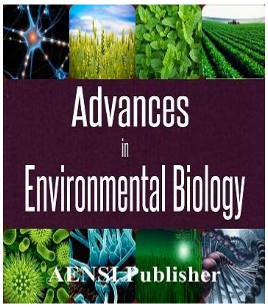
AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/AEB/



Presenting the Proposed System of Eccentrically Braced Frames with Oblique Shear Link

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ARTICLE INFO

Article history:
Received 12 October 2014
Received in revised form 26 December 2014
Accepted 1 January 2015
Available online 18 February 2015

Keywords:
Eccentrically braced frame, oblique link, cyclic loadings, nonlinear finite element analysis.

ABSTRACT

In this paper, a proposed system to be used as eccentrically braced frame (As a control tool used to disable the seismic design of building frames) has been provide. In eccentrically braced systems, link beam that is strengthened with stiffeners between the beam connections and braces to increase hardness as well as plastic deformation capacity is involved with structure roof system that is generally considered to be rigid because of the relatively high hardness. While this main effect is ignored in modelling and analysis and in practice, the expected ideal hysteresis behavior will be challenged under cyclic loads. In the proposed system, the horizontal link which is part of braced opening beam was transferred to the opening due to the reason cited and its performance for reciprocating loads using nonlinear finite element method was evaluated by ABAQUS11.0 software and compare with common samples of convergent and divergent braces with the same dimensions. It is shown that the proposed system, while having good strength and hardness, has plastic deformation capacity and therefore high energy absorption capacity.

To Cite This Article: HosseinOmidi., Presenting the Proposed System of Eccentrically Braced Frames with Oblique Shear Link. ***Adv. Environ. Biol., 9(2),*** *404-408, 2015*

INTRODUCTION

Today, the biggest challenge for engineers is perhaps controlling the lateral displacement of structures. Selecting the right side bearing system in different situations is the main tasks of designers. Many side bearing systems are presented, including a moment frame system that even if well designed, it has good plasticity and is desirable by architecture due to the relationship between spaces, but it has little stiffness. In contrast, convergent brace system that has high hardness and ductility, while not having good plasticity, it is less popular in terms of architecture (due to the disconnection between spaces). Many common behavioral defects of convergent braces is the difference between compressive and tensile capacity of the braces and their deterioration of resistance, especially under cyclical loads [1].

Among proposed lateral loading system, eccentrically braced frame, though has little stiffness compared to the types of convergent braces, it has high strength, especially high energy absorption capability and tolerates stability hysteresis cycle under reciprocating loadings that achieving to this important issue is not possible regarding convergent braces due to buckling under the pressure.

Eccentrically braced system was presented in 1978 by Popov *et al* [3]. Although divergent braces have not the defects of convergent defects, but what challenge the function of this type of lateral load system, it is the involvement of linking beam with floor aperture that which prevents expected plastic deformations in this area. To solve this problem, researchers have presented different systems in recent years, including the system under study in which braced beam are paralleled into two beams that one of them is involved with roof bars and can withstand vertical loads and the other beam merely acts on the lateral loadings and is attached to the braces [2]. Also divergent braces were considered with vertical linking members, including the proposed system by Aristizabal – Ochoa can be mentioned where the input energy is depreciated by an interchangeable interface named knee member [4]. Zahraie and Mahrouzadeh investigates the effects of using shear panel systems in increasing ductility and depreciation of the energy applied to the structure as laboratory which the tested samples showed good ductility [5]. Although the use of ductile steel to reach ductile instruments is essential, but

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structure ductility is different from steel ductility (which has a unique ductility among materials). Structure ductility resulting from the ductility of its members is such that the ductile member can experience deformations beyond elasticity limit without reducing resistance and to achieve this issue, it is also necessary that the general and local instabilities are prevented [2]. In terms of the degree of bracing, the research done by Block and colleagues can be mentioned that after the experiments, they suggested section forms below in order of better performance to be used as an inhibitory member:

1. Tube section
2. Can section
3. I-shaped section
4. T-shaped section
5. Angle pair degree [6].

In divergent conventional braces, I-shaped sections are used for building linking beam piece that requires lateral bracing to prevent lateral torsional buckling (that's why in the bridge piers and towers, this system is not used against lateral loads). But in the case of using thin rectangular sections, there is no need for lateral bracing [7].

The introduction of the proposed system:

In this study, the proposed system is evaluated for use as a brace divergent that can be seen in Figure 1. In this system, the linking part is passed into the mouth from the mouth beam (that is the main member the structure and because its replacement is difficult due to its connection to floors diaphragm).

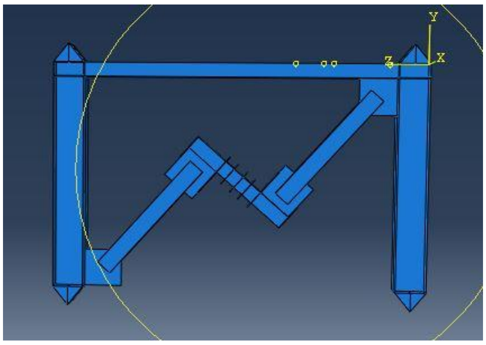

Fig. 1: sample frame for the review of the proposed system.

In the proposed system, columns, beams and braced members is remained elastically and the energy is absorbed by plastic deformations of connection link and due to the short length of bracing members, buckling modes of behavior were not dominant on the system no matter what the lateral load is applied to the frame, the same behavior (oblique connection link shear) from the structure can be seen. The length of the part of oblique link should be the way that it has shear behavior and is equivalent to equation 1 [8].

$$e = 1.6\frac{M_p}{V_p}$$

In the above equation, M_p and V_p are the anchor and plastic shear of connection part section and e is its length. To verify the results achieved, the analysis and comparison between the proposed system with common convergent and divergent bracing systems, a laboratory model that its results are available are selected and the section of the same model, that in Figures 2 and 3, the model details and an overview of the experiment related in the time of breaking the connection link can be seen, is used. In this frame, the supports are in the form of joints and the load has been applied in a controlled way by displacement to the top of the frame. Due to using can-shaped section for the beam, stiffeners are embedded outside bar to prevent local buckling. This test is conducted by Berman and Bärnau [7]. Released mouth length in this experiment is 334 cm and released height of pillars is 246 cm. The pillar section is I-shaped which the width and thickness of its wing are 31 and 2.3 cm, respectively and the depth and thickness are considered 32.3 and 1.4 cm, respectively [7].

Elements:

After considering the various elements, Bremen and Bärnau used S4R elements in numerical analysis using Abaqus 9 software that had no significant effect on the results while reducing the time of analysis. Therefore, Shell element was used in the current study that is a four-node element with three degrees of freedom and three rotational degrees of freedom at each node. This element has the capability of large deformations, strain hardening and plasticity [7].

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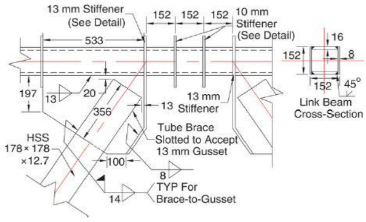

Fig. 2: Details of the test model by Berman and Bärnau [7].

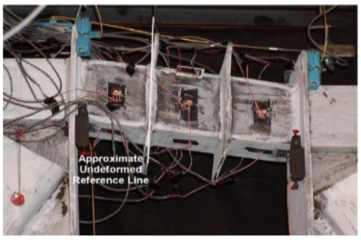

Fig. 3: the rupture of connection link and in the experiment model by Berman and Bärnau [7].

Materials:

The two types of steel have been used as the materials used in the tests for a) link beam flange and the other members and b) the center of linking bar. The stress-strain curves of the two steels can be seen in the forms 4-A and 4-B below.

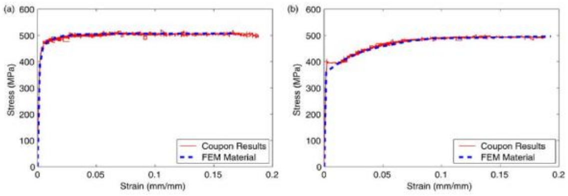

Fig. 4: The stress-strain curve of the steel in the model test by Berman and Bärnau, a) link beam flange and the other members and b) the center of linking bar [7].

Loading And Hardening Model:

Monotonic loading alone does not indicate good performance of a subsidiary system. About converging braces (with a high aspect ratio), loss of compressive strength under cyclic lateral load between the first and second cycle was very intense and the subsequent cycles, the degree of resistance reduction will be decreased. However, in the first cycle (equivalent to monotonic loading), approximately the same tensile strength and compressive strength is observed. Therefore, in the analyzes conducted in this study, cyclic loading in terms of the criteria of AISC2005 regulations, Appendix S, to evaluate the behavior of the system (resistance or hardness as well as the capability of energy dissipation), appendix S, to evaluate the behavior of the system (reduced strength and stiffness as well as the potential loss of energy) will be applied which its changing curve based on drift percentage is as Figure 5. Results of model analysis mentioned has an acceptable fitness with the experiment. Since in this experiment, the degree of connection link rotation is studied, and this study aims to investigate and compare the stiffness, strength and ductility of the proposed system is convergent and divergent braced systems, thus its results will not be expressed and it is noted that this test used to confirm the modeling process which the analysis results confirm this issue.

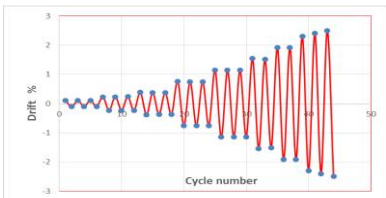

Fig. 5: cyclic loading in terms of the criteria of AISC2005 regulations (8).

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To analyze these kind of issues, Kinematic hardening model should be used which has a section called nonlinear isotropic hardening / kinematics, and the most complete and accurate model for the analysis of cyclic issues. In the isotropic hardening model, the current level of disruption remained stable, and just its shape will be expanded with increasing plastic strain. In contrast, in kinematic hardening, it is assumed that the flowing level remains constant with progressive flowing, but its location in the tension space will be changed. The two hypotheses can be seen in Figure 6. In the present study, since the parameters of the steel used in the experiments are not available, isotropic hardening property is used for analysis under cyclic loading [9].

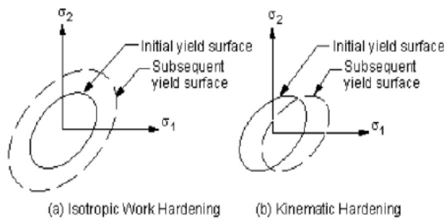

Fig. 6: hardening models, a) kinematic model b) isotropic model.

The Results Of The Samples Analysis:
Divergent bracing system:
The mentioned frame with divergent braces is located under cyclic loading (Fig. 5) and deformation model and the horizontal displacement hysteresis curve of the frame in Fig. 7-A and 7-B base section is shown.

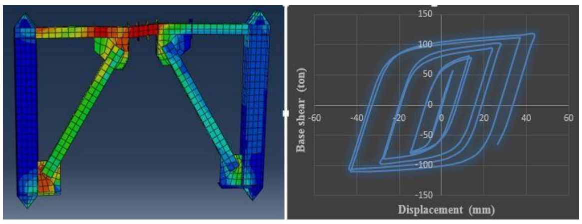

Fig. 7: results of frame analysis with divergent bracing, A) displacement hysteresis curve of the frame in front of the base shear) deformation model of the frame

Convergent bracing system:
The mentioned frame with a single diagonal bracing, under cyclic loading (Fig. 5) were placed under cyclic loading (Fig. 5) and deformation model and the horizontal hysteresis displacement curves above the frame against the base shear are shown in Fig. 8-A and 8-B.

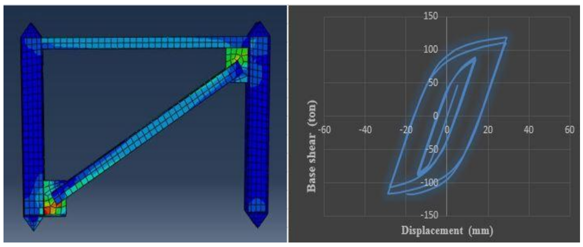

Fig. 8: The results of the frame analysis with single-diagonal bracing, a) displacement hysteresis curve above the frame in front of the base shear) deformation model for the frame.

Suggested bracing system:
The mentioned frame with suggested bracing was placed under cyclic loading (Fig. 5) and deformation model and the horizontal displacement hysteresis curves above the frame against the base shear is shown in Fig. 9-A and 9-B.

Comparing the analysis results:
Although convergent bracing frame has high stiffness, it has not shown an appropriate ductility and has less absorption capacity. Although the frame with divergent bracing has an acceptable stiffness, because of the

sample size and analysis), it has shown a very acceptable plasticity. But it should be noted that in the experiment and modeling, the effect of involvement of connection beam with the floor's ceiling and an absolutely perfect behavior indicates high energy absorption capability. Despite an 8.7% reduction in strength than the previous two models, the braced frame with the suggested system has shown stiffness and ductility and as a result shows high energy absorption capability (especially compared to converge bracing).

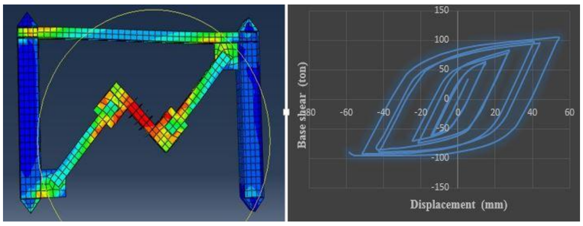

Fig. 9: results of frame analysis with the proposed bracing, a) displacement hysteresis curve of the frame in front of the base shear, B) deformation model of the frame.

Conclusion:

The analysis results show that the proposed system has good strength and stiffness, and show stability hysteresis loops against cyclic loads. Due to the geometry of the frame, because oblique connection link acts in a shear way, its energy absorption capacity will be more (given that in the shear, a greater area of the member is inserted into the plastic zone than when the link has flexural performance. In this case, the original members (beams and roofs) will not be damaged and the connection link is easily replaceable. Not only in the design of new structures, but in the seismic upgrading of existing structures can this proposed system be used. In order to optimize the proposed system, the angle of locating bracing members and oblique shear link can be examined as a variable depending on the dimensions of bracing opening. Nevertheless, according to the author, using the proposed idea in practice requires doing full-scale experiments.

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