A Review on Seismic Behaviour Evaluation of Base – Isolated Structure with Different Isolators

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Abstract
This study concerns with the review of seismic response base isolated structure and parametric study of a base isolated structure. for most of bridge structure in India are not base isolated, so there is necessity to study the effects of base isolation system for the parameter time period, lateral torsional effect and restoring force. the objective of this paper is to give overall literature review on the work done related to base isolation system of bridges and suggesting a good isolator. from literature it is observe that most of times rubber isolator and friction isolator are used for isolation system for building and bridges. The technical development of rubber bearings and dampers in recent years has reduced their price and such systems have become an important alternative for construction of building and bridge structures in seismic areas, even for ordinary multi-story buildings such as offices, residential housing, industrial buildings and others building.

Keywords- Base isolation, rubber bearing, friction bearing, ground acceleration, bridges

1. INTRODUCTION

Base isolators are the most operative method to shrink vibrations transmitted from ground to the structure. The role of the base isolator under seismic loading, is to isolate the structure from the horizontal components of the earthquake ground movement, whereas the vertical components are transmitted to the structure relatively unchanged. Base isolators deflect and absorb the seismic input energy transmitted horizontally to the structures. The earthquake resistant structures can be categorized into rigid structures and flexible structures. In rigid structures, the control methods that are applied to withstand extreme loads are basically reducing the inter storey displacement with the help of diagonal bracing, the installation of shear walls and the use of composite materials, Base isolation involves mounting a building on bearings of low lateral stiffness. The principle of seismic isolation is to introduce flexibility in the basic structure in the horizontal plane, while at the same time adding damping elements to restrict the resulting motion. The basic concept of base isolation is to increase the natural period of the building to take it away from resonance with the forcing motions of earthquake. Increase in the period of vibration of the structure reduces the design base shear. A well designed seismic isolation system provides rigidity under low load
levels such as wind and minor earthquake.for most of bridge structure in India are not base isolated, so there is necessity to study the effects of base isolation system for the parameter time period, lateral torsional effect and restoring force.

2. LITERATURE REVIEW

Ganga Warrier*et.al*, (2015), presents design procedure for LRB adopting the procedure of IS 1893:2002 (Part-1) for earthquake resistant design of buildings. The design procedure requires different input parameters like fundamental period and damping of the fixed base structure, axial load on the column, seismic zone, type of soil and shore hardness of rubber. Using this methodology, case study has been done using SAP2000. Building displacement, acceleration and inter-storey drift are compared for model with and without base isolator. Comparative study of linear and non-linear base isolators has also been carried out. Linear and non-linear time history analysis has been done using El Centro earthquake

Sahdev V. Chauhan*et.al* (2017), The main objective of the author in this study is to evaluate seismic response of building under triaxial earthquake ground motions. In his work, TFPS isolation system is applied at the base of column in G+10 storey RC building. Non-linear time history analysis is carried out for unilateral, bilateral and triaxial earthquake ground motions. The behavior of building under unilateral, bilateral and triaxial earthquake ground motions are analyzed using SAP2000. Result of base shear, top storey displacement, bearing displacement, top storey acceleration and hysteresis behavior are compared after analysis. based on this study author drawn following conclusions

1.There is a significant effect of vertical component of earthquake on seismic response of building isolated with TFPS.

2. Under triaxial earthquakes, base shear is increased by 15.59% as compared to unilateral earthquake and 11.54% as compared to bilateral earthquakes.

3. Displacement of bearings for triaxial earthquake is increased by 8.86% compared to unilateral earthquake and 4.16 % compared to bilateral earthquake.

4. Top storey displacement for triaxial earthquake is increased by 4.70% as compared to unilateral earthquake and 2.62 % as compared to bilateral earthquakes.

5. The force-displacement relationship for the triaxial earthquake is found different than unilateral and bilateral earthquake.

6. Under triaxial earthquakes, the top storey acceleration is increased by 9.81 % then bilateral earthquake and 12.19 % then unilateral earthquakes.

G.S. Manjunath*et.al* (2016), has done analysis of G+3; G+10 and G+20 building models, studied for their base fixed and for their base isolated, using MIDAS Gen analysis software. Base isolation is achieved by two types of isolators namely lead rubber bearing and friction pendulum bearing. All the models were analyzed with equivalent static analysis procedure, response spectrum analysis and time history analysis. Building modelled with Lead rubber bearings were further analysed considering hard soil, medium soil and soft soil. The effect of all the considered parameters is assessed with respect to variations in base shear, storey displacement, storey drift, period of the structure and its frequency. It was observed that isolating a structure lengthened its period and improved its performance by reducing the inter-storey drifts and base shear. Parametric study gives an overall idea of the effect of all the considered parameters on response of the structure and an idea as to whether the parameter has to be considered or can it be safely neglected based on the importance of the work, its priority, budget of the project and the given time frame for its completion. based on this study author drawn following conclusions

1.Choice of selecting a particular type of isolation depends on assessing its overall performance in terms of drifts, displacements, shear and period. Engineer has to bear in mind all the physical and financial constraints together with its performance before selecting the type of isolation technique.

2. Base shear reduced considerably when the base is isolated using friction pendulum bearing and analysed using time history analysis but the reduction in base shear was relatively lesser when analysed with equivalent static force procedure.

3. From the study it was observed that the storey drift was relatively greater for isolated structure at the base but as the number of storeys increased the storey drifts in isolated buildings reduced in comparison with fixed base structure

4. Introduction of base isolation reduced the inter storey drift but increased the storey displacement relative to fixed base structure due to the elasticity imparted by the isolation system

5. Introduction of isolation increased the flexibility of the structure as a whole thus increasing the period of the structure and making it less susceptible to attract greater magnitude of lateral forces.

Smita Gupta *et.al* (2015), focused on the time history analysis of a soft-storey building with and without lead rubber isolator. The soft-storey building with and without isolator is analyzed using Elcenrto earthquake data and the dynamic characteristics are compared. based on this study author drawn following conclusions The investigation on soft-storey frame with modifications using lead rubber isolator yielded significant results. By using lead rubber isolator under the base of building the damage in the building due to earthquake can be reduced which is evident from the reduction in the fundamental time period, base shear and base moment

Savita C. Majage*et.al* (2018), deals with the selection of suitable type of isolators. Author investigates structural behavior of multi-storey building with or without base isolation subjected to earthquake ground motion. The performance of isolator is assessed from variation of base shear, , displacement, storey drift etc for the G+8 and G+10 building by installing high damping rubber bearing (HDRB)at the foundation level then compare the performance between the fixed base condition and base isolated condition by using SAP software, based on this study author drawn following conclusions

1. Time periods are increased which increases, reaction time of a structure during earthquake.

2. Base shear get reduced after using the high damping rubber bearing (HDRB) as base isolation system, which reduces the seismic effect on building.

3. It is observed that when increasing the number of a story, maximum storey displacement becomes considerable.

4. From nonlinear analysis displacement of base isolated building reduced to 25% - 40% over the fixed base building. Base shear get reduces 55% - 80% and storey drift is get reduces up to 60 -76%.

5. It can be concluded that the performance of base isolated structure is efficient in seismic prone areas.

Ajay. G. Singh *et.al.*(2017), studied base isolation and the braced building is compared and analyzed by using SAP2000 software. The analysis is done by using modal Linear time history analysis of (G+6) RCC building. Time history analysis is performed on earthquake EL Centro 1940. The analysis on structure has been performed and response of building with base isolator and bracing is studied. The main objectives were to study the response of earthquake by providing base isolator and Cross Bracing building. The lead rubber bearing is used

as isolator and steel section is used as bracing. the result from time history analysis like time period, acceleration joint displacement of the frame structure was found out and studied..based on this study author drawn following conclusions

1. Base isolation increase the flexibility at the base of the structure which is shown horizontal flexibility helps to minimize lateral earthquake force which is being transmitted through the building hence base isolation reduce seismic force as compared to the braced structure.

2. Base isolation reduces the base shear by 60.23%

3. It has also seen that base isolation also reduces acceleration response almost 3 times then cross-braced structure in as case of base isolation max acceleration at roof is 2.52 m/sec² and for cross- bracing max acceleration at roof is 6.27 m/sec².

4. The time period of the building for base isolation structure also increases by 3 times which is 2.11sec as compared to cross braced structure which is 0.745sec

Shameena K *et.al* (2016), studied Modeling and analysis of 10 storey RC building is done in ETBS 15.1 version software for two cases. The first one is fixed base and the second one is base isolated. Two vertical irregular and Two plan irregular models are considered and analysis is done by equivalent static and response spectrum method. The Lead rubber bearing (LRB) is designed as per UBC 97 code and the same was used for analysis of base isolation system. The results obtained from analysis were Storey displacement. Storey shear, storey acceleration, and Inter storey drift. Due to the presence of isolators the inter storey drift, storey accelerations and storey shear is greatly reduced and storey displacement is increased in both X and Y directions compared to fixed base structures.based on this study author drawn following conclusions,

1) Fixed base plan irregular as well as vertical irregular models have zero displacement at the base of building whereas, base isolated building model shows considerable amount of lateral displacement at base. Also it has been observed that as floor height increases, lateral displacement increases extremely in fixed base building as compared to base isolated building. During earthquake due to this reduction in lateral displacement damages of structural as well as nonstructural is reduced.

2) In base isolated models at the base more inter storey drift was observed as compared to models of fixed base building. As storey height increases, the inter storey drift in base isolated models extremely decreases as compared to models of fixed base building.

3) Compared to equivalent static method the analysis results obtained by response spectrum method are very significant.

4) At the base fixed base models have zero storey acceleration whereas, in case of base isolated building models shows considerable amount of storey acceleration. Also it has been observed that as floor height increases, storey acceleration increase extremely in fixed base building as compared to base isolated building where it is almost constant.

5) As compared to fixed base building the storey shear is reduced considerably in case of base isolated building.

6) Reduction in base shear is more in case of plan irregular base isolated building as compared to vertical irregular base isolated building.

7) From the study it has been concluded that, by using the isolators at the base of building plan irregular building gives better performance as compared to vertical irregular building at higher seismic zone area.

Nitin Chavan *et.al* (2015), studied, first existing bridge with Elastomeric bridge bearing is modelled and analysed to get the seismic response of bridge components and then this results are compared with Elastomeric isolator in place of elastomeric bearing. Modelling and analysis of Highway Bridge is done with help of Structural Analysis and Program 2000 Software. Time history analysis of bridge is conducted for 1940 Imperial Valley earthquake ground motion record. based on this study author conclude that elastomeric bearing can be replaced with elastomeric isolator as it reduces significant amount of the base shear coming on pier. So the reduction insize and amount of reinforcement in pier and foundation can be achieved and ultimately economy of structure. But the limitation is that special care is to be taken to arrest the increased deformation of elastomeric isolator

SoumyaChandran *et.al*. (2017), done study of base isolation, with different plan shape G+6 storey with rubber isolation and friction isolation is analyzed by using ETABS. The analysis is done using nonlinear seismic time history data for with and without base isolation. Time history analysis has been performed and performance of RC building is studied with base isolation. The result is compared with and without base isolation structures. Santa Monica is the earthquake that is imposed on the structure. C. H. L and T shapes are analyzed with fixed base, friction isolator and rubber isolator. based on this study author drawn following conclusions

1. storey displacements are much higher for isolated buildings. The isolator with friction has more displacement compared to rubber isolator.
2. The base shear in X-direction & Y-direction it is reduced by Rubber isolator and friction isolator. And it is obtained from the graph and the table that is plotted for the C shape, Lshape, H shape and T shape buildings. And identified that the Friction isolator will better to reduce the base shear than using Rubber isolator.
3. Time period of both the base isolated structures i.e. Rubber and Friction isolator increases as compared to the fixed base structure. Friction isolator has got greater increase in time period than Rubber isolator. The increment value in time period while using the isolation system is obtained from the graph and table that is plotted for C shape, L shape, H shape and T shape buildings on each mode.
4. Results from storey drift that is obtained for C shape, L shape, H shape and T shape buildings with and without base isolation shows that the storey drift in both X & Y directions considerably reduced by using base isolation devices over the conventional structure.

TIAN Xue Min *et. al*. (2008), introduced, the theories and steps of base-isolated structure with rubber-bearing design, then a practical example with isolating rubber-bearings and the corresponding design process are introduced and the simulation results are analyzed. The flexible connecting device of isolation layer design and

a connection method of isolation bearing without top fixing plate are introduced. At last, they proposed isolated structure and the non-isolated structure are matched, the result shows the base isolation method can reduce the seismic response of structure evidently, based on this study author drawn conclusion that the estimated isolation layer factors have already approached or met the design and aseismic fortification objects targets with the Iterative Computation of Response Spectrum Method of SDOF. Taking the horizontal seismic decrease coefficient as 0.5, superstructure is designed by grade 7, whole structure is designed by grade 8, superstructure still has 0.5 grade antiseismic safety reserve. With the effect of severe earthquake, the max displacement of isolation layer meets the requirement of code and standards. The connection of isolation bearing without top fixing plate is safe, while the cost of isolation bearing is largely decreased.

3. RESULT AND DISCUSSION

From above literature it is observed that more research work has been done on base isolation of buildings and their effects. It is observed that base isolated structure reduces risk of structure failure in seismic condition. The above literature review showed that there is necessity to consider base isolation for bridges for seismic condition, for increasing time period and displacement for dissipation of energy.

4. CONCLUSION

The paper presented a literature review concerning the studies on base isolation of bridges. review found that less experimentation and research work has been done on base isolation of bridges, while more work is done on base isolation on multistory building and advantage of base isolation for building shows. Best result concern with the parameters time period, longitudinal and transverse displacement, lateral torsional effect and restoring forces. From above literature review various tools such as CSI bridge, CSI SAP 2000, MIDAS can be effectively used for analysis and improvement of structures

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