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"SEISMIC ANALYSIS OF RC FRAME WITH SOFT GROUND STOREY"

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Abstract

Now a day's Reinforced concrete frame buildings are common used in India with a ground storey as parking purpose called open ground storey buildings. The first storey become soft and weak relative to the other upper storeys, Structurally those unbalances are unhealthy. It is necessary to study to examine various alternative models of reinforced concrete moment resisting frame building with open first storey & unreinforced to promote safety without too much changing the concrete structures. This study focuses on the seismic performance of soft-first-storey buildings. Multistoried buildings with soft ground floor subjected to dynamic earthquake loading. The aim of this paper was to investigate the seismic performance and design of the masonry infill reinforced concrete structure with the soft first storey under a strong ground motion.

1. INTRODUCTION

Reinforced concrete (RC) frame buildings are becoming increasingly common in urban India. Many such buildings constructed in recent times have a special feature - the ground storey is left open for the purpose of parking (as shown in figure) , i.e., columns in the ground storey do not have any partition walls (of either masonry or RC) between them. Such buildings are often called open ground storey buildings or buildings on stilts. Open first storey is now a day's unavoidable feature for the most of the urban multistory buildings for vehicle parking, shops, reception etc. The first storey become soft and weak relative to the other upper storeys, since the first stories are composed of only the columns and upper storeys are divided by the rigid walls. Structurally those unbalances are unhealthy and the soft first storey buildings are well known for being susceptible to collapse through past big earthquakes (for example during 1999 Turkey, 1999 Taiwan, 2001 Bhuj and 2003 Algeria earthquakes). The most frequent failure mode of reinforced concrete (R.C.) moment frame buildings is the so called "soft storey" mechanism. It consists in a localization of buildings seismic deformations and rupture in the bottom storey of the building. This phenomenon is caused by the fact that the overall
shear force applied to the building by an earthquake is higher at the base.

Figure 1: Ground storey's of reinforced concrete Buildings are left open to facilitate parking

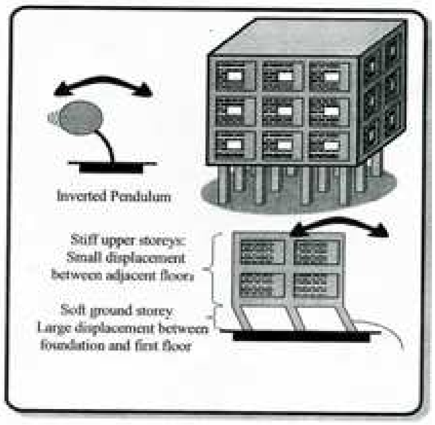
Definition :- (according to IS 1893 part I: 2002)

Soft Storey

A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of average lateral stiffness of the three storey's above.

Extreme Soft Storey

A extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of average lateral stiffness of the three storey's above. The presence of walls in upper storey's makes them much stiffer than the open ground storey. Thus, the upper storey's move almost together as a single block, and most of the horizontal displacement of the building occurs in the soft ground storey itself. Thus, such buildings swing back-and-forth like inverted pendulums during earthquake shaking (see figure), and the columns in the open ground storey are severely stressed (see figure). If the columns are weak (do not have the required strength to resist these high stresses), they may be severely damaged which may even lead to collapse of the building



The main aim of this study is to examine various alternative models of same einforced concrete moment resisting frame building with open first storey & unreinforced brick infill in the upper storey for their empirical & analytical fundamental natural periods as well as the stiffness of open first store in relation to the stiffness of upper storey by using ETABS analysis package. The objective of the work is to promote safety without too much changing the constructional practice of reinforced concrete structures

2. LITERATURE REVIEW

The various literature is collected from books, magazines and websites. From this literature data is summarized for work. Abstracts of collected literatures are as follows.

Arlekar, Jain and Murty [1]

This paper highlights the importance of explicitly recognizing the presence of the open first storey in the analysis of the building. The error involved in modeling such buildings as complete bare frames, neglecting the presence of infill in the upper storeys, is brought out through the study of an example building with different analytical models. This paper argues for immediate measures to prevent the indiscriminate use of soft first storeys in buildings, which are designed without regard to the increased displacement, ductility and force demands in the first storey columns. Alternate measures, involving stiffness balance of the open first storey and the storey above, are proposed to reduce the irregularity introduced by the open first storey. In this paper, stiffness balancing is proposed between the first and second storey of a reinforced concrete moment-resisting frame building with open first storey and brick infill in the upper storeys. A simple example building is analyzed with different models. The stiffness effect on the first storey is demonstrated through the lateral displacement profile of the building, and through the bending moment and shear force in the columns in the first storey

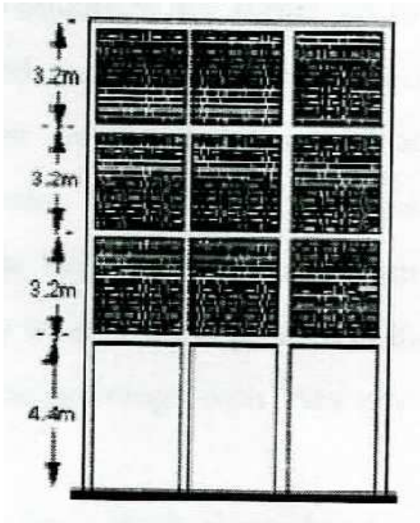


fig. Elevation of building model considered in this study

Nagae, Suita, Nakashima [2]

This study focuses on the seismic performance of soft-first-storey buildings, which are demanded specially in urban areas. Six-story reinforced concrete buildings are focused on, and the seismic response of the soft-first-storey structures and typical frame structures are statistically assessed based on the results of dynamic response analyses. The mean annual frequency of the maximum interstorey drift ratio exceeding the specified value is computed, and the mean annual frequencies for the plural values are shown as a seismic hazard curve for each case. Eventually the probabilities of the maximum interstorey drift ratios exceedingsafety limit states are computed and compared. The soft-first-story buildings with the yield strength coefficient of more than 0.7 showed the same level of safety in comparison with typical frame structures, on the condition that the same deformation capacities are given to the main structural members.

S.Haque, Khan Mahmud Amanat [3]

In the present paper, an investigation has been performed to study the behavior of the columns at ground level of multistoried buildings with soft ground floor subjected to dynamic earthquake loading. The structural action of masonry infill panels of upper floors has been taken into account by modeling them as diagonal struts. Finite element models of six, nine and twelve storied buildings are subjected to earthquake load in accordance with equivalent static force method as well as response spectrum method. It has been found that when infill is incorporated in the FE model, modal analysis shows different mode shapes indicating that dynamic behavior of buildings changes when infill is incorporated in the model. Natural period of the buildings obtained from modal analysis are close to values obtained from code equations when infill is present in the model. This indicates that for better dynamic analysis of RC frame buildings with masonry walls, infill should be present in the model as well. Equivalent static force method produces same magnitude of earthquake force regardless of the infill present in the model. However, when the same buildings are subjected to response spectrum method, significant increase in column shear and moment as well as total base shear has been observed in presence of infill. In general, a two fold increase in base shear has been observed when infill is present on upper floors with ground floor open when compared to the base shear given by equivalent static force method. The study suggests that the design of the columns of the open ground floor would be safer if these are design for shear and moment twice the magnitude obtained from conventional equivalent static force method. Study of the sway characteristics also reveals significantly high demand for ductility for columns at ground floor level. Presence of in filled wall on upper floors demands significant enhancement of column capacity or ductility to cope up with increased sway or drift.

Samir Helou & Abdul Razzaq Touqan |4]
This paper illustrates the importance of the judicious distribution of shear walls. The selected building is analyzed through nine numerical models which address the behavior of framed structures. The parameters discussed include, the fundamental period of vibration, lateral displacements and ending moment. It is noticed that an abrupt change in stiffness between the soft storey and the level above is responsible for increasing the strength demand on first storey columns. Extending the elevator shafts throughout the soft storey is strongly recommended.

Tuladhar and Kusunoki [5]
The aim of this paper was to investigate the seismic performance and design of the masonry infill reinforced concrete fame structure with the soft first storey under a strong ground motion. The study also highlighted the error involved in modeling of the RC frame buildings as completely bare frame neglecting stiffness and strength of the masonry wall in the upper floors. The attempt was made to determine the strength increasing factor to account the effect of the soft storey through various 2D analytical models using capacity spectrum method and established its relationship with initial stiffness ratio. In this study, the non linear dynamic time history analysis was also carried out with a 3D practical model in order to verify the proposed strength increasing factor.

Yong Lu,Tassios, Zhang and Vintzileou |6]
Two six-story, three-bay, reinforced concrete frames, one having a tall first story, and the other a discontinuous interior column, were designed in accordance with Eurocode 8, and their models were constructed and tested on an earthquake simulator. The main objectives of the

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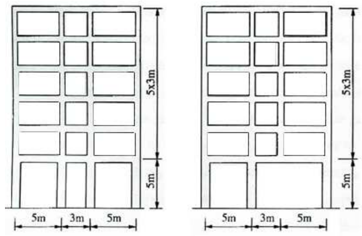
investigation were to study the structural effects of these particular irregularities and to check the relevant design code provisions. During tests, Frame having tall first storey performed in a reasonably regular manner. For discontinuous interior column frame , the response during moderate earthquakes was strongly influenced by the increased flexibility in the direction towards the missing column side, combined with the gravitational effects on the suspended beam spans. The response of discontinuous interior column frame to strong earthquakes was dominated by an apparent soft first-story mechanism. Both frames exhibited a weakness at the fifth story where discontinuity in stiffness occurred. A base shear over strength factor, with respect to the design required base shear, approximately of the order of three and two, was achieved for tall first storey frame and discontinuous interior column frame, respectively.



(a). Frame BF 1 (b).Frame DCF

Cross-section dimensions

Story	Column	Beam
6	350x350	350x400
5	350x350	350x400
4	450x450	400x450
3	450x450	400x450
2	500x500	400x500
1	600x600	400x500

Units: mm
1 mm = 0.0394 in.

Fig.Geometry of prototype frames

R.K.L. Su [7]

A literature review has been conducted aimed at improving the general understanding of the seismic response of concrete buildings with transfer structures in low-tomoderate seismicity regions. This paper summarizes and discusses the existing codified requirements for transfer structure design under seismic conditions. Based on the previous shaking table test results and numerical findings, the seismic effects on the inelastic behaviors of transfer structures are investigated. The mechanisms for the formation of a soft storey below transfer floors, the abrupt change in inter-storey drift near transfer storey and shear concentration due to local deformation of transfer structures are developed. Design principles have been established for controlling soft-storey type failure and minimizing shear concentration in exterior walls supported by transfer structures. The influence of the vertical positioning of transfer floors on the seismic response of buildings has also been reviewed.

Yong Lu [8]

In this paper a comparative study of the nonlinear behavior of reinforced concrete (RC) multistory structures is carried out on the basis of measured response of four six-story, three-bay framed structures, namely a regular bare frame, a discontinuous-column frame, a partially masonry-infill frame and a wall-frame system. The structures were designed for seismic requirements in accordance with Eurocode 8 and their models were subjected to similar earthquake simulation tests. Experimental observations and numerical analyses show that the distribution of the story shear over strength is a rather stable indicator of the general inelastic behavior of frames and hence can be employed as a characteristic parameter to quantify the frame irregularity for design purposes. Abrupt discontinuity of the geometry or arrangement of structurally effective elements, where unavoidable, may be compensated by strength enhancement targeting a smoothed over strength profile to allow for distributed inelastic deformation, and this principle applies as well to nominiformly masonry infill frames. For the wall-frame system, adequate countermeasures against rocking of the RC wall is shown to be a key to maintaining the effectiveness of the system at advanced inelastic response

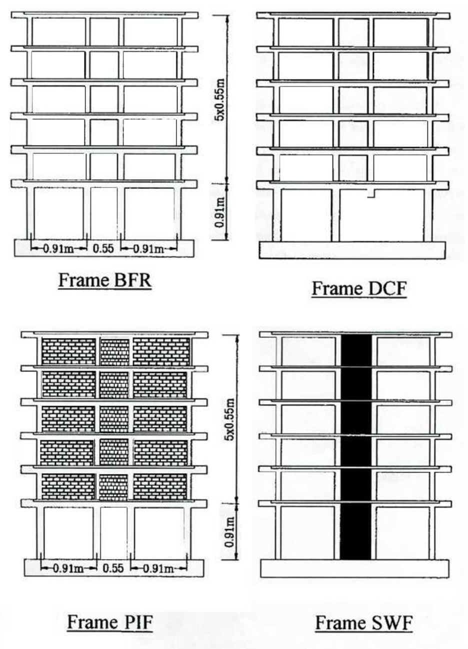


Fig. Geometry of structures

Reddy, Prakash Rao and Chandrasekaran [9]

In the present paper natural frequency of a seven storey reinforced concrete frame structure with open stilt floor were determined by monitoring its ambient vibrations using a triaxial seismometer and the results were compared with those of the analytical models. The framed structure was modeled as bare frame, frame with floor slabs and with staircase to determine most appropriate model to predict its natural frequencies and thereby its seismic behaviour. The effective modulus of elasticity of concrete to be used in the analysis was obtained by matching the experimental and analytical values. The contribution of staircase and lift well in sharing the lateral force was also investigated, particularly in the sensitive stilt floor. Suggestions to improve the performance of the building by introducing additional structural elements at stilt floor level without affecting parking requirements are also included.

03. OBJECTIVES

Following are some objectives of this dissertation work.

1. To promote safety without too much changing the constructional practice of reinforced concrete structures.
2. The main objective of this dissertation is to focused on the behaviour of RC frame building with soft first storey during earthquake.
3. To investigate appropriate model for resisting earthquake effect.
4. To analyze the performance of RC frame in relation to the storey stiffness, fundamental natural periods, storey drift, bending moment and shear force by using equivalent static analysis method and multimodal dynamic analysis using standard package of ETABS.
5. To investigate the soft storey behaviour of RC frame building so as to arrive at suitable practical conclusion for achieving earthquake resistant RC frame building.
6. The following parameters will be investigated in the proposed studya) The effect of beam size at first floor level for realizing soft storey and extreme soft storey criterion as per IS 1893 (Part I) 2002.

b) The effect of change in column size and direction of placement in the first storey while controlling soft storey effect.

c) The effect of introduction of shear walls in the stilt floor including study of importance of the selection of the location of shear walls in practice.

04. SCOPE OF THE WORK

Open first storey is a typical feature in the modern multistory constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas. I In normal practice, only the load due to masonry is considered, and do not consider the . composite action. This work might be helpful to consider this action and reduce the bending moments in beams supporting the masonry infill. It will be interesting if the comparison made between the provisions of the codes of other countries and provisions of Indian code. 12

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