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EVALUATION OF DESIGN FACTOR FOR PARTIALLY OPEN GROUND STOREY REINFORCED CONCRETE BUILDINGS

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Abstract

The idea of open ground building (OGS) has taken its place in the Indian country due to it provides the parking facility in the ground storey of the building. From the past surveys most of the OGS buildings are failed. The collapse mechanism of such type of building is due to the formation of soft-storey behaviour in the ground storey of this type of building. In the columns higher streses of ground storey under seismic loading due to absence of lateral stiffness and mass. In conventional design practice, only consider structural modelling (bare frame analysis). Design based on such analysis, results in under-estimation of the bending moments and shear forces in the columns of ground storey, and hence it may be one of the reasons responsible for the failures observed. After the Bhuj earthquake took place, the IS 1893 code was revised in 2002, and new design recommendations to address OGS framed buildings. According to clause 7.10.3(a) of the same code states that: “The columns and beams of the soft-storey are to be designed for the multiplication factor of 2.5 times the storey shears and moments calculated under seismic loads of bare frame”. The prescribed multiplication factor (MF) of 2.5, is highly vulnerable for designing the building. This MF value however does not account for number of infill walls present storeys, number of bays, numbers of storeys etc. and hence it is independent of all of the above factors. The main objective of present study is the study of comparative performance of OGS buildings designed according to various MFs using nonlinear analysis. As the more realistic performance of the OGS building requires the modelling the stiffness and strength of the infill walls.

Keywords: Open ground storey buildings, Magnification factor, Infill walls, Bare frame, Response spectrum analysis, Nonlinear analysis

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INTRODUCTION

Open Ground Storey (OGS) framed buildings are generally considered to be extremely vertical irregular buildings (with soft storey at ground storey), and Structural analysis is a part of the detailed evaluation of an existing building. A detailed evaluation is decided based on the results of preliminary evaluation. Structural analysis can be linear or non-linear, elastic or inelastic, static or dynamic. In linear elastic analysis, the deformation in a member is considered to be proportional to the internal force and recoverable when applied force is removed. In a non-linear inelastic analysis, the deformation in a member need not be proportional to the internal force. There is plastic deformation and energy absorption in a member for higher levels of internal force. This type of non-linear behaviour is referred to as material non-linearity.

In addition, geometric non-linearity due to P-Δ effect can be incorporated. The P-Δ effect refers to the increase in moment in the columns due to its lateral deflection or due to the drift of a storey.IS 1893 (2002) recommends a magnification factor of 2.5 to be applied on bending moments and shear forces calculated for the bare frame under seismic loads. Similarly other national codes, such as EC-8, UBC and Israeli codes etc specify magnification factors of similar orders. The conservative nature of these empirical recommendations has been pointed out by Subramanian (2004), Kanitkar and Kanitkar (2004) and Kaushik et. al. (2006). These recommendations have met with some resistance in design construction practice, due to the need for heavy reinforcement in the column, leading to congestion.

The energy developed during earthquake loading is dissipated by the vertical resisting elements of the ground storey resulting the occurrence of plastic deformations which transforms the ground storey into a mechanism, in which the collapse is unavoidable. The construction of open ground storey is very dangerous if not designed suitably and with proper care.

Figure 1: General Mode of Failure in OGS Buildings

Summary of Previous Research

Raghvendra deshpande, Surekha Bhalchandra[1] Investigation has been performed to examine the behavior of various alternative models of R.C. moment resisting frame building with an open first storey & unreinforced masonry infills in the upper storeys. Various parameters based on equivalent static analysis, such as drift, lateral displacement, stiffness has been discussed.

Nikhil Agrawal, Prof. P. B. Kulkarni, Pooja Raut[2] Attempt is made to assess the seismic performance of soft storey structure through computer based models. Various computer based models were created, such as bare frames, frames with solid infill walls, frames with infill walls having central & corner openings. Attempt has been made to demonstrate the effect of open ground storey on drift profiles, displacement profiles, stiffness ratio & damage pattern in model

R. Davis , D. Menon , A. M. Prasad[3]Attempt is made to assess the evaluation of Magnification factor for only open ground storey using Response Spectrum Analysis (RSA) and Nonlinear Dynamic Analysis (NDA) are carried out on a four storeyed and a seven storeyed building, for various infill wall Arrangements to find out magnification factor.

J. Prakshavel, C. Uma Rani, MUthumani, N. Gopalkrishnan[4]Attempt is made to assess the seismic performance of soft storey reinforced concrete building using shake table test. During test it is found that, damages are predominantly spread in the ground storey of the tested model. Attempt has been made to demonstrate the effect of open ground storey on drift profiles, displacement profiles, stiffness ratio & damage pattern in model.

Concepts given by (Scarlet, 1997; Kaushik, 2006; Fardis et. al., 1999; Arlekar et. al., 1997; Hashmi and Madan, 2008) and others [8] Fardis et. al. (1999)[5] noted out that the MF proposed by the EC 8 (2004) expression not only results to higher seismic forces and reinforcements to the building frame but also lacks a rational basis. Due to these reasons, despite of its general effectiveness in protecting the columns of the soft ground storey buildings, MF proposed by Euro code needs to be revised. A revision was also proposed in this study at the end based on capacity based design for the beams of the open ground storey

A.S. Kasnale, S. S. Jamkar[6] In present work an investigation has been made to study the behavior of RC frames with various arrangements of infill wall when subjected to dynamic earthquake loading. The result of bare frame, frame with infill, soft ground floor are compared & conclusions are made in view of IS 1893-2002.

Provisions in other codes [7] the provisions given in other design codes are EC 8 (2004) recommends some additional design guidelines for infill walls in vertical irregularities. Although quantitative limit criteria has not been suggested by EC 8 (2004) to check the vertical irregularity. If in case there is a drastic reduction of infill walls in any storey compared to the adjoining storeys, seismic forces in the less infilled storey.

C V R MURTY1 and Sudhir K JAIN [9] Infills are adequately separated from the RC frame such that they do not interfere with the frame under lateral deformations. The entire lateral force on the building is carried by the bare RC frame alone.

MAGNIFICATION FACTOR (MF)

It is a factor which is considered when any building frame is designed ignoring its infill wall but considering its weight i.e. for OGS type of building. Since we know that the function of infill wall in a building is to provide stiffness to the building so that it can stand on the surface but since we neglect infill wall in such building, the purpose of providing that stiffness and help any building to stand is provided by other element which is column. Whatever load the building was withstanding is now multiplied by this MF value so that it can stand still by providing sufficient stiffness. Talking about MF value there are several codes which suggests different values of MF. But in our case we have considered the Indian Code which suggests the MF value to be 2.5 and the other one we have accounted is UBC code or Bulgarian Code which suggests the value of 3.0.

Objective:

At present not much research reported in the literature to validate the accuracy of the Design factor in various codes regarding partially open ground storey (OGS) buildings. So find out the more suitable Design factor using non-linear analysis methods on following conditions:

a) In 03 storey's buildings carry out non-linear analysis on RC frames with 100%, 75%, 50% open space for parking.
b) In 06 storey's buildings carry out non-linear analysis on RC frames with 100%, 75%, 50% open space for parking.
c) In 09 storey's buildings carry out non-linear analysis on RC frames with 100%, 75%, 50% open space for parking

Methodology

a) Review of the existing literatures by different researchers and also by the Indian design code provision for designing the OGS building
b) Modelling of the selected buildings with and without considering their infill strength and stiffness.

c) Performing nonlinear analysis of the selected building models and a comparative study on the results obtained from the analyses. For doing this analysis by using computer aided software.
d) Finally the observations of results and discussions.

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Summary and Conclusions:

1. This paper investigated the factors such as given by IS Code and other comparative codes, The prescribed multiplication factor (MF) of 2.5, applicable for all OGS framed buildings, is proved to be fairly higher and suggests that all existing OGS framed buildings (those designed to earlier codes) are highly vulnerable under seismic loading
2. This paper describe suitable technique of magnification factor for open ground storey buildings
3. From the literature available it was found that the support condition for the buildings was not given much importance. Linear and nonlinear analyses show that support condition influences the response considerably and can be an important parameter to decide the force amplification factor.

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