Review on Siesmic Performance of Different Lateral Load Resisting Systems

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Abstract— Earthquake is one of the nature's greatest hazards, throughout historic time they have caused significant loss of life and severe damage to property, especially to Man-Made Structures. Therefore, it is necessary to provide special lateral load resisting design methods that improve lateral stability of the structures. Base Isolation is an effective method for earthquake resistant design to reduce vibration transmitted from ground to the structure. Bracing is a very effective and economical system which improves the seismic performance of frame by increasing the lateral stiffness and capacity of frames. Performance Based Plastic Design (PBPD) method has been recently developed to achieve enhanced performance of earthquake resistant structures. The design concept uses pre-selected target drift and yield mechanism as performance criteria and uses the concept of strong column-weak beam method. In the present study the attempt is made to understand the seismic performance of different lateral load resisting building, such as base isolated buildings, braced buildings, PBPD buildings. From this study It has been observed that all the methods have their own specialization in their performance criteria according to the requirement the designer should decide the method in terms economical, strength, aesthetic.

Key words: Base Isolation, PBPD, Bracings

I. INTRODUCTION

An earthquake is a manifestation of the rapid release of stress in the form of waves during the process of brittle rupture of rock. Earthquakes are the natural disasters of a generally unpredictable nature and their occurrence is beyond human control. Thus, we human beings are responsible to provide protective and safety measures to withstand this earthquake to some extent. In the recent major earthquakes, it is noticed that the high seismic risk in urban areas is increasing. Hence there is an urgent need of practical design methods to reverse this situations there are different lateral load resisting methods are available such as PBPD, Base Isolation, Bracing.

Performance based plastic design method is a rapidly growing design methodology based on the probable performance of the building under different ground motions. Which is developed by lee and goel in 2001 in university of Michigan The methodology used here is direct design method in which uses pre-selected target drifts and yield mechanisms as key performance criteria from the very start.

In the last few years, using base isolation systems as a mean of a seismic design of structures has attracted considerable attention. Different designs for base isolators have special features in common, the most important of which are the horizontal flexibility and the energy dissipation capacity. Base isolation can greatly reduce earthquake intensity and losses, which directly reduces the shaking intensity and damages. The main use of isolation system is to reduce the displacements, base reactions and member forces in structure.

In order to make multistory structures stronger and stiffer, which are more susceptible to earthquake, the cross sections of the member increases from top to bottom of the building this makes the structure un economical owing to safety of structures. Therefore it is necessary to provide special mechanism and / or mechanisms that to improve lateral stability of the structures.

II. LITERATURE REVIEW

T. Subramani, et al (2014): In this paper the author has been studied that, the present state of base isolation with special emphasis and the dynamic analysis procedure for isolated structure is briefly explained by using G+10 storied building. Base isolation a technique in which the flexible material is provided at the base of structure to reduce seismic forces. The base isolation reduces the ground motion transmitted to the superstructure. The loads are taken from the IS-875-1987. The modeling has been done by SAP-2000 for Nonlinear pushover analysis using software. The other data has been assumed as per IS-1893-2002 and the design has been carried as per IS-456-2000. After all the study, the author has been concluded that ,the value of base shear and displacement of base isolation building is less than the fixed building and it resist earthquake forces for longer period.

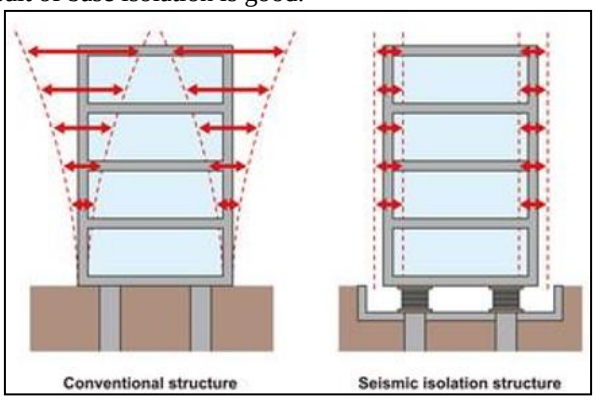
S. J. Patil, et al (2012): In this paper the author has been studied that the base isolation technique with special emphasis and a brief on other techniques developed world over for mitigating earthquake force on the structures. The isolated structures are briefly explained with the procedure of dynamic analysis. The provision of FEMA 450 for base isolated structures is highlighted and the effects of base isolation on structures located on soft soil and near active folts are given in brief. The author has been concluded the provision of sand layer below base of structure reduces frequency of the structure and reduction in frequency is more with more excitation force if frequency are reduced, the response of the structure also reduces the part of the excitation the energy gets decapitated in the movement and friction of the sand layer, thereby the energy reaching to the structure reduces giving lesser accelerations to the structure.

Mustafa EFILOGLU (2013): In this paper the, author explained the concept of base isolation by giving some examples of engineering and sport branches. These examples are automobile suspension system and some defense techniques in boxing. Additionally some experiments and analytic graphs will be demonstrated to provide better understanding of the concept of base isolation. From this study authors have been concluded that the base isolation technique is very effective solution to an engineering problem. They have been also concluded that once the

concept is understood it is highly possible to use this concept for solving other engineering problem.

Naveena K. et al (2017): In this paper the author has studied that, the different types of base isolation system by referring to some literature papers. In those papers, CANCELLARA et al studied on dynamic nonlinear analysis of different base isolations, and they concluded that behavior of the structure isolated by the two considered base isolation system & corresponding behavior of the traditional fixed base structure. ATHANASIOS et al studied on response simulation of hybrid base isolation system under earthquake excitation soil and he carried out to study the behavior of the considered hybrid base isolation system under different excitation & site condition. FABIO DE ANGELIS et al studied on nonlinear dynamic analysis for multi storey RC structure with hybrid base isolation system, in presence of bidirectional ground motions composite structure and they finally concluded and the comparative analysis is presented between the base isolated structure with the three considered base isolation system & fixed base structure. N. MURALI KRISHNA et al studied nonlinear time history analysis of building with seismic control; he indicated that significant effect of the base isolation was observed on the storey drift, storey shear, storey displacement & torsional moment of low rise asymmetric building and significant effect. From the above literature, author found that the use of base isolation considerably reduces the response of the structure due to earthquake loading base isolation is a very promising technology to protect the different structures like building, bridges, airport terminals & nuclear power plant etc. Base isolation system affects the super structure to have rigid movement and storey drift of structural element will be decreased and consequently the internal forces of beams and columns will be reduced. From the above points the author has concluded that the performance of isolated structure is efficient in earthquake prone areas.

Aparna verma, et al (2017): In this paper the author has studied that the behavior of different base isolation with using shake table. In this paper A. N. Lin et al told that the base isolation was designed to reduce 25% to 50% of the lateral forces. Using linear time history analysis the author has concluded that performance of base isolation structure depends on the type of underlying soil for hard strata the risk is less the soft soil increase the acceleration the author has also concluded that for low to medium height of building, the result of base isolation is good.



Fig, 1: Conventional & Seismic Isolation Structure

Saif Hussain and Associates: In this paper the author has studied that the seismic base isolation can use elastomeric pads, sliding plates or inverted pendulums. Each method can include an energy dissipation means, but only as some kind of hysteretic damping. Hysteretic damping has limitations in terms of energy absorption and may tend to excite higher mode in some cases. Base isolation dampers are significantly larger than automotive dampers, it is possible to avoid these problems with viscous dampers through loads that are 90 degree out of phase with bending and shear loads so even with damping levels as high as 40% of critical adverse side effects tend to be minimal point viscous damper being built for the new san Bernardino medical center reduce both deflection and loads by 50% compared with high damping elastomer base isolation bearing by themselves. From the above studies the author has concluded that the incorporation of viscous damping elements into any type of conventional base isolation system can often significantly improve performance, and also reduce overall cost of the structure.

BHARAT PATEL, et al (2017): In this paper, it has been studied that the high rise buildings which are made up of RC frame, to protect the structure from the effect of earthquake and to provide stability and stiffness to the structure, the three structural configurations used in this paper are, moment resisting frame (MRF), V-Braced frame (VBF) and X-Braced frame (XBF) for (G+10) storied building, the bracing system is provided at the periphery of the column and the models are analyzed as per IS- 1893-2000 using STADD Pro V8i and ETABS software. The lateral loads are considered as per Indian standard codes. All the above mentioned building frames have been carried out as per IS-456-2000 and IS-875-1987. The equivalent static loads analysis has been carried out using STADD Pro V8i and response spectrum analysis by ETABS. Load combinations considered in seismic analysis are done as per IS-893-2002. From the above study the author has concluded that the 'base shear in XBF gives higher value as compared to VBF and MRF shown in Fig-2(a). The storey displacement can reduce up to 55% to 60% by XBF and VBF shown in Fig-2(b) and the performance of XBF is safer than the VBF.

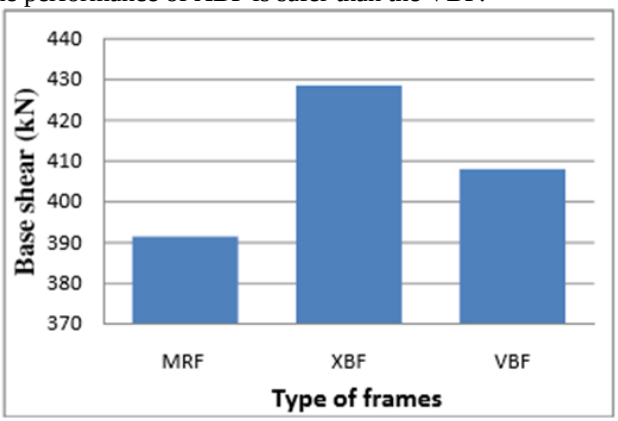


Fig 2(a): Base Shear

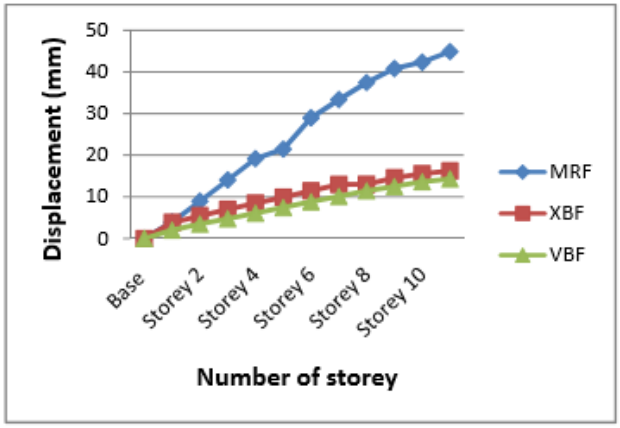


Fig 2(b): Storey Displacement

H. Yallapa Halli et al (2014): In this paper the author has studied that, the seismic performance of the steel inverted V and V-Braced frame structures are investigated. The selected frame models are analyzed by using push over analysis to evaluate the effect of distributing the bracing in different numbers of storey's and cross section of bracing. The lower time period makes the building to vibrate for shorter period and the lesser is the damage. The value of time period depends on the stiffness and mass of the structure. The inverted V-Braced frame with tube section, exhibit lower time period than the double section and I-Section. From the above studies the author has concluded that, the energy absorbed by inverted V-Bracing system is 43%-49% which is more than the V-Bracing system. Steel bracing reduces flexure and shear demands on beams and columns and transfer the lateral loads through axial load mechanism. The performance of the inverted V-Braced frame is better as compared to that of the V-Braced frame.

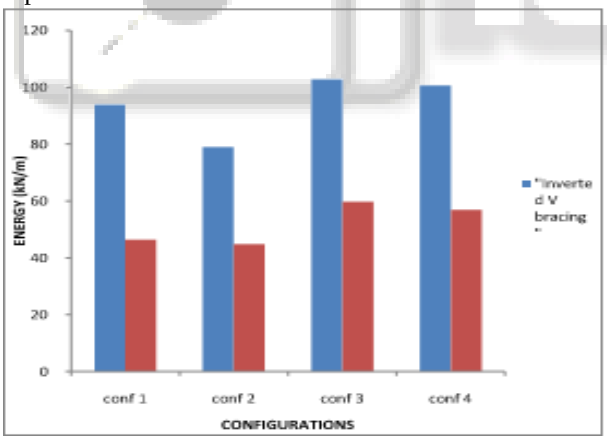


Fig. 3: Energy absorbed by V and Inverted V bracing systems with different configurations

Hendramawat A Safarizkia, et al (2013): In this paper the author has studied that, to evaluate the possible improvement of seismic performance of existing reinforced concrete building by the use of steel bracing. In this paper two methods of seismic evaluation are employed i.e. Nonlinear Static Pushover and dynamic time history analysis. In this study the results show that the target displacement determined from nonlinear pushover analysis of the existing building in X direction is 0.188 m and in Y direction is 0.132 m. It is also indicated that the storey drifts in Y direction exceed the serviceability limit criterion when the recorded El Centro accelerogram was used for dynamic time history analysis. The performance of the existing building could be improved if steel bracings are utilized for seismic retrofitting. It is shown from the nonlinear pushover analysis that target displacements in both directions are reduced by 16%-55%, if the proposed steel bracings are used. Furthermore, dynamic time history analysis points out that the story drifts of the retrofitted building are within the limit criteria. Meanwhile, the size of steel bracing elements does not significantly affect the seismic performance of retrofitted building.

Subhash. C. Goel, et al (2012): In this paper author has studied that the performance based plastic design method as applied to the seismic design of building structure the method uses pre-selected drift and yield mechanism as key performance criteria. Plastic design is performed to detail the frame members and collection in order to achieve the target field has been successfully applied to a variety of common steel framing system and more recently to the reinforced concrete moment frames. Results of extensive inelastic storey drift and ductility demands were well within the target value thus meeting the deserved performance object. From the above study is the author has concluded that. The method has been successfully applied to member of commonly used Steel framing system stop development of the PB PD methodology for RCC structures the youth degrading highest rating behavior is currently in progress. The example of 20-story steel and RCC moment frames as presented in this paper sword that the method is especially advantages photo frames the cumbersome and lengthy iterative process in current design practice can be completely illuminated while leading to excellent performance as targeted. The result as presented in this paper showed excellent agreement with those obtained from more elaborated inelastic time history analysis

Kushappa M. Kabade, et al (2014): In the present study comparison of a ten-storey R.C and Composite (CFRST column and Steel beam) moment resisting frames are designed by the PBPD method in terms of lateral force distribution, and the seismic performance of MRF is evaluated by non-linear static pushover analysis and non-linear dynamic time history analysis under five different ground motions using the ETABS-2013 software, with user defined hinge properties. From the above studies it is found that for nonlinear static pushover analysis shows formation of hinges in beams and at the base of the columns only for both frames leading to increased performance which clearly indicates that the PBPD method gives economical sections in terms of the optimum capacity utilization, but it is observed that the composite MRF has better yield mechanism compared to R.C MRF as shown in Fig-4(a) and (b). From the nonlinear time history analysis it has been seen that the ground motions causes larger displacements and acceleration in the PBPD of Composite frame as compared to R.C frame. Hence it is concluded that composite moment resisting frame has performed better for high seismicity as compared to R.C moment resisting frame as shown in Fig-5(a)and (b).

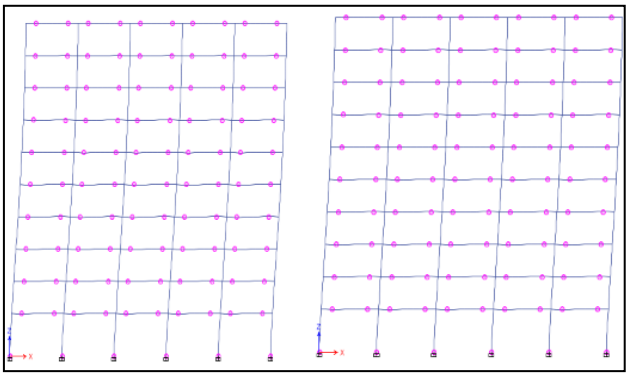


Fig. 4(a): Hinge formation in Composite

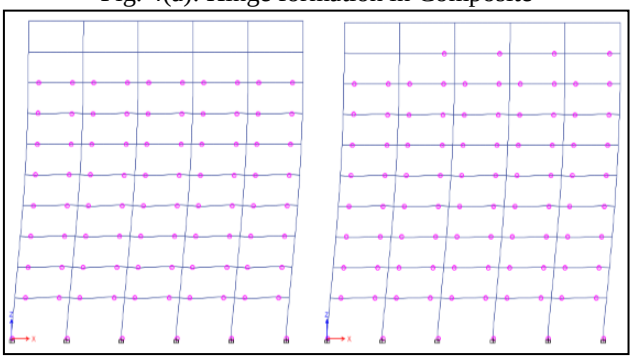


Fig. 4(b): Hinge formation in RCC

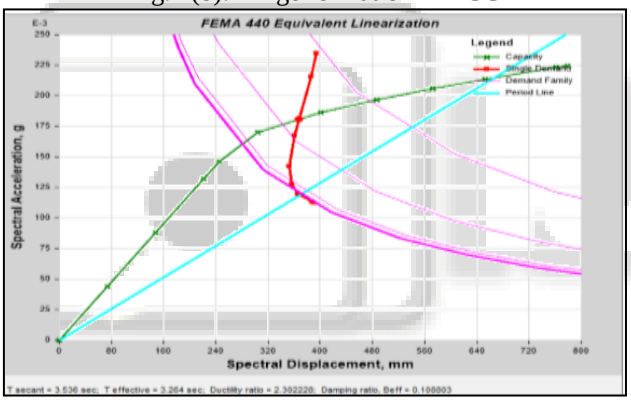


Fig. 5(a): Performance Point in Composite

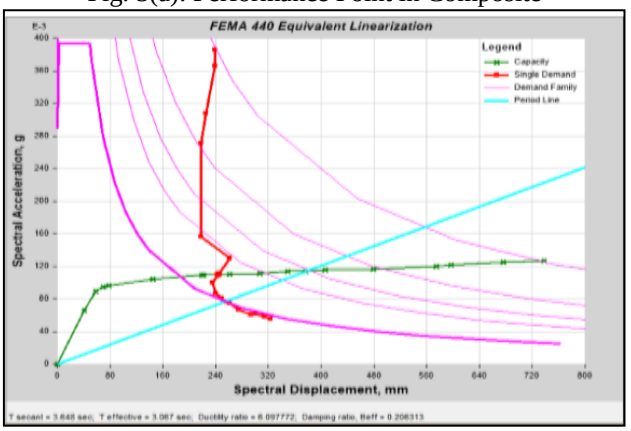


Fig. 5(b): Performance Point in RCC

L. Nayeemulla S. Inamdar, et al (2014): In this paper the author has used a 15 storey steel moment resisting frames which are designed by the performance based plastic design method and conventional elastic design method and evaluated by nonlinear static (push over analysis) and nonlinear dynamic analysis (time history analysis) under 8 different ground motions using sap 2000 V-15 software. From the nonlinear time history analysis it has been seen that ground motions cause larger displacements and acceleration in the performance based plastic design frame as compared to the elastic design frame and it is a very tedious and complex analysis, having a lot of mathematical calculations. Even though, nonlinear dynamic analysis is usually considered to be the most accurate of the existing analysis methods. For elastic design method the ongoing Indian standard code (IS 800:2007) makes use of the limit state procedure for the designing of steel structures to make sure a good earthquake resistance design which at times may fail in case of a major earthquakes as it is based on elastic analysis. The dead and imposed loads are calculated using IS 875, (parts 1 to 5) and the seismic loads are calculated using ISI 893:2002 based on elastic design spectrum. The target and yield mechanism chosen for the frame while designing it using the performance based plastic design method. The hinges are to be formed at the bottom of the base column and in beams only. The beams are designed to behave in-elastically, while the columns are designed to behave elastically. From the above studies the author has concluded that the nonlinear static pushover analysis shows formation of hinges in columns of the frame designed using elastic design approach leading to collapse and formation of hinges in the beams of the performance based plastic design frame leading to increased performance which indicates that the performance based plastic design method is superior to the elastic design method in terms of the optimum capacity utilization.

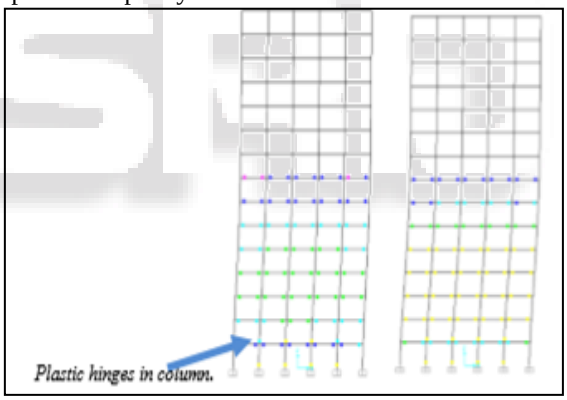


Fig. 6(a): Hinge formation By Elastic design approach

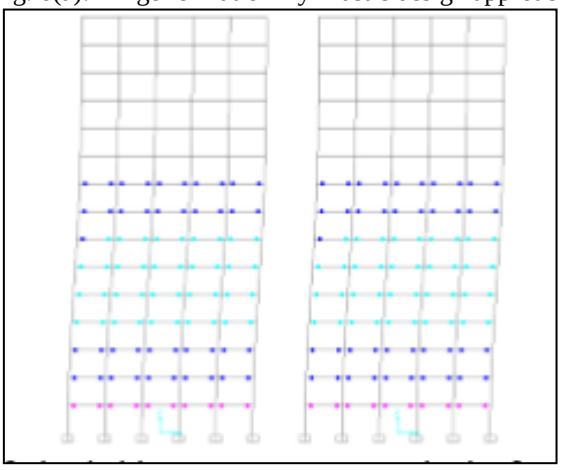


Fig. 6(b): Hinge formation by plastic design approach

M. URVESH A SHAH, et al (2015): In this paper, the authors have stated that, if structure is designed for seismic loads as per current code method, it generally

satisfies the strength and serviceability criteria. But during strong ground shaking, it may undergo total collapse. The PBPD method can prove better as it prevents total collapse of the structure by designing it for a predetermined failure and yield mechanism (strong column-weak beam principle). Hence authors aimed at proposing a PBPD method for RCC frames attuned with our code. The PBPD method differs from current code method mainly in terms of analysis, i.e. calculation of forces and moments. As the analysis method in PBPD method is based on basic equation of equilibrium. It can be directly implemented. The design can then carry out satisfying the IS 456:2000 code. The PBPD design proposed for Indian designers is further made clear by designing a 15 storey L-shaped RCC frame. From this study, authors found that the values of lateral forces are higher compared to code specified lateral force distribution which gives conservative results and better performance, and also found that columns are designed for higher moments compared to beam which fulfill the "strong column-weak beam" principle.

N. Hamidreza Tavakoli, et al (2015): In this paper the author has studied that, to increase the Performance of PBPD method for steel moments frame, including gravity loads. The solutions are used, these solutions represent their yielding point and two models frames of 5&10 storey are designed based on PBPD method and used nonlinear static pushover analysis and dynamic analysis which includes the main object in terms of yield Mechanism and target drift level are used. The author has concluded that the PBPD method is applied only on condition of strong column & weak beam. The author has also concluded that 'To prevent the overturning of structure, the PBPD method is good'.

III. CONCLUSIONS

The main objective of this study is to understand and study the concept and seismic performance of different lateral load resisting systems. From the above literatures studies of different lateral load resisting systems, such as Base Isolation, Bracings, and Performance based plastic design, main intention is to find out the most effective system of lateral load resisting system.

From the above discussion following conclusions can be made.

A. PBPD

From the above literature study regarding Performance Based plastic design method, this is a direct design method which is developed by Lee and Goel in the Michigan university (U.S.A) which uses the pre-selected target drift and yield mechanisms as key performance objectives that determine the degree and distribution of expected structural damage.

- This method has been successfully applied to variety of moment resisting frames such RC, Steel, Composite moment resisting frames, so from the above study the performance of all moment resisting frames was given good results, but among the all MRF's the composite moment resisting frames gives more efficient results in terms of yield mechanism, performance etc.
- It is observed that Composite moment resisting frames has performed better for high seismicity as compared to other MRF's in terms of optimum capacity utilization.

B. Bracings

- From above literature study, it has been concluded that the storey displacement of the building is reduced by 55%-60% by using X-braced and V-braced frame compared to Moment resisting frame.
- The performance X-braced has more margin of safety compared V-braced frame.
- From the above study some of the authors also concluded that the energy absorbed by an Inverted-V bracing system is 43% to 49%, which is more than V-braced frames, hence the performance of Inverted-V braced frame is better as compared V-braced frame.

C. Base Isolation

- From the literature study regarding Base isolation there are different types of base isolation has been studied such as lead rubber bearing, friction pendulum system, laminated rubber bearing (elastomeric), High damping rubber etc.
- It is observed that effectiveness base isolated base structure it depends on underlying soil on which the structure rests, i.e. the response of base isolated structure is relatively good compared to soft soil.
- It concluded that the base isolation system is an efficient method in high seismicity risk.

D. Comments

- The PBPD method is direct design method and it uses optimum capacity utilization of the sections that means it is economical in earthquake prone area and compared Base isolation. But in PBPD method the structural elements undergo large inelastic deformation and plastic hinges will form in structural elements due to this structure unusable.
- There is no IS-code for Composite structural design for this authors used AISC-360-10 code. At present still research working is going on this method.
- It is observed that X-bracing and Inverted-V bracings systems are performing better as compared to different types of bracings to resist the lateral loads.
- Steel bracings are more preferred because the dead of the structure will get reduced compared to concrete bracings.
- The base isolation method is had better performance compared to all method because the base of the structure is going decouple or separate from ground so that the super structure will not affected much.
- The Base isolation technique is uneconomical, but its dissipate energy of earthquake.
- Of course all the methods have their own specialization in their performance criteria according to the requirement the designer should decide the method in terms economical, strength, aesthetic. Etc.

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