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Design of Steel Braced Frames Dampers

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ABSTRACT:

The study of braced steel frame response is widely studied in many branches of Structural engineering. Many researchers have been deeply studying these structures, over the years, mainly for their greater capacity of carrying external loads. Every Special moment resisting frames undergo lateral displacement because they are susceptible to large lateral loading. The problems associated with this are theP-Δ effect and the ductile and brittle failure at beamsand columns connections . As a consequence, engineers have increasingly turned to braced steel frames as a economical means for earthquake resistant loads. The present study consist of two models. Model 1 is a Steel Moment Resisting Frame (SMRFs) with concentric bracing as per IS 800-2007.

1. Introduction

In the present time, Steel structure plays an important role in the construction industry. Previous earthquakes in India show that not only non-engineered structures but engineered structures need to be designed in such a way that they perform well under seismic loading. Structural response can be increased in Steel moment resisting frames by introducing steel bracings in the structural system. Bracing can be applied as concentric bracing or ecentric bracing. There are 'n' number of possibilities to arrange steel bracings, such as cross bracing 'X', diagonal bracing 'D', and'V' type bracing.

The present study will clearly estimate the advantage of concentrically braced steel frames over Steel moment resisting frames. A simple computer based modeling in Staad Pro. Software is Performed for Equivalent static analysis, Response spectrum analysis, and linear Time history analysis subjected to earthquake loading.

In structural engineering, a braced frame is a structural system designed to resist wind and earthquake forces. Members in a braced frame are not allowed to sway laterally (which can be done using shear wall or a diagonal steel sections, similar to a truss).

Characteristics of buckling-restrained braces

Because BRBs achieve a high level of ductility and stable, repeatable hysteresis loops, BRBs can absorb significant amount of energy during cyclic loadings, such as an earthquake event.

Preventing buckling leads to similar strength and ductile behavior in compression and tension, illustrating the envelope of the hysteresis curves, also referred as a backbone curve. This curve is considered as an important basis of practical design. The beneficial cyclic behavior of the steel material can therefore be extrapolated to an element level and thus to the overall structural level; an extremely dissipative structure can be designed using BRBs.

Experimental results prove the ductile, stable and repeatable hysteretic behavior of structures built with BRBs. Depending on the configuration of braces, the building codes in the United States allow the use of a response modification factor up to 8, that is comparable to special moment resisting frames (SMRFs); a higher response modification is associated with greater ductility, and thus enhanced post-yielding performance. Thus, the seismic load applied to the structure is efficiently reduced, which results in smaller cross sections for the beams and columns of the braced frames, smaller demands on the connections and, most importantly, the loads on the foundation are drastically decreased.

Connections

The purpose of buckling-restrained braces is to dissipate lateral forces from columns and beams. Therefore, the connection of the braces to beams and columns can greatly affect the performance of the brace in the case of a seismic event. Typically, the brace is attached to a gusset plate, which in turn is welded to the beam and/or column that the brace will be attached to. Usually three types of connections are used for BRBs:

- Welded connection – the brace is fully welded to the gusset plate in the field. Although this option requires additional man-hours on-site, it can increase the performance of the brace itself by improving the force transfer mechanism, and potentially lead to smaller braces.
- Bolted connection – the brace is bolted to the gusset plate in the field.

- Pinned connection – the brace and gusset plate are both designed to accept a pin, which connects them to each other and allows for free rotation. This can be beneficial to the design engineer if he or she needs to specify a pinned-type connection.

In addition to the connection type, the details of the connection can also affect the transfer of forces into the brace, and thus its ultimate performance. Typically, the brace design firm will specify the proper connection details along with the brace dimensions.

Advantages

Comparative studies, as well as completed construction projects, confirm the advantages of buckling-restrained braced frame (BRBF) systems.[10] BRBF systems can be superior to other common dissipative structures with global respect to cost efficiency for the following reasons:

Buckling-restrained braces have energy dissipative behavior that is much improved from that of Special Concentrically Braced Frames (SCBFs). Also, because their behavior factor is higher than that of most other seismic systems (R=8), and the buildings are typically designed with an increased fundamental period, the seismic loads are typically lower. This in turn can lead to a reduction in member (column and beam) sizes, smaller and simpler connections, and smaller foundation demands. Also, BRBs are usually faster to erect than SCBFs, resulting in cost savings to the contractor. Additionally, BRBs can be used in seismic retrofitting. Finally, in the event of an earthquake, since the damage is concentrated over a relatively small area (the brace's yielding core), post-earthquake investigation and replacement is relatively easy.[11]

An independent study concluded that the use of BRBF systems, in lieu of other earthquake systems, produced a savings of up to $5 per square foot.[12]

Disadvantages

Buckling restrained braces rely on the ductility of the steel core to dissipate seismic energy. As the steel core yields, the material work-hardens and becomes stiffer. This work hardening can represent increases in the expected force of up to 2x the initial yield force. This increased stiffness decreases the building's period (negating some of the initial increases) and increases the expected spectral acceleration response requiring stronger foundations and connection strengths.

Buckling restrained braces rely on ductility and generally must be replaced after usage during a major earthquake.

Conventional earthquake design requirements for buildings have focused primarily on prevention of collapse to ensure life-safety, and they have not explicitly addressed damage control that is necessary to limit the risk of significant economic losses and building downtime after a major earthquake. As stated in the Uniform Building Code, “The purpose of the earthquake provisions herein is primarily to safeguard against major structural failures and loss of life, not to limit damage or maintain function” (ICBO, 1997). A code conforming building thus designed is likely to survive an earthquake without collapse, but it may suffer significant damage or even cease to be functional. illustrates a typical scenario of a deformed steel eccentrically braced frame (EBF) responding to an earthquake. The structure absorbs earthquake energy through plastic deformation in the steel links, which can result in a permanently deformed frame that is difficult to repair. Large story drifts cause architectural and structural damage, and may leave residual drifts in the building after the earthquake. Depending on the extent of damage, the building may not be suitable for continued occupancy without repairing, or may even need to be torn down and rebuilt if the repair costs are excessive. Whereas most engineers are cognizant of this, typical owners and the general public are not aware of the level of damage that is likely to occur.

1.7 Self centering system

Self-Centering Systems Application of PT strands in structures has been explored to take advantage of their high elastic deformation capacity to provide self-centering function for structures undergoing large inelastic deformations. Kurama et al. (2006) studied concrete walls coupled by post-tensioned steel beams . Under large nonlinear rotations, damage was concentrated in the top and seat angles connecting the beam to the walls, and residual deformations were negligible upon unloading due to the elastic restoring action of the PT tendons. A similar concept was applied in the post-tensioned steel beam-column connection design (Garlock et al., 2005, 2007) as shown in fig. The PT strands provide both moment resistance and self-centering function while the seat angles dissipate energy as gaps open and close between the beam and column surfaces. Lee et al. (2007) installed PT tendons down the center of a concrete bridge pier column to reduce residual drift as shown in Figure . Shaking table tests showed that under a design level ground motion, residual drift was reduced from 1% to 0.1% compared to a conventional reinforced concrete pier without the PT tendons. Past research efforts have demonstrated the effectiveness of PT strands as a source of elastic restoring force for structural systems, which inspired the current research to employ PT strands to introduce self-centering to a rocking structure. 1.2.3 Shear Plates with Openings as Structural F

Selected seismic design issues of the controlled rocking system are addressed in this research project to establish the basic guidelines concerning the most fundamental design decisions. The issues include (1) determination of required system strength, (2) required post-fuse-yield stiffness, (3) design of the PT and fuse components, (4) sizing of the braced frame members, and (5) detailing of key parts of the system. The topic of gravity framing is also explored to raise attention to some of the framing details and their design implications. There are various strategies for establishing the required strength and stiffness of the frame. For this initial design discussion, it is assumed that the required system strength, estimated drift, and required frame member force are established following the conventional building code approach (ASCE 7, 2005). Other approaches will be examined later through experimental and analytical examination of the behavior of rocking frames. Following the conventional design approach, design coefficients and factors are first selected based on referencing existing building frame systems that are considered equivalent in certain aspects to the rocking system. It is assumed that the rocking frame with energy dissipating fuses has ductility on the order of the eccentrically braced frame (EBF) system, and thus the response modification coefficient, R = 8, is adopted. Also in accordance to the category of EBF, the system over strength factor, 36 Ω0 = 2, is adopted as the basis to determine force demand in the braced frame members, and deflection amplification factor, Cd = 4, is used to calculate design story drift by elastic analysis. Note the adequacy of the conventional design approach using these assumed coefficients is examined later in this study. As will be discussed, the basic R-factor method is retained as the recommended approach for determining system strength, however, alternative approaches are developed for calculating the rocking frame drift and member force demands.

Proportioning Braced Frame Members and Rocking Base Support

The proportioning of braced frame members is first attempted according to force demand obtained from elastic

Description of the Controlled Rocking System

In concept, there are multiple ways to implement controlled rocking systems using alternative configurations and materials. Shown in are two alternative frame configurations: the single frame and dual frame systems. In both configurations, the system primarily comprises steel braced frames, post-tensioning (PT) strands or rods, and replaceable fuses that are sacrificial structural elements used to dissipate energy. Unlike conventional structures with fixed base connections, columns of the braced frames are untied from the foundation and allowed to uplift; horizontal sliding of the frames is prevented by confinement of the column bases in the foundation. Under severe earthquake loading, the columns lift off and the braced frames can rock upon the base, stretching the PT strands and activating the fuses to provide overturning resistance. During the rocking, the frames and PT strands are designed to remain elastic, while energy is dissipated through plastic deformation in the replaceable fuses. At the end of the shaking, the system can self-center through elastic restoring action provided by the PT strands. When properly designed, the damage control and self-centering capabilities of the system will ensure that the building is structurally safe for continued occupancy after a large earthquake. Damage and repairs to the structure are limited to the replaceable fuses and localized regions of the floor slab around the rocking frame. Damage that may occur to floor slab and architectural components should not affect the structural integrity of the building, such that the necessary repairs can commence without delays following the earthquake. 3 The fuses can be any structural elements with energy absorption capability. Shown in these examples are shear plate fuses which are engaged through shear deformation between the vertical edges. Shear plates are employed as fuses for their compatibility with both the single and dual frame configurations, and their simplicity in design and installation. In the single frame configuration of Figure 1.2a, the shear fuses are located in the center of the frame, coincident with the PT. In the dual frame configuration, the shear fuses are located between the two frames. The single frame has the advantage of simplicity and compactness (less floor space), since fewer components are required. The dual frame has the capability to distribute fuses along the height of the building, and therefore is potentially more suitable for tall buildings requiring more fuses. 1.1.2 Alternative Configurations of the Single Rocking Frame Alternative single frame configurations can be conceived as shown in fig. These options primarily differ in the locations of PT strands and shear fuses. Option 1 (left) splits the fuse into two smaller fuses and connects them to the columns. Option 2 (center) reverses the locations of fuses and PT strands, and option 3 (right) has both the fuses and PT located along the columns. When PT strands are along column lines, only strands at one location are stretched at any one time depending on which side of the frame lifts off, whereas when they are in the center, all strands are stretched regardless of the rocking direction. For the same uplift ratio, strands located along columns experience twice as much elongation as those located in the center, which results in higher deformation and force demands in each strand. The same can be said about the location of the fuses. In addition, location of the PT and fuses also lead to different space occupation, which has implications for architectural considerations. These alternatives show the flexibility in the implementation of the controlled rocking scheme.

Examples of Existing and Potential Application

Controlled rocking frames have been implemented for earthquake resistance in a twostory building located in California. The rocking system employs single rocking frames with structural steel angles as energy dissipating elements installed at the base of rocking columns. The configuration is similar to a side-PT and side-fuse scheme, except that the PT strands run continuously through the foundation and are anchored at the roof, which extends length of the strands and reduces deformation demand. Another application was proposed for the seismic retrofit of an existing building as shown in fig. This arrangement features a center-PT and side-fuse configuration, with shear plate fuses distributed along the first story columns. This example is intended to illustrate the potential versatility of the rocking-frame system for alternative building configurations and applications.

1.8 OBJECTIVES

Following are the main objective of the present study:

a) To investigate the seismic performance of a multi-story steel frame building

- When un braced and then with different bracing arrangement such as cross bracing ‘X’ and diagonal bracing using Equivalent Static analysis, Response Spectrum analysis and linear Time History analysis.
- Under different earthquake loading and loading combinations.

b) To investigate the seismic response of a multi story steel frame building

- Under same bracing configuration but with varying number of story i.e.with varying height of the building.

c) A thorough literature review to understand the seismic evaluation of building structures and application of Equivalent Static analysis, Response Spectrum analysis, and linear Time History analysis.

d) Seismic behavior of steel frames with various concentric bracings and eccentric bracing geometrical and structural details.

e) Modeling the steel frame with various concentric bracing by computer software Stand pro.

f) Carry out Equivalent Static analysis, Response Spectrum analysis and linear Time History analysis on the models and arrive at conclusion.

SCOPE OF THE PRESENT STUDY

In the present study, modeling of the steel frame under the three analysis mentioned above using Staad Pro software is done and the results so obtained are compared. Conclusions are drawn based on the tables and graphs obtained .

Results and Discussion

SEISMIC RESPONSE OF STEEL FRAME UNDER DIFFERENT BRACING CONFIGURATION AND LOADING

5.1 MODEL 1

LATERAL LOAD PROFILE

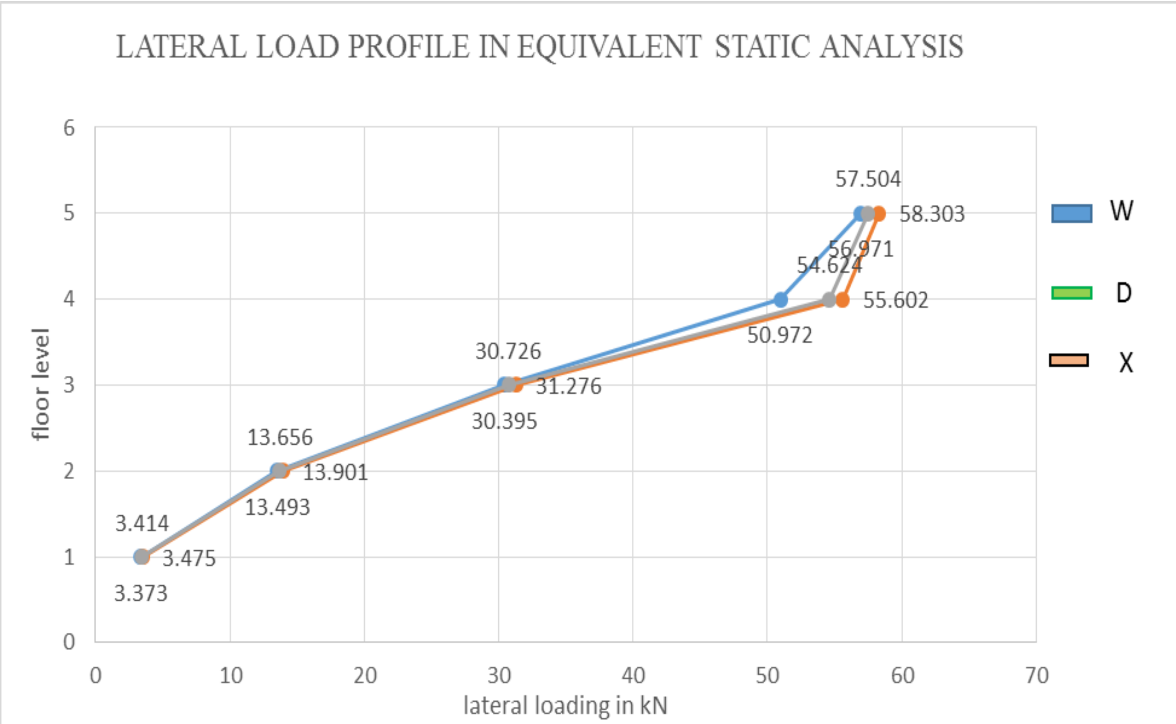

FIG 5.1 Lateral load profile in equivalent static analysis

Cross bracing have the highest lateral stiffness as compared to diagonal bracing, and obviously to frame without bracing. A increase in stiffness attracts larger inertia force and this is evident from the graph.

Table.5.1 BASE SHEAR COMPARISION OF MODAL ANALYSIS (RESPONSE SPECTRUM ANALYSIS) WITH IS CODE 1893:2002 CALCULATED DESIGN BASE SHEAR

	EQUIVALENTSTATIC ANALYSIS (kN)	RESPONSE SPECTRUM ANALYSIS (kN), Modal participation factor considered till 6th mode, SRSS method
WITHOUT BRACING	18.12	22.84
WITH DIAGONAL BRACING	22.24	23.99
WITH CROSS BRACING	24.64	24.27

From table 5.1, it is evident that the design bases hear provided by the code is less as compared to by modal analysis. A 26% increase in design base shear is observed in moment resisting frame without bracings. It can also be concluded that by increasing the lateral stiffness of the steel frame, base shear of the frame will obviously increase.

Table .5.2 PEAK STORY SHEAR FOR RESPONSE SPECTRUM ANALYSIS

FLOORS	WITHOUT BRACING	WITH DIAGONAL BRACING	WITH CROSS BRACING
5	5.97	6.06	6.41
4	12.75	13.25	13.89
3	17.97	18.79	19.40
2	21.43	22.41	22.82
1	22.84	23.99	24.27
BASE	22.84	23.99	24.27

STORY DRIFT OF THE MODEL

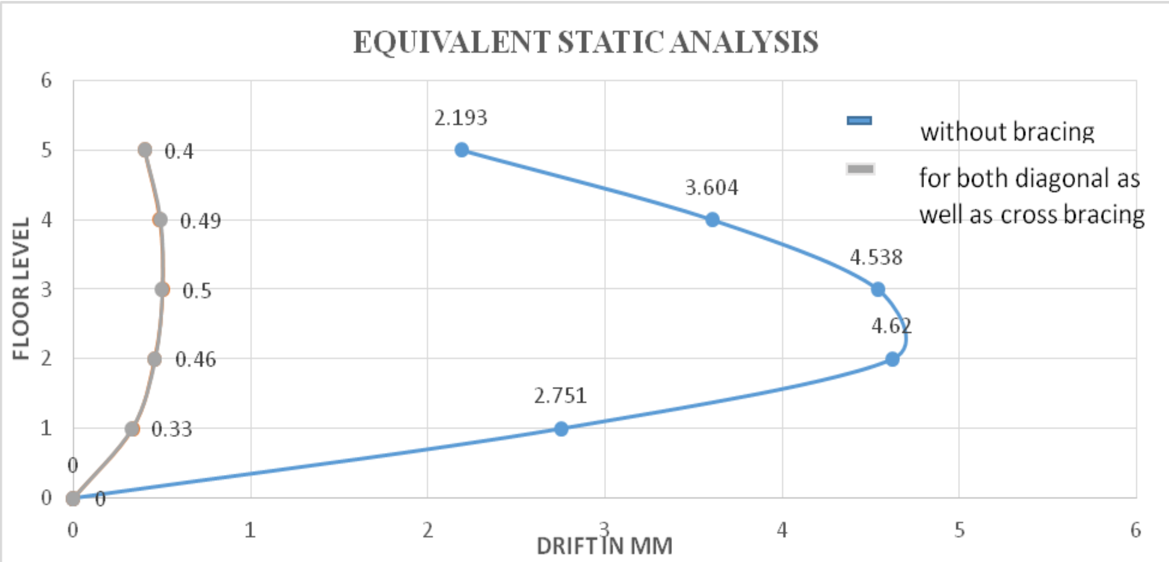

FIG 5.2 STORY DRIFT OF THE MODEL

CONCLUSION

- Braced steel frame have more base shear than un braced frames.
- Cross bracing under go more base shear than diagonal bracing.
- Bracings reduce the lateral displacement of floors.
- Cross bracing under go lesser lateral displacement than diagonal bracing.
- Cross braced stories will have more peak story shear than un braced and diagonal braced frames.
- Axial forces in columns increases from unbraced to braced system.
- Shear forces in columns decrease from unbraced to braced system. Diagonal braced columns undergo more shear force than cross braced.
- Bending moment in column decreases from unbraced to braced system. Diagonal braced column undergo more bending moment than cross braced frame.

REFERENCES

- Tremblay, R.; et al., Performance of steel structures during the 1994 Northridge earthquake, Canadian Journal of Civil Engineering,22,2,Apr.1995,pages338-360.
- Khatib,I.andMahin,S.,Dynamic in elastic behavior of chevron braced steel frames, Fifth Canadian Conference on Earthquake Engineering, Balkema, Rotterdam, 1987, pages 211-220.
- AISC(American Institute of Steel Construction),Seismic Provisions for Structural Steel Buildings, Chicago, 1997.
- AISC(American institute of Steel Construction).(1999),load and resistance factor design specification for structural steel buildings, chicago.

- A.MeherPrasad:"Response Spectrum",Department of Civil Engineering, IIT Madras.
- DavidT.Finley,RickyA.Cribbs:"Equivalent Static vs Response Spectrum–A comparision of two methods"