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EATHQUAKE RESISTANT STRUCTURES USING VOIDED SLAB SYSTEMS

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ABSTRACT

The field of Earthquake Engineering has existed in our country for over 35 years now. Indian earthquake engineers have made significant contributions to the seismic safety of several important structures in the country.

However, as the recent earthquakes have shown, the performance of normal structures during past Indian earthquakes has been less satisfactory. This is mainly due to the lack of awareness amongst most practicing engineers of the special provisions that need to be followed in earthquake resistant design and thereafter in construction.

This project describes an experimental and theoretical study of the feasibility of using Kinematic bearings with voided slab system (U-boot Beton) to produce Lightened intermediate slabs, more stability to structure. It is assumed to be flexible in extension, but completely without flexure rigidity. The fiber-reinforced isolator is significantly lighter and can be made by a much less labor-intensive manufacturing process.

The slab is very important structure member in building and slab is one of the largest member consuming concrete. When the load acting on the slab is large or clear span between columns is more, the slab thickness is on increasing. To avoid this voided slab System (U-BOOT TECHNOLOGY) is used and to Construct a Durable and Economical High rise building in Earthquake zones. It leads to consume more material such as concrete and steel, due to that self-weight of slab is increase. To avoid this voided slab System (U-BOOT TECHNOLOGY) is used.

KEYWORDS: seismic isolation, elastomeric isolators, dead load, laminated rubber bearings, polypropylene.

INTRODUCTION

When designing a reinforced concrete structure, a primary design limitation is the span of the slab between columns. Designing large spans between columns often requires the use of support beams and/or very thick slabs, thereby increasing the weight of the structure by requiring.

In seismically active regions because a larger dead load for a building increases the magnitude of inertia forces the structure must resist as large dead load contributes to higher seismic weight. Incorporating support beams can also contribute to larger floor-to-floor heights which consequently increases costs for finish materials and cladding.

A new solution to reduce the weight of concrete structures and increase the spans of two-way reinforced concrete slab systems was developed in the 1990s in Europe and is gaining popularity and acceptance worldwide. Plastic voided slabs provide similar load carrying capacity to traditional flat plate concrete slabs but weigh significantly less. Plastic voided slabs remove concrete from non-critical areas and replace the removed concrete with hollow plastic void formers while achieving similar load capacity as solid slabs.

This Project examines the design process of plastic voided slabs. The principles behind plastic voided slab systems are presented. Before plastic voided slabs can be fully understood, a thorough knowledge of flat plate reinforced concrete slabs- behavior, failure mechanisms, design, and limitations- is critical. Traditional flat plate reinforced concrete slabs by describing how the slabs are constructed and resulting advantages and disadvantages of this construction. The design procedure and failure mechanisms for solid slabs are also described. The principles of using voids in slabs have been applied in various applications for many years. The principles of voided slabs that led to the eventual invention of plastic voided slabs including previous applications of voided slab principles.

METHODS USED FOR PREVENTING STRUCTURAL DAMAGE

1. Base isolating the building.
2. Use of Damping Devices

2.1 BASE ISOLATION SYSTEM

Base isolation is the components of earth's ground motion by mounting rubber bearings between building and foundation. When a building is built away (isolated) from the ground, resting on flexible bearings or pads known as base isolators, it will only move a little or not at all during an earthquake.

2.2 KINEMATIC BASE ISOLATION SYSTEM

Kinematic bearing base isolation system is groups of vertical floating piles connected through rigid massless caps and subjected to vertically propagating harmonic *S*-waves. It was invented in Sochi city situated in Krasnodar kai, Russia. It is a type of pile made up of laminated layers of rubber and steel to provide high axial stiffness and low lateral stiffness.

Fig 1 kinematic Bearing

2.3 TECHNICAL DETAILS

1. Kinematic bearings can accommodate movement amplitude up to 80 cm.
2. Kinematic bearings can reduce horizontal accelerations by 0.8 m/sec^2
3. Kinematic bearings use fairy little rooms in basement, leaving enough space for parking and other usages.
4. Kinematic bearings do not react with wind.

2.4 VOIDED SLAB SYSTEM

Voided biaxial slabs are reinforced concrete slabs in which voids reduce the amount of concrete and steel by placing different type of formworks or materials.

Bubble Deck is one brand of plastic void system which uses a precast filigree method to form voided slabs. In this method, the voids are assembled in steel cages and then concrete is poured to a height part way up the voids.

The slab panels (filigree) are typically eight feet (2.5m) wide and thirty feet (9m) long. The filigree are then transported to the construction site and lifted in place by crane. Once in place, the top layer of concrete is placed, covering the voids and completing the slab. Wire trusses run between the precast and cast-in-place layers of concrete to ensure that the two layers bond properly.

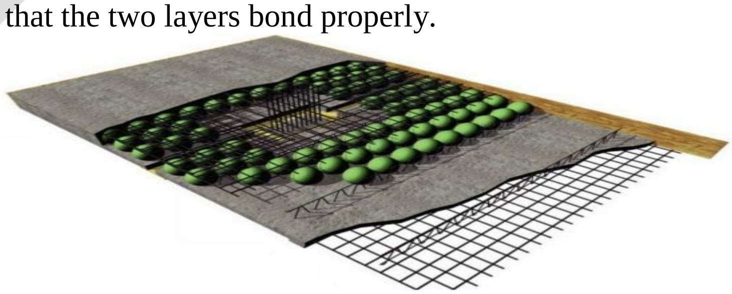

Fig 2 Bubble Deck

Cobiax is another major brand of plastic void system. As compared to the Bubble Deck filigree system, Cobiax systems are an on-site application. When using Cobiax, workers first must use deck forms to form the bottom of the slab and the bottom layer of reinforcing steel must also be placed.

The voids arrive at the site bundled in steel wire cages which can be altered to fit the particular application, but the void bundles are secured to the reinforcement steel. After the bundles are in place, the top layer of reinforcement can be placed.

Concrete is then placed in two lifts. Similar to the filigree method, the first lift covers the bottom reinforcement and a portion of the voids and holds the voids in place as the concrete becomes stiff. The second lift is poured after the first lift is stiff but still fresh, finishing the slab. This method requires more formwork and on-site labor than the Bubble Deck filigree method, but requires less transportation of materials.

Fig 3 Cobiax

2.4.1 UBOOT BETON

U-Boot is a recycled polypropylene formwork that was designed to create lightened slabs and rafts. U-Boot is used to create slabs with large span or that are able to support large loads without beams.

It is a recyclable material which is used in construction. It is a lightweight material; its Tensile strength is quite high. It shows strong resistance to stress and cracking. It can be moulded in any shape. It is an excellent insulator. Its melting point is above 160^{D}C.It is corrosion resistance. It is good moisture absorbent. It is a non-toxic substance. It does not get stained easily. It can retain its stiffness and flexibility intact at high temperatures.

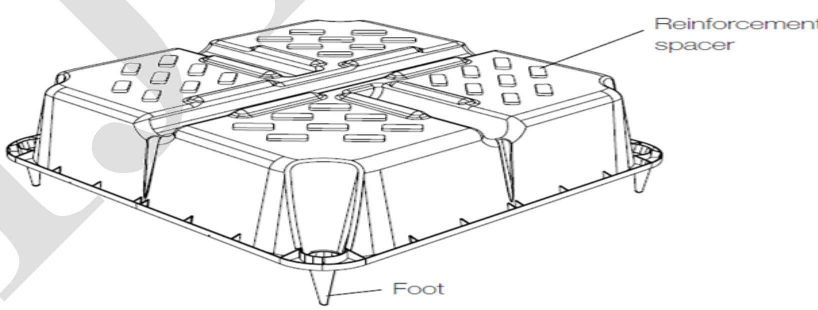

Fig 4 UBoot Beton

2.4.2 EFFECT ON DESIGN

The Unique invention is the arrangement is made such that it forms indirectly a I-SECTION beam in slab perpendicular to each other by which the load is distributed bidirectional.

Plastic voided slab systems can reduce the dead load of slabs by as much as 35% when compared to solid slab construction with the same capacity. Lighter slabs affect many aspect of structural design such as floor-to-floor height, column reinforcement, size, seismic effects & sustainability.

By eliminating unnecessary concrete and reducing floor weight, voided slabs are able to achieve longer spans than traditional slabs. Typically, voided slab systems are thicker than solid slabs with the same capacity, but voided slab systems usually do not require beam supports. The cumulative height of beams and solid slabs is generally more than the height of voided slabs, meaning that the utilization of avoided slab can allow for reduced floor-to-floor heights.

Lighter floors mean smaller columns are able to be used as well as less reinforcing steel. One of the biggest advantages of voided slabs is seismic performance.

In plastic void construction, the voids are made using recycled plastic and the steel is made using recycled steel. If desired, the concrete can even be made using recycled aggregate. All these different aspects lead to a high degree of sustainability and an environmentally friendly design.

METHODOLOGY

There are many methods of preventing structural damage like Base isolation, seismic damper and these two are commonly used.

3.1SEISMIC DAMPERS - A mechanical device to dissipate kinetic energy of seismic waves penetrating a building structure.

3.1.1TUNED MASS DAMPER- Typically the tuned mass dampers are huge concrete blocks mounted in skyscrapers or other structures and moved in opposition to the resonance frequency oscillations of the structures by means of some sort of spring mechanism. Hysteretic dampers-Hysteretic damper is intended to provide better and more reliable seismic performance than that of a conventional structure at the expense of the seismic input energy dissipation. There are five major groups of hysteretic dampers used for the purpose, namely.

3.1.2 FLUID VISCOUS DAMPERS (FVDS) - Viscous Dampers have the benefit of being a supplemental damping system. They have an oval hysteretic loop and the damping is velocity dependent. While some minor maintenance is potentially required, viscous dampers generally do not need to be replaced after an earthquake. While more expensive than other damping technologies they can be used for both seismic and wind loads and are the most commonly used hysteric damper.

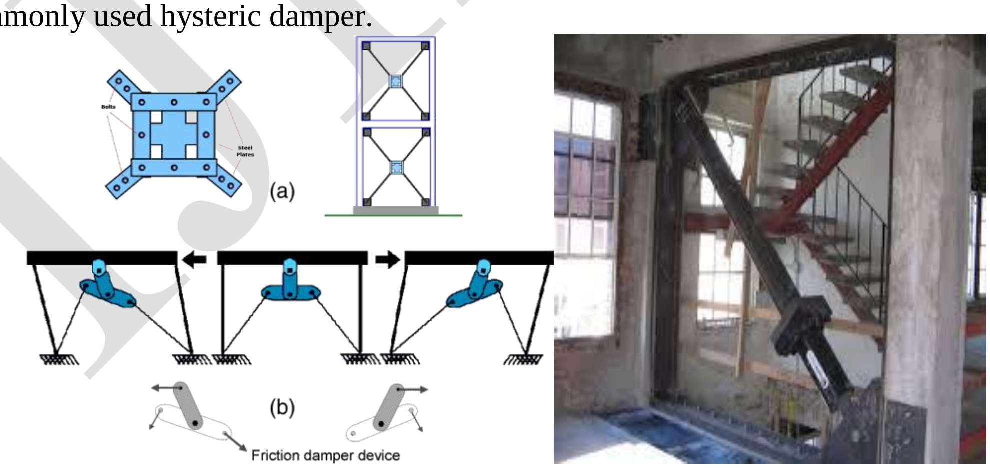

Fig 5 Fluid Viscous Damper

3.1.3 Friction dampers (FDs)- Friction dampers tend to be available in two major types, linear and rotational and dissipate energy by heat. The damper operates on the principle of a coulomb damper. Depending on the design, friction dampers can experience stick-slip phenomenon and Cold welding.

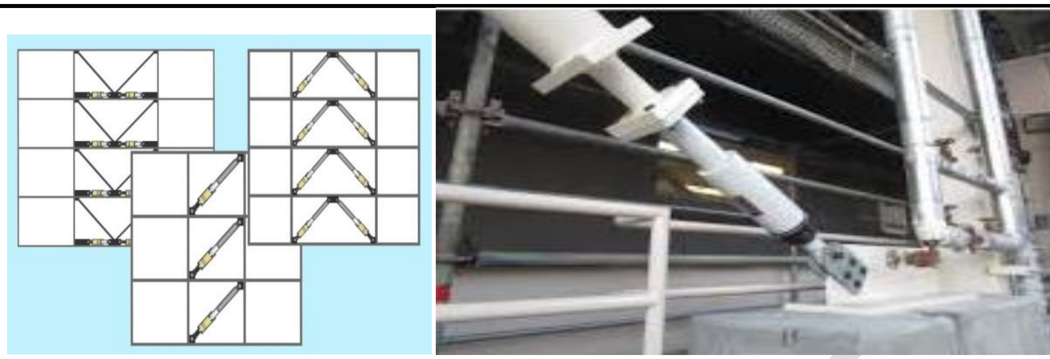

Fig 6Friction Damper

METALLIC YIELDING DAMPERS (MYDS) -Metallic yielding dampers, as the name implies, yield in order to absorb the earthquake's energy. This type of damper absorbs a large amount of energy however they must be replaced after an earthquake and may prevent the building from settling back to its original position.

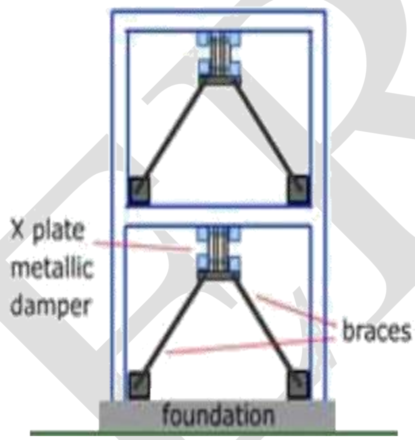

Fig 7 Metallic Yielding Damper

Viscoelastic dampers (VEDs) - Viscoelastic dampers are useful in that they can be used for both wind and seismic applications, they are usually limited to small displacements. There is some concern as to the reliability of the technology as some brands have been banned from use in buildings in the United States.

Fig 8Viscoelastic Damper

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Base Isolation System-Base Isolation seeks to prevent the kinetic energy of the earthquake from being transferred into elastic energy in the building. These technologies do so by isolating the structure from the ground, thus enabling them to move somewhat independently. The degree to which the energy is transferred into the structure and how the energy is dissipated will vary depending on the technology used.

LEAD RUBBER BEARING - Lead Rubber Bearing or LRB is a type of base isolation employing a heavy damping. It was invented by Bill Robinson. It provides high axial stiffness and low lateral stiffness during earthquakes.

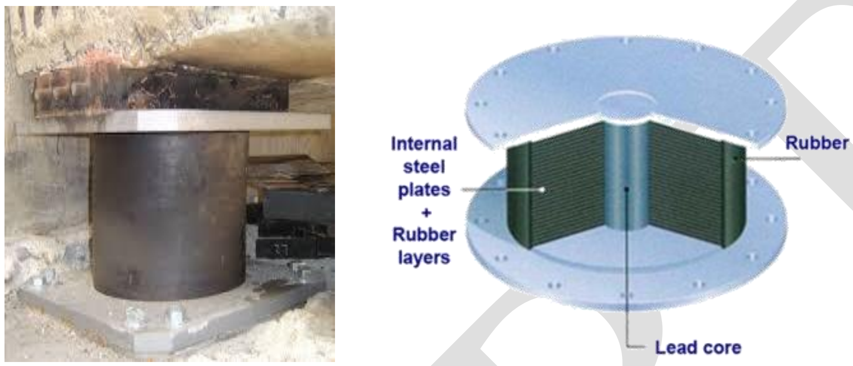

Fig 9 Lead rubber bearing

Springs-with-damper base isolator - Springs-with-damper base isolator installed under a three-story town-house.

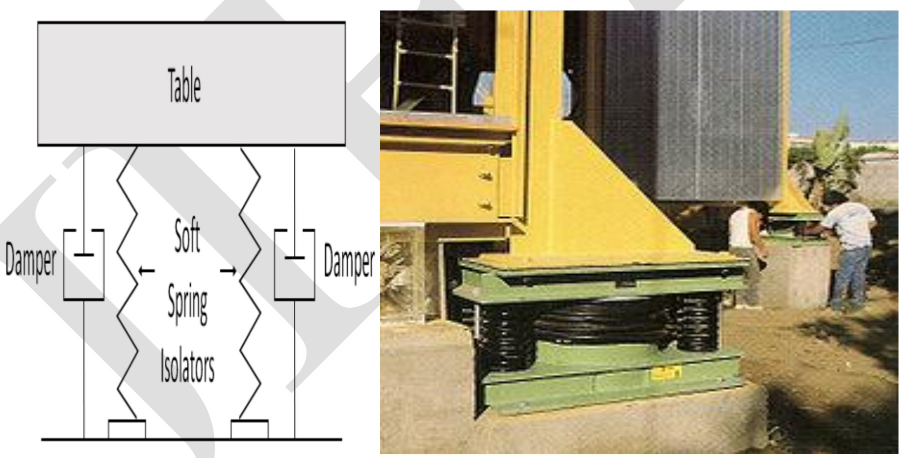

Fig 10 Springs With Base Isolator

Simple roller bearing - Simple roller bearing is a base isolation device which is intended for protection of various building and non-building structures against potentially damaging lateral impacts of strong earthquakes.
Friction pendulum bearing-Friction Pendulum Bearing (FPB) is another name of Friction Pendulum System (FPS). It is based on three pillars like articulated friction slider; spherical concave sliding surface; enclosing cylinder for lateral displacement restraint.

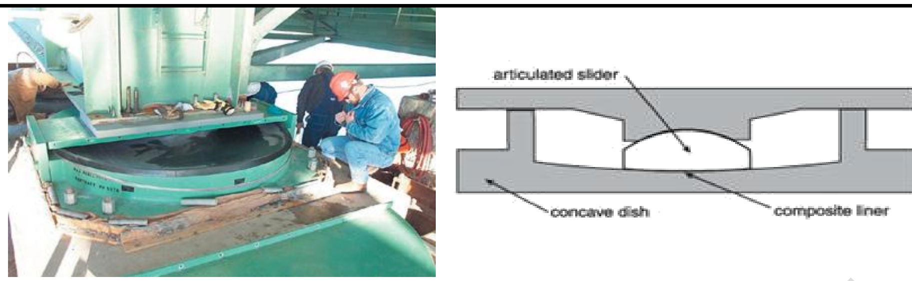

Fig 11 Friction Pendulum Bearing

ADVANTAGES

1. Structure will be durable.
2. Earthquake proof up to 6.0 magnitudes on Ritcher scale.
3. The Design of structure is simple.
4. Economical than any other system.
5. Kinematic Bearings and Uboot beton reduce usage of steel and concrete in construction of the whole building, reducing its cost by 10% to 15%.
6. No heavy equipment required.
7. Reduces Dead load up to 50% and concrete up to 40%
8. Simple, monolithic behavior, uniform and continuous distribution of Forces.
9. Eliminates beams in structure.
10. Reduced Deformation (maximum stiffness loss up to 15%.
11. Reduces number of columns.
12. Flexible design easily adapts to irregular and curved plan layouts, longer spans and fewer supports.
13. Reduces slab thickness, thus more no of floors.
14. 1kg of plastic replaces 100kg of concrete.
15. Structure is fire Resistant.

APPLICATIONS

There are many applications of UBoot all over the world. But In India, there only three structures.

Fig 12UBoot in Foundaion

CERTIFICATIONS AND TESTIMG OF PRODUCT

1. Fire resistance Certification REI 180 for U-Boot Beton issued by the CSI of Bollate (MI).
2. Load Test Certificate with Slab U-Boot Beton issued by the University of Darmstadt.
3. Acoustic test according to UNI EN ISO 140-6 - Measurement of sound insulation in buildings and of building elements Laboratory measurements of impact noise from footsteps of attics issued by Istituto Giordan

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4. Acoustic test according to UNI EN ISO 140-3 - Measurement of sound insulation in buildings; Laboratory measurements of sound insulation by air of building elements issued by Istituto Giordano of Gatteo (FC).
5. Loading and breaking test certified by the University of Padua.
6. Certification System according to UNI EN ISO 9001, ISO 14001 and SA 8000.
7. Environmental Compatibility Certification (CCA).
8. A member of the Green Building Council Italy
9. Daliform Group proves once again extremely careful to respect health and environment managing to get first the Environmental Compatibility Certification (CCA) for its products. Importance of this Certificate for U-Boot Beton is ragguardavole because it demonstrates: the' absence of hazardous substances in the composition (although they employ recycled materials); 's lack of emissivity of toxic substances during the different stages of the life cycle and product processing with resulting benefits for the health of the intermediate users (production workers and installation personnel) and final (people living in the building) is in general for the environment.

CONCLUSION

The main aim of our Project is to safeguard the earth prone areas. In India various regions such as Kashmir, Northern and Central Himalayas, North Bihar are the following regions fall in the Zone V. Since Delhi is the capital of India also falls under the Zone IV which causes severe damages to Structures as well as Habitants.
Also to reduce structure weight with minimum impact to overall building design. It also reduces the amount of concrete in structure reducing the overall building cost by 10%-15%. Steel which is today the most expensive material in construction is reduced to large extent.
This technology is environmentally green and sustainable and as to save human life and property in seismic zones USING VOIDED SLAB SYSTEM EARTHQUAKE RESISTANT STRUCTURES should be constructed.

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