

# Performance of Reinforced Concrete Structures with and Without Infill Walls

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## ABSTRACT

The most of human occupation is acquired by residential and office buildings for our living and working purposes. To fulfill the demand of urbanization high rise buildings becomes necessary which are more vulnerable to the effects of earthquakes. Despite of having similar structural frame, size and shape residential and office buildings exhibit different infill wall positions. Use of brick infills in building construction is most common practice in India, this practice results in the function of the masonry brick infill wall as a bracing system to stiffen and enhance the strength of the structure. There is no consensus on performance of structures of with and without infill walls at different seismic zones for strong ground motions. To provide solution to this, a eight storey model at different seismic zones with and without infill is analyzed. The non linear static pushover analysis is carried out by using SAP2000 to enhance the performance of model structure at different seismic zones.

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## INTRODUCTION

### General

An earthquake force is very unpredictable and different compare to other loads. There is lots of life damage if structure is not designed for earthquake forces when earthquake hits to the RC structure. In the past many countries like Nepal in the year 2015, hit by an earthquake of intensity 7.8M<sub>w</sub>. It has killed more than 8800 and injured 23000 people and Hundreds of thousands of people were made homeless with entire villages flattened. The study has been conducted to evaluate the behavior of RC bare and infill structures for all zones.

Most studies on infill wall behavior aim to understand their part in terms of strength in the assessment of the resistant capacity of existing buildings. Whereas less attention is paid to infill wall - RCC frame interaction modeling in order to evaluate their influence on RCC frame response

Usually, in the design of new buildings, two different approaches are followed. The first one is oriented at completely neglecting the presence of the infill (which is considered unreliable because of the uncertainties arising during the execution) and hence includes the disjunction of the panels from the supporting frame. The second approach is completely opposite of first. The several positive effects brought by the infill panels, especially under severe earthquakes are increase of the overall strength, stiffness and enhancement of energy dissipation. Infill panels, according to this philosophy, are always connected with the resisting RC frame by using specific devices (ties, belts, posts or shear connectors). This idea is often followed in the case of existing buildings, by applying specific bandaging as a retrofitting technique, in order to encourage an integral behavior of the infill panels with the RC frame and avoid the early expulsion and collapse of the infill.

C.V.R Murthy and S.K. Jain conducted the experimental studies on infill panel and rc frame. They constructed 12 single bay single storey models and applied cyclic loading to it till it completely gets collapse. Their observations were that mechanism of frame action changes to the truss action. Columns are subjected to more axial load then compare to the bare frame column.

According to EERI report on Bhuj earthquake, building with open first storey creates soft storey situation which gets damaged during the earthquake. Most of buildings are design for gravity load only neglecting the lateral force. Moreover,

many architects prefer small size column, small size may be as low as 125 mm, or 5 inches. Government building suffered less damage than the privately constructed ones. Most of such building suffered only nonstructural damage.

### **Behavior of Infilled Frames**

The modeling of the behavior of infilled frames under lateral loading (and primarily earthquake-induced loads) is a complex issue because the structures exhibit a highly nonlinear response that is caused by the interaction of the masonry-infill panel and the surrounding frame. It results in several modes of failures, which has a different failure load and hence a different ultimate capacity and overall behavior.

## **LITERATURE REVIEW**

**Murty, C. V. R and Jain, S. K. (2000)**, this paper shows the experimental study of RC frame with & without infill masonry. The test is carried out by applying the cyclic displacement-controlled loading to the 12 single-bay single-story models, out of which 2 are bare and 10 are infilled with masonry. Out of 10, 5 are unreinforced masonry infill (URM) frame models and 5 are reinforced masonry (RM) infill frame models. this paper concludes from the experimental results that, the infill masonry frames having higher stiffness, strength, overall ductility and energy dissipation than the bare frames and also observed that there is a wide reduction in displacement and ductility demand of RC frame members. The provision of reinforcement in infill masonry reduced the overall strength and stiffness of frames as compare to URM infill frames, only it's help in avoiding the out-of-plane collapse of masonry

**Ghosh, A. K., and Amde, A. M. (2002)** has found out the same order of occurrence of the five distinct failure modes based on the finite-element method and including interface elements at the frame-infill interface. Of the five modes, only the CC and SS modes are of practical importance because most infills are not slender and the second mode (DC) is therefore not favoured. The fourth mode (DK) should not be considered a failure mode because of the post cracking capacity of the infill to carry additional load. The fifth mode (FF) relates to the failure of the frame and it is particularly important when examining existing structures, which in many cases exhibit frame weakness. These failure modes are only seen or applicable to infill walls without openings on the diagonal of the infill panel.

**Ju et al. (2012)**, this paper shows the experimental study of steel moment frame with RC infill wall. The pushover analysis is done on four proposed steel moment resisting RC infill frames models, one with bare frame, one with ordinary RC infill walls, two with side slits between RC wall and frame member. From the results, this paper conclude that the slits RC infill frame have less deformation and less damage as compare to ordinary RC infill frame at small drift ratio.

## **ANALYSIS OF INFILL WALLS IN RC STRUCTURE**

### **Introduction**

There is large uncertainty in the accuracy of RC structures with infill because the modulus of elasticity of concrete and infill are difficult to determine. They vary with stress level, loading condition (static or dynamic), material strength, and age. For this reason the elastic modulus value specified by different design codes for different grades of material differ from one another. This implies there is considerable difference in actual and estimated fundamental time periods of structure and hence seismic force experienced by it.

Various International codes on infill can be broadly divided into two categories, the one which consider the effect of infill in design and the other which does not consider the effect of infill in design. A very few code neglect the stiffness of masonry infill while calculating the total stiffness of structure (NEW ZEALAND- 3101 1995, Source Normalized Impact Per Paper (SNIP)-II-7-81 1996). As result masonry infill is not consider in design and analysis.

Another group of people tries to take the advantage of positive effect of infill such as high initial lateral stiffness, cost effectiveness and ease in construction and they want to incorporate this effect in design and analysis.

## **MODELLING OF INFILL WALL IN RC STRUCTURE**

To take into the account the modeling of infill in structure we need to model the effect of infill in structure. However it is difficult to model as built structures due to various constrains because of various physical parameters associated with it. Even if all physical parameters are known like coefficient of friction between frame and infill, amount of separation, material properties there is no guarantee that the real structure behaves similar to the model. However the structural behavior also depends on material of construction, workmanship, quality and etc.

### Modeling of infill can be done in two ways

#### Micro element modeling

Micro element modeling is the finite element modeling where the frame elements, masonry element, contact surface, separation, slipping are model to achieve to results. This method gives the better result but it is lengthy and cumbersome method.

#### Macro element modeling

According to this procedure no distinction between the individual masonry units and joints is made, and masonry is considered as a homogeneous, isotropic. While this procedure may be preferred for the analysis of large masonry structures, it is not suitable for the detailed stress analysis of a small panel, due to the fact that it is difficult to capture all its failure mechanisms. The influence of the mortar joints acting as planes of weakness cannot be addressed.

## METHODOLOGY OF PUSHOVER ANALYSIS FOR RC STRUCTURE

### Introduction

Pushover Analysis option will allow engineers to perform pushover analysis as per FEMA 356 and ATC-40. Pushover analysis is a static, nonlinear procedure using simplified nonlinear technique to estimate seismic structural deformations. It is an incremental static analysis used to determine the force-displacement relationship, or the capacity curve, for a structure or structural element. The analysis involves applying horizontal loads, in a prescribed pattern, to the structure incrementally, i.e. pushing the structure and plotting the total applied shear force and associated lateral displacement at each increment, until the structure or collapse condition. (sermin, 2005)

Pushover analysis is a technique by which a computer model of the building is subjected to a lateral load of a certain shape. The intensity of the lateral load is slowly increased and the sequence of cracks, yielding, plastic hinge formation, and failure of various structural components is recorded. Pushover analysis can provide a significant insight into the weak links in seismic performance of a structure. A series of iterations are usually required during which, the structural deficiencies observed in one iteration, are rectified and followed by another. This iterative analysis and design process continues until the design satisfies pre-established performance criteria. The performance criteria for pushover analysis are generally established as the desired state of the building given roof-top or spectral displacement amplitude.

### Methods of Analysis

For seismic performance evaluation, a structural analysis of the mathematical model of the structure is required to determine force and displacement demands in various components of the structure. Several analysis methods, both elastic and inelastic, are available to predict the seismic performance of the structures. (sermin, 2005)

## ANALYSIS AND RESULTS OF RC STRUCTURE MODEL IN ALL ZONES

### Structure Specification

1. Type of structure	Multistorey frame
2. Zone	II III IV V
3. Layout	As shown in fig
4. Number of storeys	Eight
5. Floor to floor height	3 m
6. Live load	3.5
7. Materials	M 20 and fe415
8. Size of column	400 x 400 mm for 1 to 4 storey 300 x 300 mm for 4 to 8 storey
9. Size of beam	230 x 300 mm
10. Total depth of slab	120 mm
11. Soil type	Medium
12. Floor finish	0.5 KN/m <sup>2</sup>
13. Terrace water proofing	1.5 KN/m <sup>2</sup>

### Models on SAP2000

A regular eight storey structure is model in the structural analysis programme (SAP2000). The longitudinal direction of three storey structure is 12 m and in transverse direction of structure is 9 m. The building has 4 bays in X direction and 3 bays in Y directions. In sap two types of model one with bare frame and the other with infill frame. The following figures shows the various model in the SAP2000.

## CONCLUSIONS

Design of structure plays important role during the earthquake and the effect of infill should be considered while designing of the structure. In present study infill is modeled as the diagonal strut. The width of infill strut is obtained from FEMA 354. The behavior of the infill frame is different from the bare frame. The time period of infill frame structure is less compare to the bare frame structure. Lesser is the time period more will be the force and hence the infilled frame structure should be design considering the effect of infill in the structure. Bare frame displaces more compare to the infill frame and more displacement found in zone five bare frames. Base shear in bare frame is less compare to the infill frame. The inter-storey drift is more in bare frame compare to the infill frame. The columns, beams and infill walls in the lower storeys are more vulnerable to damage than those in upper storey. Moreover, in particular storey, the columns and beams in the exterior bay and the infill panels in the interior bays undergo more yielding.

Capacity of infill structure is more compare to bare frame and different in different zones i.e. II III IV V, more vulnerable zone for earthquake is zone V. It requires more capable structure to resist lateral forces compare to other zone structures in the above study we found that zone V has higher capacity from capacity spectrum curves and it goes on decreasing with subsequent lower zone values. The salient features of pushover curve for various cases are summarized in table 1. Table 1 gives information about number of hinges formed at different performance levels, base shear, and roof displacement for the four zone cases considered. It is observed that infilled RC structure in zone V building shows high lateral resistance compared to all other zone buildings.

### Future scope and study

Building with unsymmetrical and irregular location of infill walls can be analyzed with the procedures explained in this thesis. This can provide detail view of structural behavior for changing location of infill wall in a particular storey or in several stories. This can help a designer to predict the structural response for such buildings. Performance based design of structure can be done Building with the unsymmetrical plan can also be analyzed with procedure explained in this thesis.

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