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BASE ISOLATION SYSTEM FOR EARTHQUAKE RESISTANT STRUCTURES

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ABSTRACT

Earthquakes constitute one of the greatest hazards of life and property on the earth. The earthquake resistant construction is considered to be very important to mitigate their effects. Due to suddenness of their occurrence, they are least understood and most dreaded. This paper presents the brief essentials of earthquake resistant construction and a few techniques to improve the resistance of building and building materials to earthquake forces, economically.

Keywords*: TYPES OF BEARING ,EARTHQUAKE ,STRUCTURAL BEARING , BASE ISOLATION .*

I. INTRODUCTION

Base isolation (BI) is a mechanism that provides earthquake resistance to the newstructure. The BI system decouple the building from the horizontal ground motion induced by earthquake, and offer a very stiff vertical components to the base level of the superstructure in connection to substructure (foundation). It shifts the fundamental lateral period, Ta, dissipates the energy in damping, and reduces the amount of the lateral forces that transferred to the inter-story drift, and the floor acceleration. The Structural Engineers Association of Northern California(SEONC) published a simple regulation titled "Tentative Isolation Design Requirements" in1986, which laterwas added as provisions in the Uniform Building Code 1997, FEMA 273 with exception of permit to pushover, and IBC2000.The structural bearing criteria include vertical and horizontal loads, lateral motion, and lateral rotation that transferred from the superstructure into the bearing and from the bearing to the substructure. Bearing allows for stress-free support of the structure in terms of (1) they can rotate in all directions, (2) they deform in all directions, (3) they take horizontal forces (wind, earthquake).Base isolation (BI) system for buildings is introduced to decouple the building structure from potentially damaging induced by earthquake motion, preventing the building superstructures from absorbing the earthquake energy. The mechanism of the base isolator increases the natural period of the overall structure, and decreases its acceleration response to earthquake / seismic motion. Base-isolation relies on the structural bearing, which is the connection element between the superstructure and substructure to dissipate the horizontal displacement, rotation or translation, as shown in Figure 2.1. The bearing that prevents translation is called a fixed bearing or fix point bearing if it is fixed in all directions; it is called a unidirectional movable bearing or a guided bearing. Base shear introduced due to seismic ground acceleration for fixed base building or base-isolated building is investigated .

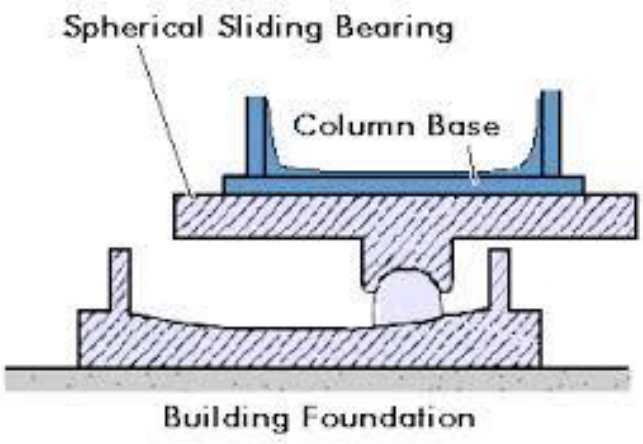

Fig .1 Building Isolation

Problems due to earthquake:

Reducing the effect of the horizontal forces generated from wind pressure orearthquake load is of great concern to designers. The structural bearing technique is one ofthose tools to reduce the lateral displacement of the building, to increase the structural safety,and to increase the human comfort during the occurrence of such event. This study tries ofclarify the advantage of the base isolation technique with respect to buildings since only fewresearches were done into this area.

Fig 2.Earthquake effects

II. HISTORY OF BASE ISOLATION

The first base isolation was registered as a patent in 1800's, and the one of the first few buildings that used the base isolation was in early 1900's in Tokoyo Imperial Hotel, in which after that structural bearing commercially used in bridge construction. The first material used for BI was made of lead rubber bearing (LBR) providing high flexibility and damping. In early 1980's the high damping rubber (HDR) was used in US. But the drawback was that these products have no restoring force where they dislocate after the shaking force. The developed friction pendulum system (FPS) in shape of spherical surface overcomes this demerit of sliding bearing, and providing a restoring force. "Since 1840's the natural rubber has been used for base isolation, through the process of material development synthetic rubber or polytetrafluoroethylene (PTFE) which is developed by DuPont was used, and designed for 50 years or more. About 40 years ago, the elastomeric (layered rubber and steel) was used in bridges, providing an increase of 7% in stiffness after 37 years from installation, with oxidation restriction to 10 mm to 20 mm. Few design equations were developed for base isolation and bearing by codes committees like UBC, IBC2000, FEMA273, NZS4203, CHBDC S6, AISI and AASHTO LRFD for bridges. According to the CHBDC, clause 11.6.11, it states "Bearing shall support and transfer all loads while accommodating translations and rotations in the structure", also added in clause 1.8.3.3 that "Bridges with superstructures supported on bearings shall be designed to permit the jacking of the superstructure. Jack and shimming locations shall be shown on the drawings. The design shall allow for movement at the permanent bearing locations sufficient to permit bearing replacemet". Building should have the same provisions for bearing and its replacement as per CHBDC as well. Nevertheless more provision must be added for building since it is more complex structure than that of bridges. Due to the presence of the base isolation, the superstructure of the building above ground needs a transfer slab. sometimes lateral movement is restrained at selected bearing. Design procedures of BI building can be listed as:

- Response spectrum method
- Time history analysis
- Ultimate capacity of isolator

Where a study for the restoring system must be considered

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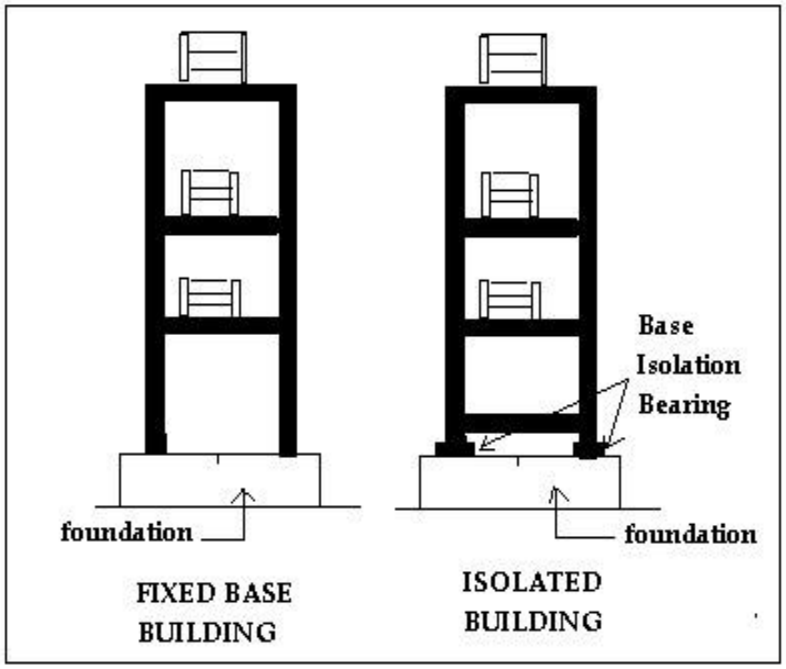

Fig 3.Bulding Base Isolation

III. COMMON TYPE OF STRUCTURAL BEARING:

Base-isolation may be referred to its function, main material, or may receive a combined terms. The main functions maybe listed as:

- Point rocker bearing
- Sliding bearing
- Pot bearing
- Spherical bearing
- Deformation bearing
- Fixed bearing
- Movable bearing
- Restraints
- Guide bearing

The Base-Isolation can be referred to the main material:

- Steel bearing
- PTFE bearing (polytetrafluoroethylene)
- Elastomeric bearing (reinforced/not reinforced)

The Base 10 Isolation can also be referred as of combined terms:

- Point rocker sliding bearing
- Pot sliding bearing
- Spherical sliding bearing
- Deformation sliding bearing

Types of structural bearings

In revision to the CHBDC clause 11, the code requires that the bearings (1) carry high permaent compression load with minimum compression deflection; (2) to accommodate horizontal movement by shear deflection with low shear

stiffness to prevent excessive loads on the buildings footings due to thermal expansion and contraction; (3) to accommodate rotational deflections due to the transfer slab hogging and sagging; (4) to accommodate live loads with minimal additional compressive deflection; (5) to have a natural frequency particular to the application. The standards recognized the bearing as follows:

- Plain elastomeric
- Natural Rubber (polyisoprene)
- Neoprene (polychloroprene)
- Steel reinforced elastomeric
- Roller bearing
- Rocker bearing
- Pot bearing
- Disc bearing
- Spherical and cylindrical bearing

Where factors affecting the selection criterion include:

- Dead load
- Total load
- Lateral load
- Uplift
- Rotations
- Translations
- Cost and Durability.

Pot bearing

- Pot bearingsare designed to carry combinations of vertical loads, horizontal loads, longitudinal and transversal movements, and rotations.
- This type of bearing can carry very high loads of over 50,000 kN. A completely encased natural rubber pad is positioned in a steel pot.
- Under high pressure the pad behaves like a liquid. The elasticity of the rubber allows tilting movement (rotation) of the piston in the horizontal axis.

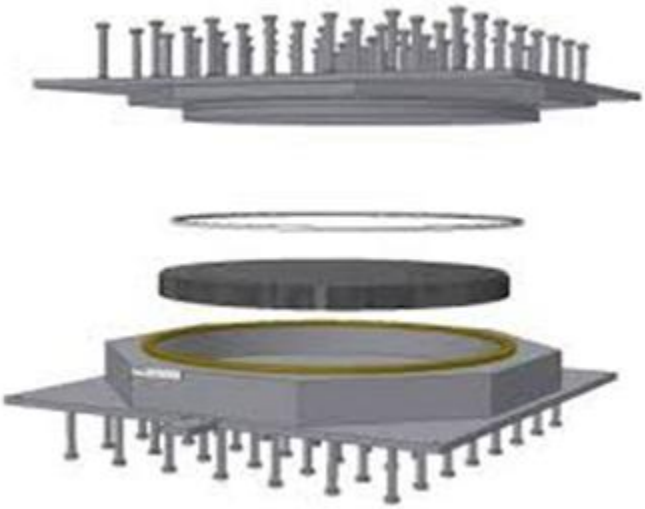

Fig 4 Pot Bearings

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Roller Bearing

- Rolling bearingis a bearing which carries a load by placing round elements between the two pieces.
- The relative motion of the pieces causes the round elements to roll with very little rolling resistance and with little sliding.

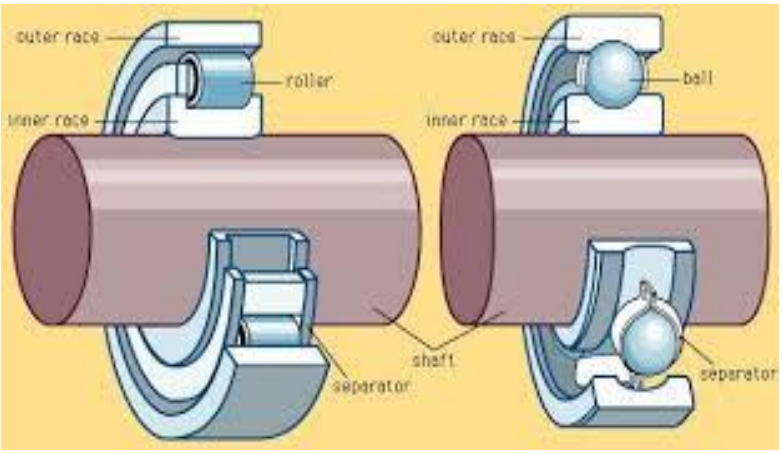

Fig 5 .Roller Bearing

Elastomeric Bearing

- Elastomeric bearingdeveloped in 1936 and consists from circular or rectangular laminated pads, layers made of reinforced rubber, and layers made of steel plates.
- The horizontal displacement is resisted by the friction forces F which depends on the compressive force C of these bearing, and its coefficient of friction p, with
- F = Cp.

Spherical Bearing

- Spherical bearingconsists from three main parts; the pan, the sphere part, and the upper plate made of constructional steel.
- The horizontal displacement causes friction resistance, and moment due to rotation.

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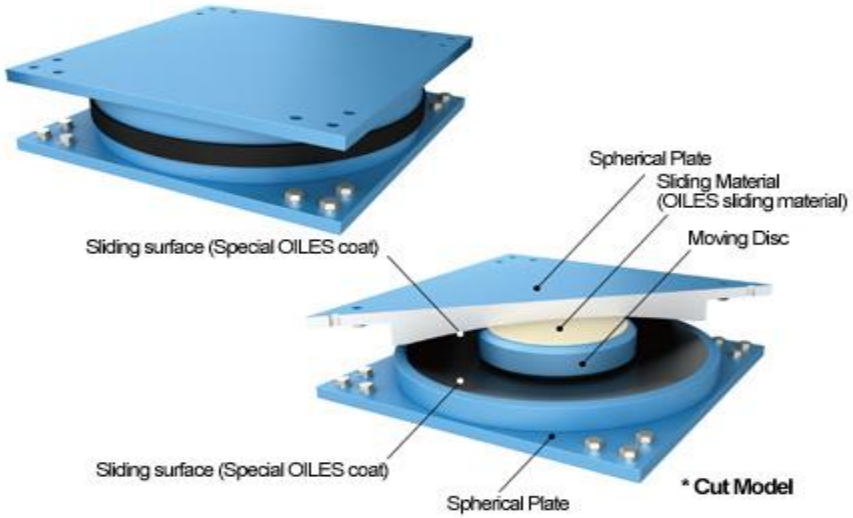

Fig 6. Spherical Bearing

Rocker Bearing

- Rocker bearing consist of one or more rollers of steel along with a rocker arrangement which permits a longitudinal and rotational movement.
- There are three types of Linear Rocker Bearings: fixed, guided-sliding and free-sliding Linear Rocker Bearings.
- Disc Bearingaccommodates rotation by deformation of a single elastomeric disc, molded from a urethane compound.
- It may contain a device for partially confining the disc against lateral expansion
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Fig 7 Rocker Bearing

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IV. STUDY OF PASADENA CITY HALL

Fig 8 Pasadena City Hall

History Of Pasadena Hall:

In 1923, the people of Pasadena approved a bond measure issuing $3.5 million towards the development of a civic center. City Hall was to be the central element of this center. The San Francisco architecture firm of Bakewell and Brown designed City Hall, which has elements of both Mediterranean Revival Style and Spanish Colonial Revival Style architecture. It was completed on December 27, 1927 at a cost of $1.3 million. It measures 361 feet (110 m) by 242 feet (74 m), and rises 6 stories. There are over 235 rooms and passageways that cover over 170,000 square feet (16,000 m^2). The defining dome, located above the west entrance, is 26 feet (7.9 m) tall and 54 feet (16 m) in diameter. On July 28, 1980 the Civic Center District, including Pasadena City Hall, was listed on the National Register of Historic Places as listing #80000813.

Seismic Rehabilitation Of Pasadena City Hall

The friction pendulum sliding FPS isolator, as shown in Figure 2.26 has a great impact in reducing the base shear effect as shown in Figure 2.27. Figure 2.28 show structural detailing for the proposed system, which was successfully used in In California, U.S., for the historical Pasadena City Hall, as shown Figures 2.29 & 2.30. The building was rehabilitated with the seismic isolation that consists of removal of the original basement floor slab, excavation and installation of new foundation, placement of a new basement transfer system, and installation of 240 friction pendulum sliding (FPS) isolators between the foundation and basement level.

V. CONCLUSION

The report comprises with the above bearing showing the importance and necessitiy during the planning of any building either resisdential or public. It is important to use "BASE ISOLATION TECHNIQUES".Base isolation system for building is introduced to decouple the building structure from potentially damaging induced by earthquake motion, preventing the building superstructure from absorbing the earthquake energy. The mechanism of the base isolater increases the natural period of the overall structure and decreases its acceleration response to earthquake, seismic motion. A steel building with structure rubber bearing is introduced throughout this study.The study analysis performed to check for the accurancy of base isolation against building drift and inter story drift as per allowance in National Building code of Canada 2010

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