Analysis of Earthquake Resistant Buildings Using Recent Construction Techniques

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Abstract-
The area affected by earthquake activity in our country, engineering has been around for more than 35 years. Significant contributions have been made by Indian earthquake engineers to the seismic safety of some significant national buildings. But as the most recent earthquakes have demonstrated, typical constructions have not performed as well in previous Indian earthquakes. This is mostly because the majority of practicing engineers are unaware of the unique guidelines that must be adhered to when designing structures that are earthquake resistant and while building those structures. One of the greatest risks to human life and property on Earth is earthquakes. They are the most feared and least understood because of how suddenly they happen.

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INTRODUCTION

Natural disasters of many kinds, such as floods, tornadoes, tsunamis, volcanic eruptions, earthquakes, storms, etc., are common on our planet. It seriously harms both natural and living things. It is arbitrary and inequitable. An earthquake, commonly referred to as a tremor or quake, is one of the risky natural catastrophes. In densely inhabited areas, there is significant damage. The world has been unevenly colonised. The several plates that make up Earth's lithosphere are referred to as tectonic plates. Tectonic plates are segments of the outermost mantle and crust of the earth. It must be divided into two parts: the continental crust (dominant with SIAL {silicon and aluminium}) and the oceanic crust (dominant with SIMA {silicon and magnesium}). Geologists concur that there are definite borders for the tectonic plate. Additional research indicates that eight main plates the Pacific, North American, Eurasian, African, Antarctic, Australian, Indian, and South American plates can be used to investigate the earth's lithosphere & a few lesser plates, such as the Juan de Fuca, Philippine, Arabian, Caribbean, Cocos, and Nazca plates. Tectonic plates are like a giant mystery that stretches over the surface of the globe; they constantly agitate, fall, and collide. Plate borders are the boundaries formed by these plates. Numerous faults make up the plate borders. Sometimes the flaws stick to one another, causing the plate to continue moving and storing energy at the faults. When the force overcomes the jagged fault's friction, a quick release of energy, resembling a ripple in a pond, shoots forth from the fault in all directions. Anything on the surface is moved by these waves that shake it. An earthquake is defined as this shaking of the earth's surface. It is well recognised that earthquakes have the capacity to seriously harm both human life and the built environment. India has seen more than nine powerful earthquakes between 1990 and 2010, with an estimated 30,000 fatalities. While some areas of the nation are more vulnerable to earthquakes than others (seismic zone V of IS 1893(Part 1)-2016), no area is completely earthquake-free. In the Indian scenario, several minor earthquakes are recorded every day close to the subduction zone (Himalayan belt), but over time, only a few significant earthquakes have been seen in the intraplate area (Deccanplateau). The way the built environment performed during previous earthquakes revealed how brittle it is, which has prompted engineers and architects to design seismically efficient structures. About 60% of the Indian landmass is vulnerable to moderate to extremely strong earthquakes. When compared to a mild earthquake in a heavily populated region, a huge earthquake in an unoccupied location may do less damage. According to every field survey study carried out following a significant earthquake, building collapses were the primary cause of the majority of recorded fatalities.

ESSENTIAL FOR THE QUAKE-RESISTANT BUILDING

India has around 330 million dwelling units, with two thirds of them being rural homes, according to the 2011 census (GOI, 2011). As seen in Figure 1, the Geological Survey of India divided the nation into four seismic zones with different seismic potential. Approximately 30% of the dwelling units are located in seismic zones IV and V. These rural building units are mostly built from locally accessible materials including burned brick walls, stone walls, and mud. All of these materials are very susceptible to damage from improper construction and upkeep (BMTPC, 2006). Apart from the higher proportion of housing stock in rural areas, there has been a noticeable surge in the urban population in the past. According to the Indian census, the number of people living in cities increased by 32% between 2001 and 2011, from 286 million to 377 million. By 2030, there will be around 590 million people living in urban areas. According to data, the infrastructure sector in India accounts for half of the demand for construction activity; the remaining half is derived from industrial, residential, and commercial development, among other sources (Make India, 2015). The increasing need for infrastructure, basic services, residential layouts, and community development is a result of this fast urbanisation. Building occupancy is directly impacted by earthquakes, therefore the time of day or night they occur also matters. For instance, the Latur earthquake (1993) struck in the wee hours of the morning, at around 3:53 AM, when most people in the impacted region were still asleep. In contrast, the Bhuj earthquake of 2001 happened in the morning at 8:46 AM, when most people were still asleep and the structure was only partially occupied.

Figure 1- Apartment collapse in 2001 Bhuj earthquake with separation of the lift shaft

These two earthquakes demonstrated the subpar performance of both contemporary multi-story RC-framed structures (Figure 1) and random rubble masonry in mud mortar with heavy roofs. The experience with previous earthquakes has shown that modern residential structures lack seismic design. Simultaneously, it has become more evident how crucial it is for structural designers to take seismic principles into account if they want their buildings to function as one cohesive structure during an earthquake. Educating rural populations about earthquakes and the value of earthquake-resistant construction is essential to ensuring the seismic safety of the building stock. In metropolitan areas, the built environment must be carefully planned and developed from the beginning to ensure that building configurations are optimal for strong seismic performance.

RECENT TECHNIQUES TO MAKE BUILDING EARTHQUAKE RESISTANT

(i) Shape Memory Alloy- The main ingredients of shape memory alloys are aluminium, nickel, copper, and zinc. These alloys are created because, as a result of the shape memory effect, they may be heated to a certain temperature and restore their previous shape following deformation. Because of the form memory effect, these materials are entirely distinct. These materials are biocompatible, long-lasting, very durable, and devoid of corrosion. These materials are capable of bearing high loads without deforming, allowing us to create a wide range of forms, including bars, wires, plates, and rings.

(ii) Base Isolation- This method involves decoupling the building's foundation from the ground and isolating it using devices like flexible beds or frictionless rollers positioned between the building's base and the ground bed, to provide an example. It is used to the best kinds of structures, such as low- to medium-rise buildings with hard soil beds. Using this technique, we cut off the building's ground contact, preventing deformation or other effects of an earthquake on the structure when it occurs. With better materials, such as rubber bearings, slider bearings, frictionless rollers, springs, etc., we can create isolated beds.

Figure 2- Base isolators

(iii) Carbon Fibres- Japan has lately adopted this technique. With this technique, the structure is supported by carbonic fabric that resembles a spider web. Although this approach is not widely employed, it is working well in the location where it is being implemented. There is a significant seismic zone near the structure.It is hence earthquake-resistant. In addition, we may carry out more study and design earthquake-resistant buildings.

(iv) Members of prestressed concrete- Buildings resistant to earthquakes and bridges are now the most typical constructions made using this technique. With this technique, the constructions are utterly sturdy and long-lasting. The members are assembled in a designated area where temperature and other variables affecting the concrete may be controlled, increasing its strength and durability. Steel tendons are used in this procedure to prestressed the members. Post-tensioning and pre-tensioning are the two methods used to stress the steel tendons. Prior to casting the member, the wires are pre-tensioned. After casting the member in between the holes that are ready for post-tensioning in the members, the cables are post-tensioned.

Figure 3- Structure made with carbon fibremateria

(v) Steel Plate Shear Walls- The steel plates and shear walls are the primary parts of this approach.

We are aware that steel has a high ductility and that shear walls are employed in systems to resist lateral stresses. Steel plate shear walls, which combine these two qualities, are used in earthquake-resistant constructions. With this approach, the structure is constructed such that, in the event of an earthquake, the building's constituent parts can flex rather than the structure failing. The building's mechanism is put to the test frequently during earthquakes in Japan. Because these walls are lighter and thinner, the building's weight is decreased. In addition, these walls require less drying, which allows us to expedite construction.

(vi) Seismic Dampers- In essence, seismic dampers are shockers that are utilised during the construction of earthquake-resistant structures. These are positioned diagonally inside the structure to withstand lateral stresses. These function similarly to hydraulic shock absorbers during earthquakes, transferring unexpected shocks into the hydraulic fluid to lessen the force pressing on the structure. Seismic dampers come in a variety of forms, including yielding, friction, and viscous dampers.

BUILDING TYPOLOGIES

The classification of the building is based on the material used in the building such as:

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

(i) Classification of masonry units -

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

(ii) 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.

METHODOLOGY

(i) Load Calculations- As a guide, load calculations for dead load and superimposed load are performed using IS: 875-1987. The code's precise unit weight values for the materials used in the construction were taken out and utilised in the computations. Material thickness was determined based on design specifications. As per IS: 1893–2002, Nepal is located in the fifth zone. As a result, the impact of earthquakes is greater than that of wind. Thus, the frame's lateral load is examined for the earthquake. It is anticipated that the mass to be aggregated at floor level and lumped mass with the value corresponding to the mass of the floor, as well as a portion of the support system above and below, will be used to determine the lateral load.

(ii) Response Spectrum Method- Any building's reaction spectrum provides a depiction of the peak or steady state response (displacement, velocity, or acceleration) of many oscillators sent into motion by the same base vibration or shock and with varied natural frequencies. Given the natural frequency of oscillation of any linear system, the resultant plot may then be used to identify the response of any linear system. It is necessary to represent isolator units using amplitude-dependent effective stiffness values in order to perform response spectrum analysis.

(iii) Methods of analysis- Since the building is modelled as a space frame, SAP 2000 V16 is utilised as the primary tool for carrying out analysis. The programme is based on the Finite Element Method, and because of potential actions within the building, SAP 2000 V16 is used to obtain stresses, displacements, and fundamental time periods that are used for member design.

(iv) Detailing- The structure complies with IS: 456-2000, IS: 1893-2002, and IS 13920:1993 criteria and is developed with ductile behaviour in mind. In order to detail an element, the dimensions and areas of steel needed were determined, along with the quantity, size, arrangement, and placement of reinforcement.

CONCLUSION

Researchers from all across the world are working to develop efficient and affordable construction technologies by utilising locally accessible resources. Researchers in Peru have created significantly stronger traditional adobe constructions by using plastic mesh to reinforce the walls. Numerous instances exist, such as in India, where engineers have effectively reinforced concrete using bamboo. Some houses in Indonesia are now supported by bears that are made quite simply out of used tyres that have been packed with stones and sand. Furthermore, it was shown that occasionally, even unengineered structures have the necessary resistance to seismic ground vibrations.The primary components of earthquake-safe construction technology should include the use of ductile materials, building designs that are resilient to earthquakes, lightweight structural elements that lessen seismic forces, and robust architectural forms.

REFERENCES

[1]. Abarkane, C., Galé-Lamuela, D., Benavent, A., Suárez, E., Gallego, A. (2017). Ultrasonic Pulse-Echo Signal Analysis for Damage Evaluation of Metallic Slit-Plate Hysteretic Dampers. Ammor Books, New York.

[2]. BMTPC (2006). Vulnerability Atlas of India. Building materials and technology promotion council, Ministry of Urban Development, Government of India, New Delhi.

[3]. Duggal, S. (2007). Earthquake Resistant design of Structures. Oxford University Press, USA.

[4] IS 1893 (part 1) : 2016. Criteria For Earthquake Resistant Design of Structure.Bureau of Indian Standards, New Delhi.

[5]. Jain, S. K., Brzev, S., Bhargava, L. K., Basu, D., Ghosh, I., Rai, D. C., & Ghaisas, K. V. (2015). Confined masonry for residential construction, campus on theSabarmati monograph. Indian Institute of Technology, Gandhinagar.

[6]. Make India Statistics. (2015). makeindia.com/sector/construction.

[7]. MacGREGOR, J., Wight, J.K. (2009). Reinforced Concrete: Mechanics and Design, Pearson Publisher, 5th Edition, New York.

[8]. Abhilash Thakur and Ravi Kumar (2017) An experimental study on the behavior of self compacting concrete and hybrid fiber reinforced self compacting concrete. International Journal of Engineering Researches and Management Studies. Vol 4(2):37-42.

[9]. Segui, W. (2013). Steel Design. Cengage Learning, 5th Ed, LA.

[10]. Sinha, R., Goyal, A. (2004).A national policy for seismic vulnerability assessment of buildings and procedure for rapid visual screening of buildings for potential seismic vulnerability. Report to Disaster

Management Division, Ministry of Home Affairs, Government of India.

[11]. Kumar, S. L. , Paper presented at the Punjab Engineering Congress, 1933.

[12]. Rai, D. C., Prasad, A. M. and Jain. S. K., In 2001 Bhuj, India earthquake reconnaissance report(eds Jain, S. K. et al.), Earthquake Spectra, supplement A to volume 18, Earthquake Engineering Reaearch Institute, Oakland, CA, July 2002, pp. 265 – 277.

[13]. Jain, S. K., Murthy, C. V. R., Roy, D. C., Malik, J., Sheth, A. and Jaiswal, A., Curr. Sci., 2005, 88, 357 – 359.

[14]. Spence, R., In keeping Schools Safe in Earthquakes, Organization for Economic Co- operation and Development, Paris, 2004, pp. 217-228.

[15]. Dunn, J. A., Mem. Geol. Surv. India, 1939, 73, 161-181.

[16]. Cvetanovska N.G. and R., Petrusevska, (1996). "Non Linear Analysis of RC Structures using Computer Program INELA with Included Bank of Hysteretic Models", Third European Conference on Structural Dynamics, EURODYN '96, Florence, Italy, pp.515-522.

[17]. Fardis M.N., Panagiotakos T.B., "Displacement based design of RC buildings: Proposed approach and application", Proceeding Seismic design methodologies for the next generation of Codes, Balkema, Rotterdam, 1997.

[18]. Gulkan P., Sozen M., "Inelastic Response of Reinforced Concrete Structures to Earthquake Motions", ACI Journal, December, 1974.

[19]. Kowalsky M., Priestly M.J.N., MacRae G., "Displacement-Based Design-A Methodology for Seismic Design Applied to Single Degree of Freedom Reinforced Concrete Structures", University of California, Report No. SSRP-94/16.

[20] REINFORCED CONCRETE (limit state design), Ashok K. Jain

[21] Indian Standard codes IS 456:2000 and SP-16

[22] Indian Standard code IS 1893:2002 (part 1 and 2)

[23] Indian Standard code IS 13920:1993

[24] Design of Concrete Structure, S. Ramamurthan.

[25] EARTHQUAKE RESISTANT DESIGN OF STRUCTURES, second edition, S.K. Duggal

[26] Staircases: Version 2 CE IIT, Kharagpur

[27] CSI, (2010), Structural Analysis Program (SAP) 2000, Version 14, Computers and Structures Inc., USA

[28] Compression Members: Version 2 CE IIT, Kharagpur

[29] A Study on Earthquake Resistant Construction Techniques ; Mohammad Adil Dar1, Prof (Dr) A.R. Dar2 , Asim Qureshi 3 ,Jayalakshmi Raju4 1PG

[30] Arya AS, Chandra B and Qamaruddin M, "A New Concept for Resistance of Masonry Buildings in Severe Earthquake Shocks", Journal of the Institution of Engineer's, India, Vol. 61, No. 2, Aug, 1981, pp. 302-308.