness of infill 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%.

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 crisscross the applicability of the multiplication factor of 2.5 as specified in the Indian Standard IS 1893:2002 for design of midrise open ground storey building.

iii) To measure the effect of changing the infill arrangements on the investigation 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 a vital functional prerequisite of almost all the urban multi-storey buildings and hence cannot be excluded. 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 promising schemes to circumvent the vulnerability of open ground storey buildings under earthquake forces can be providing stiff columns in open ground storey buildings or by providing contiguous infill walls at each corner of soft ground storey buildings.

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