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Case Study of Earthquake Resistant Structure and Its Recent Innovation In Construction

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ABSTRACT- Earthquakes may create various kinds of causalities like loss of life and damage of property depending upon its magnitude; causalities could range from small property damage to landslides and a long range of liquefaction. Secondary effects like fire; blockage on services such as water supply, electricity, and transportation; and communication disruption are even more disastrous.Man-made infrastructures are however the major contributor of casualties during earthquake devastations. These structures therefore should be carefully designed and constructed.It is very important to develop new technologies to minimize these losses. Thus, we started to do research regarding these new techniques and to improve our knowledge and become aware of these recent methods and their usage in our daily life to optimize earthquake effects on our structures. We cannot make fully earthquake-proof structures but we will reduce its damage and make structures earthquake resistant. In this research paper, we will discuss modern technologies that make our structure earthquake resistant.

KEYWORDS- Advanced Techniques, Earthquake, Effective Designs Process, Ideal Resistant Ratio, Structure failure

I. INTRODUCTION

An earthquake is the sudden shaking of the surface of the earth caused by the passage of seismic waves through the earth's crust. During the earthquake, vibrations occur in all directions radiating from the epicenter. The sudden release of energy cause structure to vibrate and inertia forces are acting on them. Most of the earthquakes are result from tectonic events, primarily movements on the faults, and remaining related to the manmade.The lack of earthquake knowledge and its incorporation in the building design and execution leads to the failure of structures.

Some of the reasons behind building failures are

- Vertical and horizontal movement and the inertia of buildings cause frequent changes in buildings' weight.
- Use of poor-quality material.
- Massive structure (greater the mass of the structure, more the lateral force is exerted on the building).
- More the height of building, lesser its stability.

There are 9 severe earthquakes has witnessed by India in the last 3 decades between 1990 to 2020 and reports claim the number of causalities approx. 30500. Although, certain parts of the country are more prone to earthquakes (seismic zone V of IS 1893(Part 1)- 2016) than the others [4]. No region can be considered free from earthquakes. In the Indian scenario,minor earthquakes are reported near the seduction zone (Himalayan belt) on a daily basis, whereas in the interpolate region (Deccan plateau) few major earthquakes have been observed over the years. The performance of the built environment during the past earthquakes has shown its brittle nature and has created an itch among the engineers and architects to move towards seismically efficient buildings.

Analysis of earthquake resistant Design structures against natural earthquakes he said that buildings can effectively protect against earthquake using multiple design options[3].Load factors of earthquake designing structures where a number of options, details for earthquake types can be found[9].

About 60 % of the Indian landmass, is susceptible to moderate to very severe earthquakes. A great earthquake in an unoccupied area may produce minimum damage when compared to a moderate earthquake in a densely populated area. All the field survey studies conducted after a major earthquake suggested that the maximum casualties reported were caused by structure collapse.The seismic performance of a building during an earthquake depends on its shape, size, geometry, and the nature of the load path. The aim of seismic design philosophy is to ensure the safety of structural components and human life. Design philosophies state that the load-bearing structural elements must suffer no damage in the case of a minor shaking, sustain repairable damage in the case of moderate shaking and sustain severe damage without collapse under strong shaking.

RESEARCH OBJECTIVE

The main aim of a structural engineer is to prevent the structural damages that are caused due to earthquakes.
So, the main objective of this paper is to fulfil the following.

- To increase the stability of structures against inertial forces using modern techniques
- To know about new and advanced methods for earthquake-resistant structures.
- To prevent deflection of structure which causes failure by using new and advanced methods.

II. METHODOLOGY

Since it is clear that our main reason for this research is to make the public aware and improve towards this ruinous phenomenon that is Earthquake matter.We have decided to research new technologies for the construction of earthquake-resistant structures, starting with local building projects, and then discovered and cited new approaches that the world is still using right now. Thus,the methodology process is given below

- Creating idea
- Evaluation for its necessity
- Supervising projects
- Researching website
- Collecting information
- Conclusion

III. NECESSITY FOR EARTHQUAKE-RESISTANT CONSTRUCTION

As per census 2011 India, there are more than 330 million dwelling units in the country, two-thirds out of which are rural households. According to India's geological survey, the country has been classified into four seismic zones having different seismic capabilities as shown in Figure1 [10]

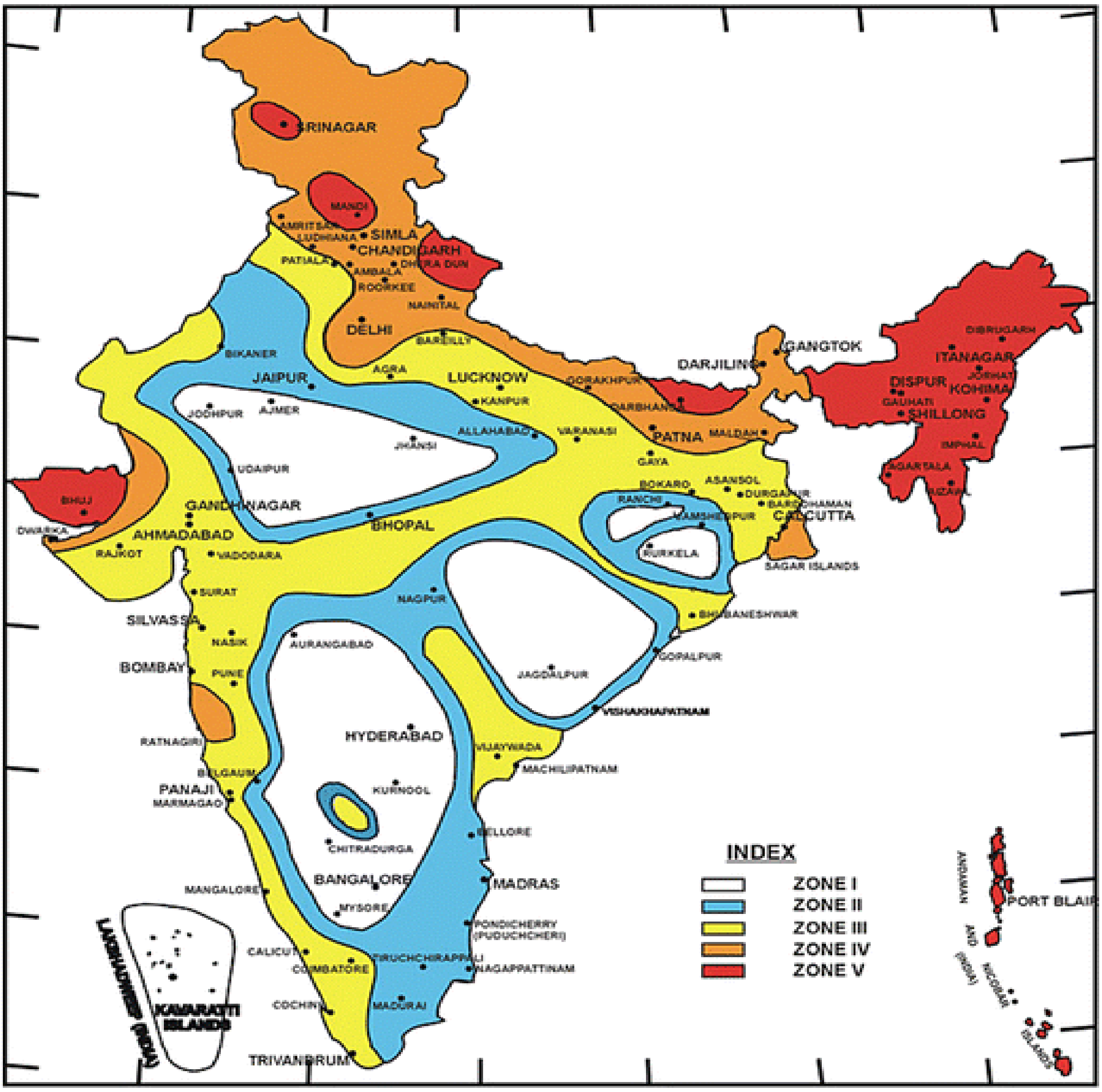

Figure. 1: S eismic zonation map of India

On the other hand, up to more percentage of housing reserves in rural areas, the urban population grew rapidly during last decade.The growth of the urban population in the Indian census by 32% has increased from 286 million in 2001 to 377 million in 2011.
About 30% constitute residential units of seismic zone IV and V.These rural building units are mainly made by the

use of locally available materials like mud and unburnt bricks, stone walls, or walls made of burnt bricks, all these are very poor in construction and maintenance[2].Besides a large percentage of housing facilities in rural areas, the urban population has increased rapidly during the last decade.The growth of the urban population in the Indian census by 32% has increased from 286 million in 2001 to 377 million in 2011. The urban population is estimated to be around 590 million by the end of 2030.As per the statistics, 50% of the demand for construction work in India comes from infrastructure. Sector,the rest comes from industrial activities, residential and commercial development, etc [1][6]. Due to this rapid urbanization, demand for infrastructure, essential infrastructure, residential layout, and community development has increased.

The occurrence of earthquakes in (day time or night time) plays a major role as they have a direct impact on the occupancy of buildings. for example. The Latur earthquake (1993) took place in the early hours around 3:53 AM most people were sleeping in the affected area.On the contrary, the Bhuj earthquake (2001) occurred around 8.46 AM, in which most people woke up and there was minimal interference in the building.The two earthquakes showed poor performance of non - engineered building unitssuch as random rubble masonry in mud mortar with heavy roofs as well as modern multi-story RC framed buildings (Figure 2).

Figure. 2: Apartment collapse in Bhuj (2001)earthquake.(https://www.gettyimages.in/photos/gujarat-earthquake)

The Last seismic experience shows that modern residential buildings lack seismic designs.Further,the importance of incorporating seismic principles in the structural design of the building to function as a single unit during the earthquake has become clear.Empowering rural communities to ensure seismic safety of building stock by generating awareness about earthquakes and the significance of earthquake-resistant buildings.The environment built in urban areas should be planned and has to be carefully prepared in the initial stages so that the constructing layout is suited for seismic performance.

IV. BUILDING TYPOLOGIES

The classification of the building is based on the material used in the building such as [7]

- Type of mortar used
- Concrete used in the structure
- Reinforcement
- Wooden structures

A. Classification of masonry units -

Stonemasonry - doing stonework
Wooden masonry - doing wooden work
Reinforcement masonry - doing steelwork
Brick masonry - doing brickwork

B. Classification of load-bearing units in structures-

Reinforced walls - the walls can be made load bearable
Trusses- H shaped girders made of steel
Braces- made of steel
Columns - vertical reinforced concrete bars
Beams - horizontal reinforced concrete.

V. TECHNIQUES TO MAKE BUILDING EARTHQUAKE RESISTANT

A. Shape Memory Alloy

- The shape memory alloys are made from basically nickel -copper-zinc- aluminium.
- These alloys are made because they regain their original shape when heated at a specific temperature after deformation due to the shape memory effect [5].
- These materials are completely different due to the shape memory effect.
- These materials have high strength, corrosion-free, biocompatible, and durable.
- With these materials we can make various shapes like bars, wires, plates, rings.
- They can bear large stresses without coming under deformation.

B. Base Isolation

- It is the process in which the base of the building is not directly connected to the ground it is decoupled with making base-isolated with isolators like a flexible bed or it is explained by an example by placing frictionless rollers in between the base of building and ground bed.
- It is used for the most suitable structures like low to medium-rise buildings where soil bed is hard.
- In this method we break the contact between the building and the ground so when the earthquake comes the building remains flexible and does not come under deformation or any effect of an earthquake.
- We can make isolated beds using preferable materials like frictionless rollers rubber bearings, springs, slider bearings, etc.
- This method can make the building earthquake resistant.

Figure 3: Base isolators {https://www.theengineeringcommunity.org/what-is-base-isolation-for-a-structure/amp/}

C. Carbon Fibres

It is the method recently used in Japan.
In this method, the building is supported with carbonic fabric material like a spider web on the building. This method is not generally used but it is doing a good job at the site where it is built.
The building is in a high seismic zone.So, it is resistant to earthquakes. We can also do more research on that and make building earthquake resistant.

Figure 4: Structure made with carbon fibrematerial in Japan (https://dchub.me/digital-construction/a-stringy-approach-to-protecting-buildings-from-earthquakes/)

D. Prestressedconcretemembers

- This method is now most commonly used in making bridges and earthquake-resistant buildings.
- In this method the structures are completely stable and durable
- The members are prepared at the specific place where we can control temperature and other effects on concrete which make it more durable and higher strength.
- In this method the members are prestressed with steel tendons.
- The steel tendons are stressed in two ways post-tensioning and pre-tensioning.
- In pre-tensioning the cables are pre-tensioned before casting the member.
- In post-tensioning the cables are post-tensioned after casting the member in between the holes which are prepared for post-tensioning in the members.

E. Steel Plate Shear Walls

In this method, the main components are shear walls and steel plates.
We know that shear walls are used for lateral loads resisting systems and steel has the property of its high ductility. By combining these both properties we usesteel plate shear walls in earthquake-resistant buildings.
In this method, the building is designed in that way the building components can bend instead of the failure of the structure under the earthquake conditions.
This system of the building is tested many times in Japan under earthquakes.
As these walls are thinner and lighter in weight which reduces the weight of the building.
Also, these walls need not much curing so we can speed up the construction. The improved construction practice and performance, combined with the health and safety benefits, make SCC a very attractive solution for both precast concrete and civil engineering construction [8].

F. Seismic Dampers

Seismic dampers are basically shockers used in construction of earthquake resisting buildings.
These are installed diagonally in the building used for resisting the lateral loads.
Under earthquakes these are act like hydraulic shock absorbers in which the sudden jerks are transmitted into the hydraulic fluid thus reduce the magnitude of the force acting on the building.
There are many types of seismic dampers like viscous dampers, friction dampers, yielding dampers.

VI. RECOMMENDATION

After discussing several ways and alternatives for earthquake structure design, we recommend all designers and architectures to use these methods for constructing earthquake-resistant structures for saving the lives of people and assets.Some of the alternatives are economical and the methods with better efficiency are a lit bit more expensive. For example, the performance of shear plate shear walls is better but it is a little bit more expensive. Dampers and base insulation both provide better resistance and better adequate safety.New technologies are yet to come as the arena of knowledge is exceeding day by day.So, it is important to be up to date.

VII. CONCLUSION

By the use of locally available materials, researchers from all over the world are attempting to produce cost-effective and efficient construction technology. The researchers in Peru,have made traditional adobe structures by reinforcing walls with plastic mesh and they are much stronger. There are many examples such as in India, the engineers have successfully used bamboo to strengthen concrete and In Indonesia, some homes now stand in bearings which are very easy to make fashioned from old tires filled with sand and stones. Also, it was found that even the no-engineered constructions sometimes possess the required resistance to earthquake ground motions.The earthquake-safe construction technology should mainly involve the usage of materials of ductile nature, earthquake-resilient building configuration, lightweight structural components to reduce the seismic forces, and robust architectural forms.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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