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Zipper Braced Frame: A review

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Abstract

This paper reviews research conducted on zipper braced frames. Various braces are used worldwide for Residential, educational and recreational structure for seismic performance. Most of them resist the earthquake loads effectively, but each and everybrace are having their own advantages over another than others. Zipper braced frames are one of the patterns for prove braces in inclined direction for avoiding horizontal deflection, formation of hinges and flexural forces due to earthquake forces. Tremendous research has been done on zipper braced frames by researchers in steel by using software's and analytical methods. This paper represents the review on that analysis of zipper frame.

Keywords: Zipper braced frames; Chevron braced frames; Inverted braced frames; V-braced frames; X-braced frames; Pushover analysis, SAP2000

Introduction

Structures having the components as beam, columns, slab to resist lateral, gravity, wind, earthquake load. To resist the loads structures should be strong enough, so proper bracing should provide so that structure must effective. There are basically two types of frame structures: Rigid frame structures and Braced frame structure. The word rigid means the ability of structure to resist the deformation and collectively resist the moments are generated due to applied load. This type of frame structures resists the shear, moment, torsion more effectively. That's why this frame is used in high rise structures. Braced structural frames provides more efficient resistance against the earthquake and wind forces. Bracing also used to minimise the hinges that occur in buildings Bracings are generally provided between the beams and columns.in frame structures. Selections of frame structures for the high-rise building is due to their versatility and advantages over the normal traditional load bearing structures. 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. Every time it is not possible that we will construct steel structures, so using that steel frames in concrete structures may helpful most of the time. Tremendous works done on the steel structures using braced frames. Concrete is such a wonderful construction material that an Italian architect one said: "Concrete has liberated us from the rectangle".Bracing element in structural system plays vital role in structural behavior during earthquake. For analysis of structures various software, methods were applied in field of structural analysis such as time history analysis, response spectra method, push over analysys.one of this method is push over analysis which were using more in structural fields for r.c.frames.

Previous studies on zipper braced frames

Evolution of braces was taken since long ago.Ductility behaviour shown by chuang-sheng yang [1] is a pioneering work in field of braced frames using the method of pushover analysis in sac. He proposes a design methodology of zipper braced frames aimed at achieving a good ductile behaviour.it is observed that nonlinear dynamic analysis under an ensemble of 2% in 50-year pulse type near fault ground motions. From various braces one of the frame is concentrically braced frames which are prone to excessive inters Torey drift, so to overcome this Lucia Tirca et al. [2] apply the innovative idea of zipper to existing frame. A Kadid et al. [3] proposes the seismic behavior of RC buildings strengthened with different types of steel braces, X-braced, inverted V braced, ZX braced, and Zipper braced. Pourbaba M et al. [4] analysis the Behaviour of zipper braced frame was investigate and compared with concentrically braced frames. Earlier concentrically braced frames were used, but the frame behaviour is not so effective in terms of lateral loads, it has poor mechanism with a negligible ductility, so they introduced new members as a structural element called zipper to overcome the problems of concentrically braced frames problems as a result no sudden loss of bracing forces which shows the behaviour of ductility (Figure 1). Similarly, Nouri et.al investigated the limitations of concentric braced frames subjected to seismic loading and thereby proposes the another bracing to overcome the problem of vertical unbalances forces in case of chevron braced frames [5].

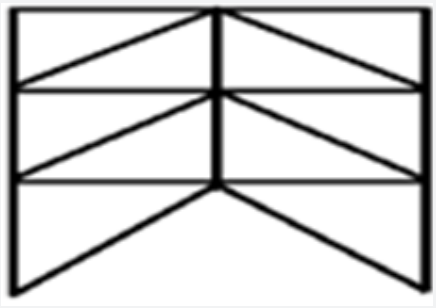

Figure 1: Zipper braced frames.

Comparisons of different Braced Frames

Various researches have been done by comparing various frames with each other with the result of showing excellent behaviour of zipper braces frames as compared to others. The seismic behaviour of different bracings systems in high rise 2-D steel buildings were carried by Dhanraj M Patil [6] to access the structural performance on different bracing systems. According to that zipper braced frames shows higher capacity than other buildings. Inverted v which is also known as the chevron braced frames have been seen as being prone to soft storey responses once the braces buckles under earthquake loading.to overcome this chevron braced frames problems zipper column were proposed which redistribute the inelastic demand over the height of the building [7]. Zipper frames are intended to improve on the behaviour of conventional inverted -v braced frames which exhibits poor performance which arises from the early buckling of the lower storey braces, for remedy on this Roberto Leon et al. [8] introduces the hat truss at top of building which prevents the formation of an overall collapse mechanism.in order to investigate the seismic performance of zipper frames with respect to chevron braced frames Haifeng Yu [9] examined the four parameters: inters Torey drifts, maximum axial deformations, vertical downward deformations, indicating zipper frames is better than chevron braced frames.it is also found that the design method of the zipper columns is conservative and a more reasonable [9,10]. There has been a considerable improvement in the field of replaceable links in the past decade. For steel eccentrically, braced frames Sina Kazemzadeh review the research for system level response [11]. Due to buckling's of compressive braces in inverted-chevron braced frames, an unbalanced vertical forces has been applied also shear capacity of the frame decreases.to overcome this shortcomings, S Naeimi [12] apply zipper to counteract the unbalanced forces.as a result by applying zipper base shear lateral displacement behaviour is enhanced. Simultaneously it increases the energy absorption capacity of the structures. Vertical displacement of the mid span point of the braced bay beam is considerably reduced. Zahrai [13] has conducted a thorough research on shear panel system proposing the method for modifications of V-braced framesas a result v-braced frames offers high levels of shear ductility and a great deal of energy dissipation. For improvements over it zipper was applied which connect the midpoint of shear links in all stories.by imposing acceleration on the structures and conducting time history analysis it was observed that zipper show stronger tendency to form shear links. Chevron braced frames have high hardness and weak buckling behaviour for preventing this condition zipper placed between the beams [14] as a result hysteresis absorbed energy in zipper frames are uniform on other side chevron has un-uniform hysteresis curves. Suspended zipper braced frames are a modified configuration of chevron braced frames in which zipper columns are added between storey beams and a hat truss is attached between top surfaces in order to redistribute the unbalanced vertical forces [15].

Zipper braced frames

Most of the braces have problems such as weakness, soft storey mechanism. There are two important dimensions to the behaviour of bracings energy absorption/dissipation capacity: ductility and failure behavior [16] According to the previous studies ductility is the ability of the constituents parts, to bear non-elastic deformations, so to counteract such problems wonderful work done by A. Mirza Gol Tabar et al. [16] for analysis they consider a chevron braced frames and turn it into zipper frames.as a result amount of energy absorption and dissipation of zipper braced frames is more than chevron bracing braces. Zipper braced frames subjected to seismic excitations [17]. Buckling of compressive braces results in a localization of the failures and loss of the lateral resistances.one of the ways to overcome this problem is to use a vertical structural element at the beam mid-span from the second to stories above called zipper strut [18]. To solve the traditional problems associated with conventional braced frames, a new class of bracing systems known as zipper frames were developed and tested. The research developed analytical tools and methodologies to allow practicing engineers to determine potential benefits of a variety of applications of zipper frames [19].

Seismic effects of zipper brace frame

Seismic performances of braced frames are governed by the buckling of brace members in compression. Structures should be strong enough to resist the seismic effect. For seismic effect of zipper braced frame some researchers had done research on the frames with respect to the seismic effect. Jay Shen et al. [20] studied on the seismic demands of two-storey x braced frames as a result required seismic strength on the brace intersected beams in two-storey x-braced frames was lower than the inverted v-braced frames. The structural responses of frames are studied in terms of capacity curve, drift ratio, global damage index, base shear, storey displacements, roof displacements [20] choosing an appropriate lateral force resisting systems has a significant effect on a performance of the structures. The results showed a good improvement in the seismic resistance of frames with the incorporation of bracings. For zipper braced frames ductility is more compared to others frame, but Rahimi R [21] recommended the suspended zipper braced frames to

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be used in high rise building, however for the low and midrise building it was recommended to use zipper frames due to economic efficiency. Zipper columns bracing system are more ductile system and efficient than any other [22]. Razavi M et al. [23] investigates seismic behaviour of zipper braced frames with different pre-stressed ratio. Moreover, it was observed that the use of prestressed cables enhances the seismic performances of zipper braced frames.

Analysis of frames by applying push over method in sap2000

Simplified method for nonlinear static analysis of buildings subjected to monotonically increasing horizontal loading {push over analysis}. Vojovo et al. [24] applied the pushover analysis of a seven-storied reinforced concrete frame wall building.

Push over technique based on the conventional displacement method of elastic analysis [25]. Mostly hinges formed in beam than in column [26], push over analysis has been developed over past 20 years ago and has become simple in analysis using sap2000,which also considers post elastic behavior [26-28]. Traditional pushover analysis is widely used for the seismic performance evaluation process. But improved pushover overcome the limitations of traditional pushover procedures [29]. By conducting the push over analysis weak zones in the structures can identified. For achieving the objective of push over analysis Abhijeet A Maske et al. [30] work on 5 and 12 stories buildings. According to them push over analysis were relatively simple ways to explore the non-linear behaviour of buildings. Various structures were analysed using push over analysis [31-40].

Conclusion

Results of experimental researches shows that zipper bracing systems performed better results as compared to normal frame structure. Performance results is depending on the type and size of the cross sections and also enhances the global capacity of building in terms of strength, deformation, ductility [3,8]. The design methods of zipper braced frames are conservative and a more reasonable design [7,9]. Distribution of inters Torey drift over the structure height is uniform using zipper braced frames [22,29]. Furthermore, the shear capacity of the frames which was obtained through hysteric analysis shows that the ultimate shear capacity of zipper strut frames 2% higher than that of regular eccentrically braced frames [23].

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