International Journal of Scientific & Engineering Research Volume 8, Issue 5, May-2017
ISSN 2229-5518

AN EXPERIMENTAL INVESTIGATION ON EARTHQUAKE RESISTANT STRUCTURES BY BASE ISOLATION TECHNIQUES

Ms.P.Pooraniya[1],V.Vishal Kanna[2],B.Balaji[2]
[1]Assistant Professor, Department of civil Engineering, Karpaga Vinayga College of Engineering &Technology ,Kanchipuram, Tamil Nadu, India. Email id: pooraniya.civil@gmail.com
[1]Student, Department of civil Engineering, Karpaga Vinayga College of Engineering &Technology ,Kanchipuram, Tamil Nadu, India.

ABSTRACT - An earthquake causes a great damage to the structure. It is very important to protect the structures from earthquake forces and it can be done by various methods. One of the methods is **SEISMIC BASE ISOLATION**. Base isolation is best technique to prevent or minimize damage to building during an earthquake disaster. The basic aim of seismic base isolation is to decouple the building structure from the damaging components of the earthquake motion and to prevent the super structure of the building from absorbing the earthquake energy. In this project, to be constructed two models of building one with base isolation and the other general model both are fixed with base. For the development of foundation to be used plywood thickness of 8mm and for the structure to be used gabion rod, it is very stiff enough to without roof weight. For the development of slab Theiron sheet (heavy metal sheet) to be used as roof slab. Cutting, drilling and welding are the major process to develop the required models. Since the base isolation for real structures are achieved by using rubber pad, for simplicity we have to be used roller to show the pattern of vibration during seismic effect. The base of the building above the roller so that any shake could move the whole model to and fro thereby minimizing the vibration on its structure. For fixing the base isolated model we have to be tied the column with the help of elastic rubber to bolt at an angle for its free movement. The general model with the help of nut and bolt fastened to the base. At first the two models have to be placed in the shaking table. A **horizontal force** of **40 kN** gives the deflection of **31mm** and period of vibration of **55 secs** in conventional frame. And the same force gives the deflection of **5.1mm** and period of vibration of **89 secs.**

Key words - *Base Isolation, Deflection, Horizontal force, Earthquake Resistant Structures.*

1. INTRODUCTION

The structures constructed with good techniques and machines in the recent past have fallen prey to earthquakes leading to enormous loss of life and property and untold sufferings to the survivors of the earthquake hit area, which has compelled the engineers and scientists to think of innovative techniques and methods to save the buildings and structures from the destructive forces of earthquake. The earthquakes in the recent past have provided enough evidence of performance of different type of structures under different earthquake conditions and at different foundation conditions as a food for thought to the engineers and scientists. The isolated buildings will be safe even in strong earthquakes. The response of an isolated structure can be ½ to 1/8 of the traditional structure. Since the super structure will be subjected to lesser earthquake forces, the cost of isolated structure compared with the cost of traditional structure for the same earthquake conditions will be cheaper. The seismic isolation can be provided to new as well as existing structures. The buildings with provision of isolators can be planned as regular or irregular in their plan or elevations. Researchers are also working on techniques like tuned mass dampers, dampers using shape memory alloys etc. Tuned mass dampers are additional mass on the structure provided in such way that the oscillations of the structure are reduced to the considerable extent. The mass may be a mass of a solid or a mass of a liquid. Dampers using shape memory alloys are being tried as remedy to earthquake forces. In this system, super elastic properties of the alloy is utilized and there by consuming the energy in deformation at the same time the structure is put back to its original shape after the earthquake.

2. LITERATURE REVIEW

Base isolation is one of the most important concepts for earthquake engineering which can be defined as separating or decoupling the structure from its foundation. In other words, base isolation is a technique developed to prevent or minimize damage to buildings during an earthquake. In this essay, the concept of base isolation will be explained by giving some examples from other engineering and sport branches. These examples are automobile suspension systems and some defence techniques in boxing. Additionally, some experiments and analytic graphs will be demonstrated to provide better understanding of the concept of base isolation.

The main objective of this work is to compare different base-isolation techniques, in order to evaluate their effects on the structural response and applicability limits under near-fault earthquakes. In particular, high-damping-laminated-rubber bearings are considered, in case acting in parallel with supplemental viscous dampers, or acting either in parallel or in series with steel-PTFE sliding bearings. A numerical investigation is carried out assuming as reference test structure a base-isolated five-storey reinforced concrete (r.c.) framed building designed according to Eurocode 8 (EC8) provisions. A bilinear model idealizes the behaviour of the r.c. frame members, while the response of the elastomeric bearings is simulated by using a viscoelastic linear model; a viscous-linear law and a rigid-plastic one are assumed to simulate the seismic behaviour of a supplemental damper and a sliding bearing, respectively. The seismic analysis of the test structures, subjected to strong ground motions recorded near faults, is carried out by using a step-by-step procedure. The earthquakes in the recent past have provided enough evidence of performance of different type of structures under different earthquake conditions and at different foundation conditions as a food for thought to the engineers and scientists. The isolated buildings will be safe even in strong earthquakes. The response of an isolated structure can be ½ to 1/8 of the traditional structure. Since the super structure will be subjected to lesser earthquake forces, the cost of isolated structure compared with the cost of traditional structure for the same earthquake conditions will be cheaper. The seismic isolation can be provided to new as well as existing structures. The buildings with provision of isolators can be planned as regular or irregular in their plan or elevations. Researchers are also working on techniques like tuned mass dampers, dampers using shape memory alloys etc. Tuned mass dampers are additional mass on the structure provided in such way that the oscillations of the structure are reduced to the considerable extent. The mass may be a mass of a solid or a mass of a liquid. Dampers using shape memory alloys are being tried as remedy to earthquake forces. In this system, super elastic properties of the alloy is utilized and there by consuming the energy in deformation at the same time the structure is put back to its original shape after the earthquake.

In 1909, a medical Doctor Calantarients in England applied for a British patent on an earthquake-resistant design approach. Frank(1921) was the first person to implement the idea of base isolation, He applied the base isolation idea to the foundation design for the Imperial Hotel in Tokyo in 1921, under the site was an eight feet layer of fairly good soil and below that a layer of soft mud. Accordingly, the idea of floating the building came into the picture for the resistance of earthquake shock.

The flexible first-storey concept was first proposed by Martel (1929) and further studied by Green (1935), Jacobsen (1938). In this approach the lateral stiffness of the columns of the first-storey would be designed to be much lower than that of the columns above, and 11 under earthquake loading the deformations would be concentrated in these first-storey columns.

In the search for a mechanism that can overcome the difficulty of a flexible first-storey, Ryuiti (1941, 1951, and 1952) and Caspe (1970, 1984) proposed many types of roller bearing system and several have been patented and tested. However, as the earthquake movement can be in any direction, these types of roller bearing system did not become popular. As a result, it made necessary to use spherical bearings or two crossed layers of rollers. Lee and Medland (1979) examined the effectiveness in respect of EI Centro earthquake excitation of a multi-storey shear type structure isolated by the lead rubber bearing. Tadjbakhsh and Ma (1982) and Pan and Kelly (1983, 1984) studied the seismic response of base isolated buildings by modeling the superstructure as a rigid block supported on an isolation system.

The hysteretic force deformation behavior of the lead rubber bearing is modeled as bi-linear. Tadjbakhsh (1983, 1985, 1985a) studied the response of a shear type building supported on the laminated rubber bearing system under random ground motion. Kelly and Tsai (1985) studied the seismic response of light internal equipment in base isolated multi degree shear type structures. They had shown that the use of base isolation can not only attenuate the response of the primary structural system but also reduce the response of the secondary systems. Mostaghel and Khodaverdian (1987) proposed the resilient-friction base isolation (R-FBI) system. Paul and Novak (1989) studied the response of base isolated building to wind loading by modeling the superstructure as a rigid block supported on an isolation system. Tasi and Kelly (1989) demonstrated effect of superstructure flexibility using a discrete multiple degrees of freedom system having only horizontal degree of freedom at each floor. Ghobarah and Ali (1989) proposed a simple 12 design procedure for highway bridges, which aims at optimum balance between the shear forces transmitted to the supports and tolerable deck displacements for isolated highway bridges using the inelastic response spectra approach. Simplified charts are presented which provide a design aid for new bridges as well as the retrofitting and upgrading of existing ones. The method is shown to be simple and reasonably accurate. It takes into account the flexibility of the pier and is suitable for a code-type approach.

3. OBJECTIVES

The objectives of the project are in the form of the following things:

- ❖ To lengthen Period of vibration.
- ❖ To reduce Relative displacements.
- ❖ Maintain Rigidity at low seismic intensity of loads.
- ❖ To construct earthquake resistant building.(prototype)
- ❖ To carry out comparison between fixed base and base isolated building on the basis of their dynamic properties.

4. SCOPE

- ❖ Base isolation provides an alternative to the conventional, fixed base design of structures.
- ❖ Base Isolation minimizes the need for strengthening measures of adding shear walls, frames, and

ISSN 2229-5518

bracing by reducing the earthquake forces imparted to the building.

- Base isolation had the effect of reducing the earthquake force demands on the superstructure to 30% of the demands for a fixed-base structure.

5. ISOLATION DEVICES

For superior seismic isolation of a structure has to choose the appropriate system and the essential features for such system should be as follows:

- Capable in supporting the structure
- Provide horizontal flexibility
- Capable to dissipate energy

6. MATERIALS USED

- Lead (Base isolators)
- Steel rod (column)
- Theirion sheet (slab)
- Plywood (Foundation)

6.1 MATERIAL PROPERTIES

Horizontal layers of natural or synthetic rubber in thin layers bonded between steel plates. The steel plates prevent the rubber layers from bulging and so the bearing is able to support higher vertical loads with only small deformations. Plain elastomeric bearings provide flexibility but no significant damping and will move under service loads.

6.1.1. LEAD

A Lead is a soft, heavy, ductile bluish grey metal, and the chemical element of atomic number 82 .It has been used in roofing, plumbing, ammunition,

- Stiffness (G) – 130mpa
- Modulus of elasticity (E) – 160gpa
- Yield stress (fv) – 10mpa
- Modulus of rigidity (G) – 61gpa

6.1.2 STEEL ROD (GAIBON ROD)

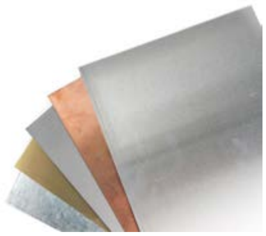
A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it.

- Poisson ratio – 0.27 to 0.3
- Tensile strength – 515 to 827mpa
- Modulus of elasticity (E) – 190 to 210gpa
- Yield strength – 207 to 552mpa

6.1.3 THEIRION SHEET

Sheet metal is metal formed by an industrial process into thin, flat pieces. It is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Countless everyday objects are fabricated from sheet metal. Thicknesses can vary significantly; extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.

- Tensile strength- 540mpa
- Modulus of elasticity – 200gpa
- Yield strength – 50mpa
- Poisson ratio – 0.291
- Hardness Rock well – 49



6.1.4 PLYWOOD

Plywood is a sheet material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotated up to 90 degrees to one another. It is an engineered wood from the family of manufactured boards which includes medium-density fibreboard (MDF) and particle board (chipboard).

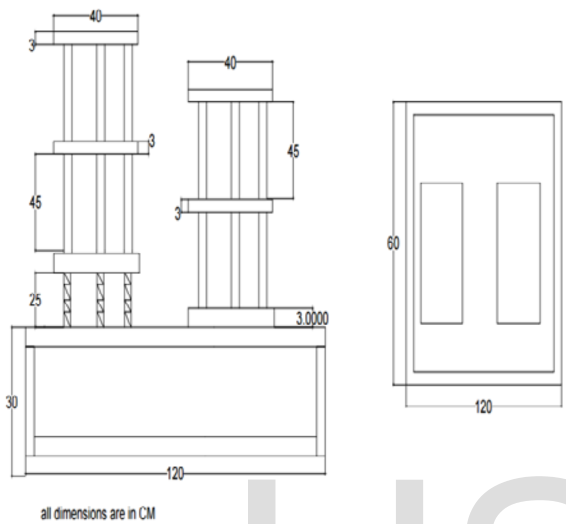
- Compressive strength – 1.62 to 3.626
- Young's modulus – 1 to 1.885 x 10^6 psi
- Modulus of rigidity – 0.23 to 0.36 x 10^6 psi
- Poisson ratio – 0.22 to 0.3
- Tensile strength – 1.45 to 6.38

7. CONSTRUCTION OF WORKING MODEL

In this we have designed and fabricated a model for base isolation

- These two models should be placed on a vibrating plate so that the base isolated model will be more stable and flexible when compared to the normal static building model.
- The basic principle behind base isolation is that the response of the structure or a building is modified such that the ground below is capable of moving without transmitting minimal or no motion to the structure above. A complete separation is possible only in an ideal system. In a real world scenario, it is necessary to have a vertical support to transfer the vertical loads to the base.
- The relative displacement of ground and the structure is zero for a perfectly rigid, zero period structure, since the acceleration induced in the structure is same as that of ground motion. Whereas in an ideal flexible structure, there is no acceleration induced in the structure, thus relative displacement of the structure will be equal to the ground displacement.
- No Structure is perfectly rigid or flexible, therefore, the response of the structure will be between the two explained above. Maximum acceleration and displacements are a function of earthquake for periods between zero to infinity. During earthquakes there will be a range of periods at which acceleration in the building will be amplified beyond maximum ground acceleration, though relative displacements may not exceed peak ground displacements. Base isolation is the ideal method to cater this, by reducing the transfer of motion; the displacement of building is controlled.
- The base-isolated building retains its original, rectangular shape. It is the linear bearings supporting the building that are deformed. The base-isolated building itself escapes the deformation and damage–which implies that the inertial forces acting on the base-isolated building have been reduced. Experiments and observations of base-isolated buildings in earthquakes have been shown to reduce building accelerations to as little as 1/4 of the acceleration of comparable fixed-base buildings, which each building undergoes as a percentage of gravity. As we noted above, inertial forces increase, and decrease, proportionally as acceleration increases or decreases. Acceleration is decreased because the base isolation system

lengthens a building's **period of vibration,** the time it takes for the building to rock back and forth and then back again. And in general, structures with longer periods of vibration tend to reduce acceleration, while those with shorter periods tend to increase or **amplify** acceleration.



7.1 VIBRATION TABLE

Vibration is a mechanical phenomenon where by oscillations occurs about an equilibrium point. The oscillations may be periodic, such as the motion of a pendulum or random, such as the movement of a tire on a gravel load.

7.2 TEST RESULTS

The following tables are shows the different parameter results for various horizontal force.

7.2.1 DEFLECTION

S.No	Conventional Frame		Base Isolated Frame	
	P in kN	δ in mm	P in kN	δ in mm
1	5	2	5	0.2
2	10	5	10	0.8
3	15	8	15	1
4	20	12	20	2.1
5	25	17	25	3.8
6	30	21	30	4.2
7	35	24	35	4.9
8	40	31	40	5.1

7.2.2 PERIOD OF VIBRATION

S.No	Conventional Frame		Base Isolated Frame	
	P in kN	T in sec	P in kN	T in sec
1	5	9	5	15
2	10	14	10	25
3	15	19	15	32
4	20	22	20	43
5	25	29	25	58
6	30	35	30	69
7	35	48	35	72
8	40	55	40	89

8. CONCLUSIONS

- Thus our test results shows base isolated frame can withstand more force compared to the conventional frames. The maximum force of **40kN** for conventional building is deflected up to **31mm** and period of vibration of **55 secs** and where the **same force** can deflect the base isolated building with lesser deflection of **5.1 mm** and the period of vibration of **89 secs**.
- Seismic base isolation method has proved to be a reliable method of earthquake resistant Design.
- The success of this method is largely attributed to the development of isolation devices and proper planning.
- Adaptable isolation systems are required to be effective during a wide range of seismic events**.**

REFERENCES

1. Eurocode 8. "European Standard, Design of structures for earthquake resistance. Part 1: Generalrules, seismic actions and rules for buildings." Draft no. 6, 2003.
2. Kelly JM. "The role of damping in seismic isolation." Earthquake Engineering and StructuralDynamics 1999; 28: 1717-1720.
3. Mazza F, Vulcano A. "Seismic response of buildings with isolation & supplemental dissipation at

ISSN 2229-5518
the base." Proceedings of the 5th World Congress on Joints, Bearings and Seismic Systems for Concrete Structures, Rome, Italy, 2001, CD-ROM.

4. Vestroni F, Vulcano A, Di Pasquale G. "Earthquake response analysis of a nonlinear model of a base-isolated structure." Proceedings of the International Meeting on Earthquake Protection of Buildings, Ancona, Italy, 1991; 181/C-190/C.

5. Jangid RS, Kelly JM. "Base isolation for near-fault motions." Earthquake Engineering and Structural Dynamics 2001; 30: 691-707.

6. Makris N, Chang S-P. "Effect of viscous, viscoplastic and friction damping on the response of seismic isolated structures." Earthquake Engineering and Structural Dynamics 2000; 29: 85-107.

7. Dolce M, Cardone D, Nigro D, Ponzo FC, Nicoletti M, La Monaca B. "Experimental comparison between conventional and innovative base isolation systems on a 1:2:5 scaled reinforced concrete frame." Proceedings of the 12th European Conference on Earthquake Engineering, London, UK. Paper no. 746. Elsevier Science Ltd, 2002.

8. Naeim F, Kelly JM. "Design of seismic isolated structures." John Wiley and Sons, New York, USA, 1999.

9. Skinner RI, Robinson WH, McVerry GH. "An introduction to seismic isolation." John Wiley and Sons, Chichester, England, 1993.