Seismic Performance of Deficient Steel CBF Through Implementation of Rocking Cores

Sanisha Santhosh[1]
[1]PG Scholar,Sree Buddha College of Engineering, Alapuzha Pathanamthitta cluster of APJ Abdul Kalam Technological University, Ayathil, Elavumthitta P.O, Pathanamthitta-689625,Kerala

Linda Ann Mathew[2]
[2]Assistant Professor, Sree Buddha College of Engineering, Alapuzha Pathanamthitta cluster of APJ Abdul Kalam Technological University, Ayathil, Elavumthitta P.O, Pathanamthitta-689625,Kerala

Abstract **- Steel concentrically braced frames are a common lateral force resisting system (LFRS) in low-rise to midrise buildings throughout the world. The CBFs efficiently provide high elastic stiffness and strength, and are believed to more effectively reduce building drift compared with other LFRSs during a seismic event. Past research has shown that even CBFs designed according to modern seismic specifications can exhibit soft-story behavior when subjected to maximum considered earthquake.This paper investigates a new seismic rehabilitation technology for low-rise and mid-rise steel Concentrically Braced Frames vulnerable to inter-story drift concentration and soft-story failures. The technology consists of installation of a single or multiple sufficient Rocking Cores pinned to the foundation and connected to an existing deficient multi-story CBF building.**

In this work two benchmark steel CBF buildings including one three-story and one six-story are rehabilitated using the RC technology. Rocking core of both truss and wall type are used.Nonlinear static pushover analyses are conducted to demonstrate the beneficial contribution of the RC in mitigating non-uniform inter-story drift distributions in the benchmark buildings. This paper also presents the study about whether the technology is applicable to high-rise buildings.

Keywords - Stiff rocking core,soft-storey

1. INTRODUCTION

Steel concentrically braced frames (CBFs) are a common lateral force resisting system (LFRS) in low-rise to midrise buildings throughout the world. The CBFs efficiently provide high elastic stiffness and strength, and are believed to more effectively reduce building drift compared with other LFRSs during a seismic event. However, CBF buildings designed according to premodern seismic standards lack the ductile detailing and member capacity design considerations required for desirable nonlinear response under seismic demands and, therefore, have potential to exhibit soft-story behavior. Additionally, past research has shown that even CBFs designed according to modern seismic specifications can exhibit soft-story behavior when subjected to maximum considered earthquake (MCE). Soft-story response involves a significant concentration of drift and damage in a single story, whereas all other stories remain relatively undamaged. This behavior is initiated by differences in the inter-story seismic shear demands and capacities due to CBF inter-story strength irregularities either inherent to the design or resulting from non uniform hysteretic degradation of brace members. The resulting inter-story shear demands on LFRS columns can cause a plastic panel mechanism that prevents redistribution of lateral forces and plastic deformation along the structure's height. Different rehabilitative or design concepts have been proposed in past research to limit inter-story drift concentration however, these studies were either primarily conceptual or dealt with the rehabilitation of particular buildings and used nonlinear transient seismic analyses for response calculation and design.

As illustrated in Fig. 1.1 the rehabilitation technology discussed throughout this paper consists of a single or multiple RCs pinned to the ground and connected to an existing multi-story steel CBF building that has the potential to develop inter-story drift concentration under earthquake loading. The links connecting the CBF and RCs are assumed to be pinned on each end. The RCs which should be designed to be sufficiently stiff and strong can re-distribute the seismic forces along the building height creating more uniform inter-story drift and ductility demand distributions. The low rotational resistance at the bases of RCs combined with their high inter-story stiffness do not attract all of the seismic forces through the core to the foundation however re-distribute seismic ductility demands from floors that would otherwise have significant concentrated ductility demands, potentially preventing formation of the soft-story mechanism. The considered RC technology is inspired by the recent research outcomes including: (1) investigations on the effect of gravity column stiffness in reduction of inter-story drift concentration in steel CBFs and steel plate shear walls (2) strengthening deficient reinforced concrete moment-resisting frame and generic multiple-degree-of-freedom moment-resisting building frames through the use of walls hinged to foundations and (3) investigation of behavior of rocking steel braced building frames that incorporate vertical post-tensioning strands to provide additional restoring force and increase the total frame lateral force resistance. In practice, RCs can be implemented through the use of different systems such as steel trusses and reinforced concrete walls (prestressed if needed) as shown in Fig. 1.1 It should be noted that this paper focuses on demonstrating the effectiveness of the rehabilitation technology and identifying the key design parameters affecting the system performance.

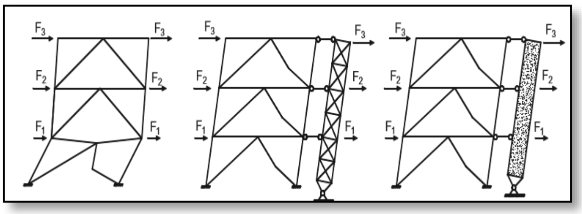

Fig. 1. Illustration of the RC seismic rehabilitation technology

II.OBJECTIVES

1. To compare the behaviour of building using Rocking truss
2. To find out the best suited section of beam by keeping depth constant
3. To carry out the analysis using Rocking wall instead of Rocking truss of same volume
4. To know whether the study is applicable to high rise buildings

III. METHODOLOGY

This chapter describes the methodology of the thesis work..The methodology includes study of SRC and ETABS software. The whole thesis work is divided into the following sequential steps.

A. Modelling

The models are created using ETABS 2016 software. Then obtain the different models should be analysed. Anlysis was performed.After analysis the results obtained are evaluated to study the behaviour of building with Rocking core. From the literature survey helps to catch the knowledge about the Rocking core.

B. Dimensional Details

A building and a building with SRC are modeled using ETABS software.The dimensional details of building are as follows,

Table I. Dimensional details

Property	Value
Floor height	3.1 m
Beam size	ISWB 500
Column size	ISMB 550
Brace size	ISMB 400

C. Material Properties

Material properties of the building and Stiff rocking core are as follows,

Table II. Material properties

Material Property	Value
Modulus of elasticity	2×10^5 MPa
Grade of steel	Fe 345
Grade of concrete	M 20

Fig. 2. Plan view of G+2 storey building

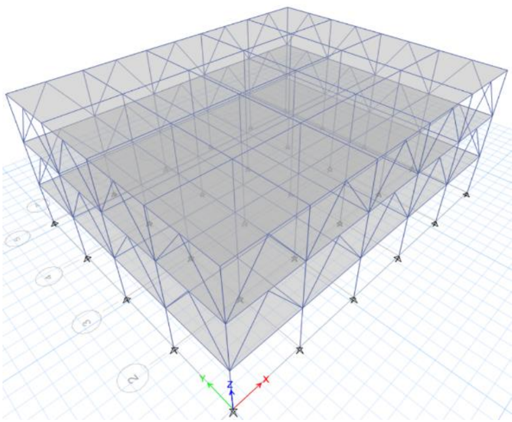

Fig. 3. Three dimensional view of G+2 storey building

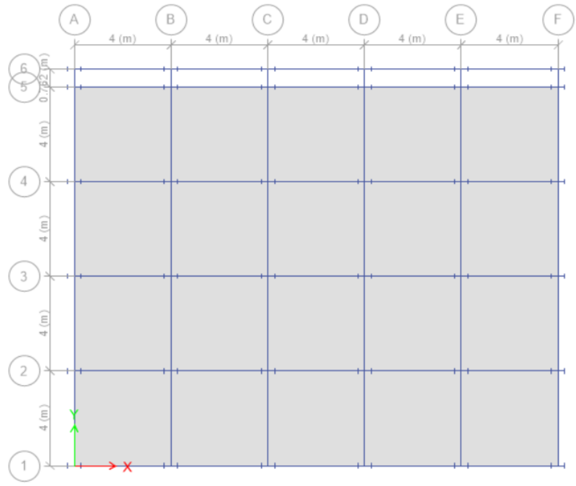

Fig. 4. Plan view of G+2 storey building with SRC truss type

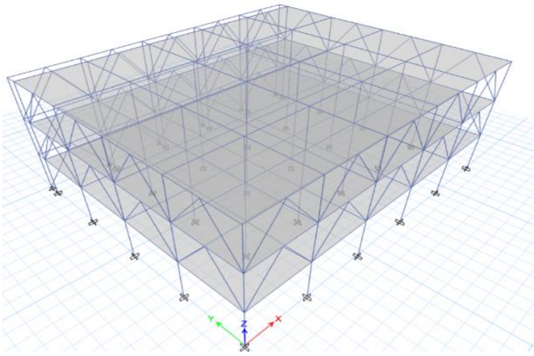

Fig.5. Three dimensional view of G+2 storey building with SRC truss type

D. Loading

After having modeled the structural components ,all possible load cases are considered.Gravity loads on the structure include the self weight of beam ,column,slab and other permanent members. The self weight of beam ,column(frame members) and slab(area section) were automatically considered the program its self. Live load of 1.5KN/m^2 (on top floor) and 3KN/m^2 (floor below top floor) is considered.

E. Analysis

Nonlinear static pushover analyses are conducted in this section to investigate the seismic performance of three storey and six storey building with Stiff rocking core. The result obtained during the initial pushover analysis of steel building are tabulated in the table below,

Table III. Maximum storey displacement(3 storey building) from nonlinear static pushover analysis

Storey number	Displacement in mm (Building without SRC)	Displacement in mm (Building with SRC)
Base	**0**	**0**
Storey 1	33.863	14.078
Storey 2	37.36	18.019
Storey 3	38.596	19.749

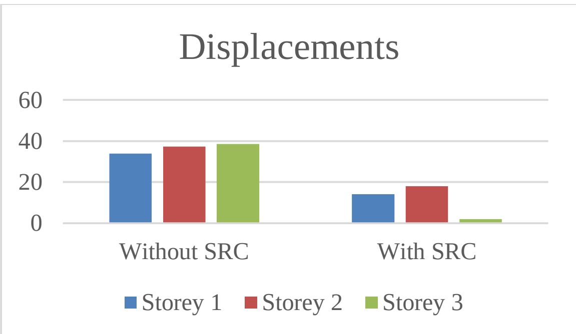

Fig. 6. Displacement of building

Inter-storey drift is the difference between the roof and floor displacement of any given storey as the building sways during earthquake.

IV. CONCLUSIONS

Building is analysed in ETABS 2016 software and the results where compared.This section represents the comparative study of building performance with and without Stiff rocking core.The maximum inter storey drift obtained building without Rocking core is 33.863mm at first storey and building with Rocking core is 14.078mm at first storey.From this study we can concluded that the building with Stiff rocking core effectively reduce the inter storey drift concentration and soft storey failure.

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