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Study of Zipper Braced Frame-Literature Review

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Abstract: In this paper we are study about the various pattern of ZBF with the numerous inventions occur around the world. This study shows that, the behaviour of zipper braced frame with Cheveron pattern and it sustain heavy load introduced in various research paper and it helps to give the knowledge for further study. In this research we are notify that, the multistory structure are not to be used for analysis. In this review we are noticed that as the structure goes on increase the structural behavior is going to be reduced and the effect of ZBF is increase with the multiple excitation of the ground.
***Keywords*: ZBF, Research Paper, Cheveron Pattern**

I. INTRODUCTION

All the structure having the various components such as beam, columns, slab to resist lateral, gravity, wind, earthquake load. To resist the loads of the structures should be strong enough to sustain this load, so proper bracing should provide so that structure must effective. The Rigid frame structure and the Braced frame structure are the two type of structure which is generally used in the building. Rigid means that the structure will able to resist the forces applied on joints and the moment produced in the joints so that the structure will remain stable under various loading. The rigid frame structure has not an ability to resist the seismic loading in X and Z direction so that we are introduce another parameter i.e. Braced frame structure. In that frame structure there are various types we are using.

Bracing is one of the damper which is used in between column and beam in the frame structure. Tremendous braced frames are available in construction world like Chevron braced frame, inverted braced frames, zipper braced frames etc. And most of our buildings were constructed as earthquake resistance, but when we talk about earthquake resistance structures then our mind totally diverted towards fully steel structures. The structural system consists of moment frames with specific bays provided with braces throughout the height of the building. Braces are provided in both plan directions such that no twisting is induced in the building owing to unsymmetrical stiffness in plan. The earthquake force is transferred as axial tensile and compressive force in the brace members.

II. PAST STUDIES ON THE DESIGN OF CONCENTRICALLY BRACED FRAMES WITH ZIPPER COLUMNS

A. Generalities

As one of the widely used seismic load resisting systems in Canada, chevron braced frame is able to provide high stiffness and moderate ductility by allowing the braces to buckle and/or yield in order to dissipate the input energy during ground motion excitations, while all other structural members such as: beams, columns, and connections behave in elastic range. However, under severe ground motion excitations, it is very likely to have storey mechanisms occurred, especially when the beams in concentrically braced frame is not designed to overcome the unbalanced forces generated by buckled braces.

When lateral forces applied, braces elements initially provide both tensile and compressive resistance to balance the lateral effect. Generally, for brace members, the tensile capacity is greater than the compression capacity. When reaching its compressive capacity, the brace member buckles, and a plastic hinge is developed at its mid-length. As a result, a large displacement occurred. At this stage, since the brace section is fully plastic, its axial capacity reduces to accommodate a larger moment developed at the plastic hinge location. Meanwhile, due to the loss in compression capacity of brace, the lateral force is transferred to the tensile brace, while a large unbalanced force is developed at the brace to beam intersection point. Nevertheless, beams sections in CBFs should be designed to accommodate plastic hinge formation at their mid-span. Most likely, the beam will buckle and the weak storey mechanism is formed as illustrated in Figure 2.1. In this stage, the failure of one floor causes the failure of the entire system. As is shown in the graph of Figure 2.1, where the base shear, V, versus inter storey drift is depicted, the capacity of the system to withstand shear force diminishes while the lateral deformation is substantially increased.

In order to avoid the problems of beam failure, different studies have been carried out by researchers such as Khatib and Mahim (1988), Sabelli (2001), Tremblay and Robert (2001), and others. To avoid this type of failure, it was proposed to use strong beams, designed to carry the unbalanced force generated after buckling of brace occurred. However, according to this strategy, the braced frame system is still likely to form weak storey mechanism.

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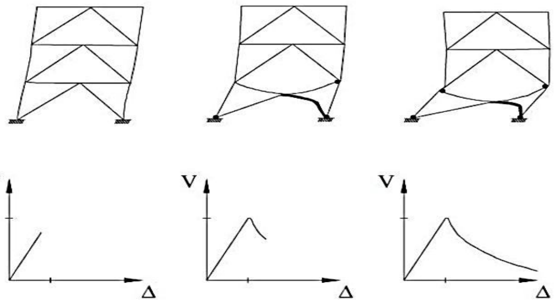

Figure 2.1Chevron braced frame behaviour (Bruneau, et al., 2005)

To overcome the above design difficulty, (Khatibet al, 1988) proposed to link all beam-to-brace intersection points of adjacent floors and to transfer the unbalanced load to the vertical member called "zipper column". In this way, the zipper members can behave either in tension or in compression and should be able to withstand the "zipper mechanism" formation, which implies buckling of braces successively. This unbalanced force transferred to the "zipper column" pushes the zipper in tension if the first buckled brace is located at first floor and buckling of braces progress upward or pushes the zipper in compression, if the brace of the roof floor buckles and buckling is propagated downward. Therefore, after brace buckled and the unbalance force is transferred to the zipper column, this member is able to re-distribute the transferred force to the braces located on the verge of buckling either at the floors above or below depending on the direction of brace buckling propagation. In this regard, the damage concentrated at one floor is spread along the structure height, involving more braces to sustain the remaining lateral loads after redistribution.

Thus, the zipper configuration is expected to improve the seismic performance of CBF systems and to overcome the problem of unbalance forces developed in chevron braced frames. This proposed system is able to maintain a more uniform damage distribution over the structure height and to develop a stable hysteresis behavior. In addition, besides offering a relatively good performance level in terms of storey drift and energy dissipation under earthquake excitations, the requirement of stiff beams should be avoided.

In the Commentary of AISC Seismic Provisions for Structural Steel Building (AISC 2002), the zipper steel frame system is recommended as a configuration which is able to improve the post-elastic seismic performance of chevron braced system. In Figure 2.2, the expected behavior and performance of zipper frame when the first brace buckles at ground floor level and zipper is loaded in tension is shown.

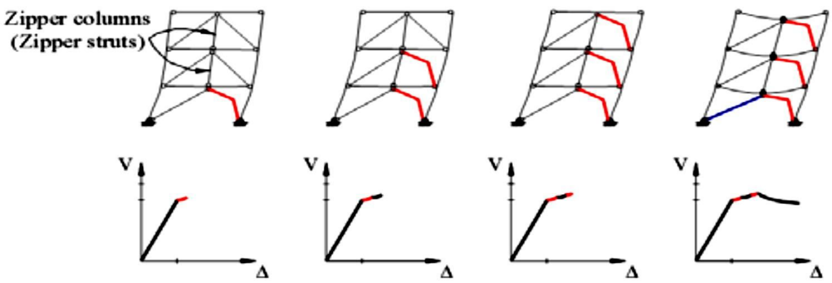

Figure 2.2 Expected behaviors and performance of zipper frame (Nouri, Imani Kalesar, & Ameli, 2009)

B. Tension Zipper strut Approach

According to Khatib and Mahin (1988), the zipper effect is triggered when the structure is deflected in the shape of the first vibration mode. The brace member at the ground floor buckles firstly and triggers tensile forces in the above zipper column, which causes the upper floor brace to buckle. The same process is gradually propagated upwards. Never-theless, based on this design approach, zipper columns are proportioned to carry only tensile forces, which means that always the first buckled brace is at the ground floor. In addition, in order to have the zipper braced frame system deflected in the first mode, it requires braces on one half-span of the braced frame to buckle, then, after ground motion reversed sign, the remaining half-span braces will buckle. In this case, the tensile forces in zipper columns can be calculated as the summation of all vertical components of the un-balanced loads resulted from internal forces developed in braces.

Moreover, corresponding to the limitations of tension zipper strut, Khatib and Mahin(1988) pointed out several questions regarding the system design and behavior:

1) "What happen if the buckling of braces initiates from other stories instead of the first storey?"
2) "Could the zipper elements be activated in compression instead of tension?"
3) "What if the structure is not in a first mode deflected shape when the zipper effect is activated?"
4) "How to proportion the braces to maximize the effectiveness of zipper effect?"
5) "How to choose the relative stiffness of the zipper elements and beams?

To date, several researchers proposed versions of ZBF systems by trying to fit the response of the above questions in the proposed design guidelines: Sabelli (2001), Trem-blay and Tirca (2003), Yang and Leon (2003).

C. Weak Zipper Strut Approach

To prevent the formation of weak storey mechanism and pursuit a uniform drift distribution along the building height, a design method called "weak zipper strut approach" is proposed by R. Sabelli (2001). According to his proposal, the design of brace members should follow the same code requirements as provided for CBF's braces. He recommended that the compressive and tensile capacity of zipper columns must reach the strength of braces located at the level below. Moreover, the inelastic demand in both cases when zipper columns act in tension and compression should be considered in design.

After applying the weak zipper strut approach in a 3- and a 6-storey zipper braced frames, R. Sabelli (2001) concluded that by having zipper column installed, the inter storey drift demand is more uniformly distributed than that in a chevron braced frames with strong beams. Between the two studied frames, the 3-storey zipper frame shows better seismic performance that the 6-storey frame, and match the expected behavior of zipper braced frame. Brace members have buckled at all floor levels and drifts are nearly equal developed at each floor. On the other hand, for the 6-storey frame, several discrepancies have been observed. Instead of deflecting on the first mode, the deformed shape of the6-storey frame approximated the shape of the second mode of vibration. In addition, there are significant buckling and tension yielding observed in zipper columns of the 6-storey frame, which was judged inconsistent with the expected performance of zipper braced frame.

D. Strong Zipper strut approach

To limit the inelastic behavior within braces, Tremblay and Tirca (2003) proposed another design method with the aim of maintaining the zipper columns to behave elastically under severe ground motions. Based on the proposed method, a 4-, 8- and 12-storey zipper braced frames have been designed and studied. The results regarding the inelastic behavior of aforementioned braced frames have shown that the zipper mechanism can be developed either in tension or in compression, and these two critical scenarios can be treated separately. For the scenario of zipper acting in tension, the brace buckling initiates at the bottom storey and propagates upward in the frame. Therefore, zipper columns are subjected to tensile forces due to unbalanced vertical forces resulted from the subsequent buckling of braces as shown in Figure 2.4 a). On the other hand, for the scenario of zipper acting in compression, the first brace buckled at the top floor, and then propagates downward. In this case, the unbalance vertical forcand eventually transferred to zipper columns as compression forces (Figure 2.4 b).

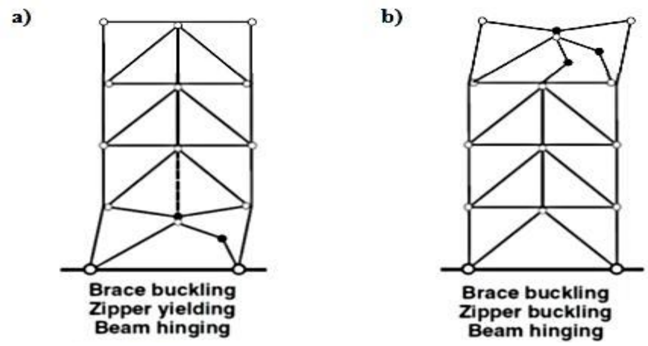

Figure 2.4 Behaviour of zipper braced frame system with strong zipper columns (Tirca & Tremblay, 2004) brace buckling initiated a) at the base; b) at the roof.

Under these scenarios, zipper columns are designed to carry the unbalance load generated due to the buckling of brace members. Therefore, two scenarios have been proposed: zipper in tension when brace buckles initiated at the ground floor and zipper in compression when braces buckles initiated at the top floor of the structure. In both cases,
the zipper struts are designed to carry either the maximum tensile force or compressive force which is expected to be transferred and is depended on the buckling/post-buckling and tensile capacity of braces. In Figure 2.5, the two buckling scenarios are shown under the sequential triangular load pattern distribution.

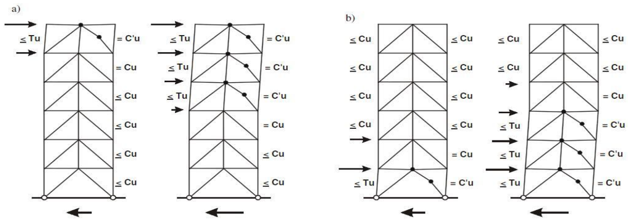

Figure 2.5 Transfer mechanisms and lateral load distributions adopted to design the zippers when brace buckling initiating at the: a) upper floors; b) lower floors (Tirca & Tremblay, 2004)

Under the circumstance of zipper columns behaving in elastic stage (strong zipper), the design method proposed by Tremblay and Tirca (2003) is able to estimate the maxi-mum tensile and compressive force envelop developed in zipper columns under various ground motion excitations.
Furthermore, several assumptions have been made in this research to make the detail calculations of the maximum compressive forces in zipper columns feasible. Some of them follow Khatib and Mahin’s es are transmitted from braces to the mid-span of the beams, assumptions when the idea of zipper frame was arisen. The applied assumptions are listed below:

1) The applied lateral load is assumed to vary linearly from a maximum value reached at the roof level to zero at the level below the studied level (triangular shape);
2) Plastic hinges are assumed to form at the mid-length of the be ams where the buckled braces are connected;
3) Braces are assumed to maintain their probable compressive strength, Cu on the verge of buckling, and their strength will drop to the post-buckling capacity, Cu’ right after the buckling occurs;
4) It is also assumed that the compressive force transmitted downward through the zipper column of the studied level is carried completely by the compressive braces at the level below. Therefore, when the zipper column of the studied level reaches its maximum compressive force, the compression brace at the floor below will be upon buckling, i.e. the compressive force in the brace reaches its probable compressive capacity, Cu, as shown in Figure 2.5 a). Meanwhile, to calculate the maximum tensile forces in the zipper columns, Tz, the following assumptions are made:
5) The lateral load is assumed to vary linearly from a maximum value at the first floor (when the tensile force developed in the brace of the first floor is smaller or equal to the probable yielding force, Tu, the corresponding force in the compressive brace reaches the probable post buckling load Cu’ and all braces belonging to the tier under study reach a force □ Cu) to zero at the floor located above the study level.
6) Plastic hinges form at the mid-span length of the beams located above the buckled braces;

The zipper column of each storey is designed to carry the cumulated difference of the tensile force developed in the brace versus the probable post-buckling force Cu’ on the subjected storey (Figure 2.5 b).
To summarize, the proposed method is able to estimate the zipper column loads and□□their elastic seismic behaviors. Under crustal ground motions, inelastic responses are ob-served in all studied structures. However, under the near-field and Cascadia (subduction) ground motions, dynamic instability may occur in the 12-storey building after the formation of a full zipper mechanism. This study has underlined the requirements of future research and the validation of the proposed design method against different pattern loads distribution over the building height, beside the considered sequential triangular pattern.

III. CONCLUSIONS

A. In this paper, we are study about the zbf and their use to reduced the seismic excitation.
B. It also gives the knowledge about the various pattern applied in the building due to which that structure is holding the loads.
C. In this study we are also found that the structural failure of the zbf in which nodes and the remedial measures applied on the building.

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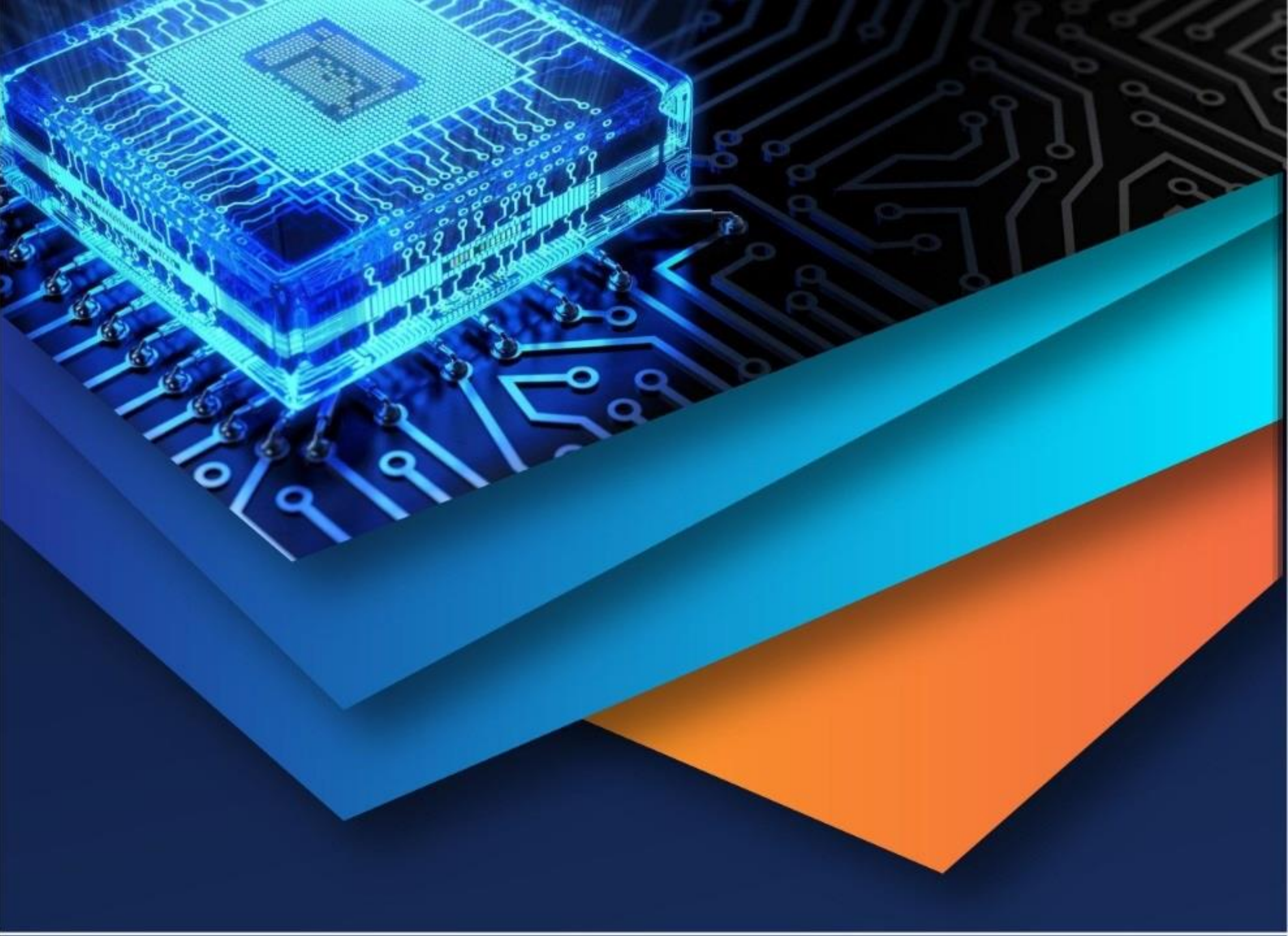

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