Jr. of Industrial Pollution Control 33(s2)(2017) pp 1251-1254
www.icontrolpollution.com
Review Article

ANALYTICAL INVESTIGATION OF LATERAL LOAD ANALYSIS OF A 2D RC FRAME BRACED WITH STEEL CABLES

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(Received 17 June, 2017; accepted 22 August, 2017)

Key words: Bracing, Steel cable, Bending moment, Shear force, Deflection

ABSTRACT

Reinforced concrete structures are predominantly constructed in India due to feasibility in construction thoughsteel braced frame is effective in lateral load resistance for multi-storeyed structures. Compared to other zones, structures in zone V is prone to higher effects of lateral load. These effects can be reduced to a greater extent by increasing the stiffness of the structure which can be achieved through introduction of bracings. In the past studies, shear wall has been adopted as the bracing technique to resist lateral load. The present paper focuses on the modelling and analysis of a (G+9) 2D frame Braced with Steel Cables in a Diagonally Meshed Pattern (BSCDMP) and compared with moment resistant frame using ANSYS Workbench V15.0.7. The parameters like total deflection of the BSCDMP were observed to be 68.47% lesser than the moment resisting frame. Hence bracing done with steel cables in a diagonally meshed pattern is found to be effective for resisting lateral loads in multi-storeyed structures.

INTRODUCTION

In developing countries like India, to fulfill the need of the land for housing and other commercial offices, vertical development that is multistory buildings are the only option (Sharma and Chadhar, 2015). In many cases RC buildings made in the 1960s and 1970s are built with poor materials, due to the scarce control during the construction phases. Concrete usually has a low strength, and it is affected by a very large variability, even within a single building (Stefano, *et al.*, 2014). In order to increase the seismic strength of framed structures, steel bracing or shear walls are often used. It is common to use steel bracing in steel-framed structures and shear walls in reinforced concrete structures (Maheri and Sahebi, 1997). It was found from the past earthquake experience that the RC shear walls in some tall buildings suffered severe damage (Wang, *et al.*, 2017). To eradicate such problems in RC structure, itcan be braced with Steel Cables in a Diagonally Meshed Pattern (SCDMP).

MODELLING AND ANALYSIS

The software used for the finite element analysis of RC structure with G+ 9 storeys is ANSYS Workbench V15.0.7and it was found in 1978. It is used for both modelling and analysis of the structure. The key feature of the software is to find total deflection, shear force and bending moment for dead load, live load and seismic load. The advantage of using this software is it efficiency in model generation, correlation between the test and analysis.

PAST RESEARCH

(Massumi and Absalan, 2013) have designed two frames based on old traditional codes, but one of them is strengthened with steel X-bracing. The authors report enhancement of seismic characteristics

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of compound system, especially on increasing of energy damping while analysing the structure using Ansys software. (Maheri and Yazdani, 2016) has set out a design basis for directly connecting bracing system to the RC frame and controlled it for accuracy and safety. (Yu, *et al.*, 2015) has confirmed through evolutionary structural optimization that the mega × brace or the double inversed V brace is the stiffest brace pattern, dependent on the aspect ratio of the braced panel and the size ratio of the columns to beams.

The availability of literature on analytical study of the behaviour of moment resisting frame and braced framed structures under seismic loads and comparison with combination of both moment and braced structures of different storey height is limited. The literatures on the use of SCDMP bracings are not available.

EXPERIMENTAL INVESTIGATION

Tensile test on steel cable

In The analysis of the SCDMP braced structure requires Young's modulus, load and elongation in ANSYS Workbench V15.0.7. The steel cables tested experimentally were 12 mm in diameter and 500 mm in length. The specimens were fixed in the Universal Testing Machine (UTM) of capacity 100 tonnes over a gauge length of 200 mm as shown in Fig. 1.

Fig. 2 shows the steel cable after failure. The steel cable failed by unwinding of the layers of the cable at 79.88 kN. The ultimate elongation and Young's modulus was found to be 29.030 mm and 2.25×10^5 N/mm^2.

ANALYTICAL INVESTIGATION

Modeling

The effective bracing system for the seismic zone is evaluated by ANSYS Workbench V15.0.7 to generate 2D model of G+9 with and G+9 without bracing system as shown in Fig. 3 and 4. The lateral load resisting capacity is analysed fordead load, live load

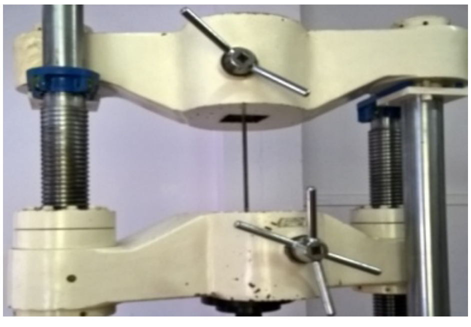

Fig. 1 Test set for testing steel cable.

Fig. 2 Steel cable after failure.

Fig. 3 Unbraced frame.

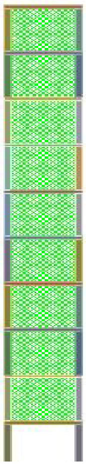

Fig. 4 Steel cable braced frame.

and wind load by using ANSYS Workbench V15.0.7. The single bay G+9 storey building of column and beam size is 500 mm × 500 mm and 400 mm × 500 mm with floor to floor height 4m has been modelled. The grade of concrete is M40 and steel grade is Fe 415.

LOADING PARAMETERS

The 2D RC frame is located in the seismic zone V where the soil condition is medium stiff and it is considered as a special moment resisting framed structure. The dead load of the structure is 3.75 kN/m² excluding self-weight and live load is 4 kN/m². The design of 2D RC framed structure for lateral load analysis is done as per (IS 875-part 3, 1987).

RESULTS AND DISCUSSION

The results for shear force, bending moment and total deflection are compared for the combination of dead load, live load and wind load for zone V analysis of braced and moment resisting framed structures. The table and graph for the above parameters are shown in the Tables 1 and 2 and Fig. 5-7.

From Tables 1 and 2 and Figures 5-7 it is evident that bracing a framed structure reduces its deflection upto 68.47% respectively which is in par with the results obtained by (Mohammed Nazrul, 2013) for analysis in STAAD Pro with different bracings such as X, V and diagonal for G+9 storey. The decrease in deflection and increases in shear force and bending moment is due to the increased stiffness provided by the SCDMP.

Table 1. Shear force

Type of Frame	Shear Force (in N)
Unbraced	0.192
Braced	4.26

Table 2. Total bending moment

Type of Frame	Bending Moment (in Nmm)
Unbraced	183.16
Braced	2958.7

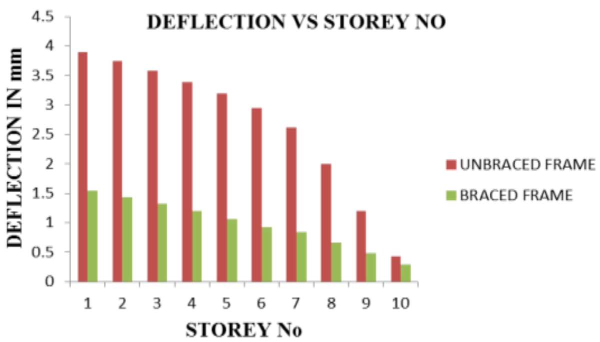

Fig. 5 Total deflection in mm.

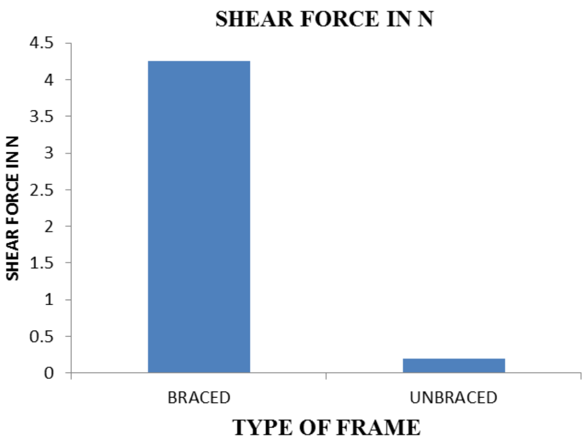

Fig. 6 Shear force in N.

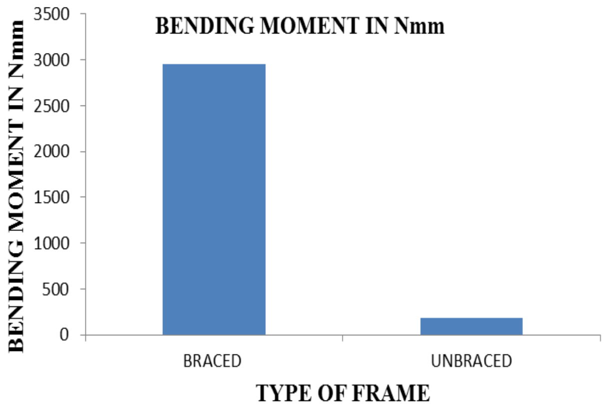

Fig. 7 Bending moment in Nmm.

CONCLUSION

1. The modelling and analysis was accomplished in ANSYS Workbench V.15.0.7.

2. The deflection of the structure was reduced upto 68.47% with the use of SCDMP

3. Adoption of SCDMP as bracings increase shear force and bending moment by 4.068 N and 2775.54 Nmm.

4. From the analysis, stiffness of braced 2D structure was found to be more when compared with moment resisting 2D frame.

5. Hence, the use of steel cables in a diagonally meshed pattern as bracings in RC framed structure is efficient in resisting the seismic loads to a great extent.

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