AUDIT COURSE - DISASTER MANAGEMENT
DISASTER RESISTANT HOUSE CONSTRUCTION

Dr. DEVI K., Department of Geology and Environmental Science

INTRODUCTION

A large portion of the wealth of any nation is invested in its built-up environment viz,, housing, infrastructure, industrial and commercial facilities. The quality of this built-up environment, expressed in terms of durability, safety and functionality, is a determining factor for the quality of life and economic development of the society, and the competitiveness of its industry and services. Extensive loss of this wealth is caused by natural disasters that strike periodically. A natural disaster is an event of nature that causes sudden destruction, damaging the economy and social structure on a massive scale. This Unit deals with the traditional as well as modern disaster resistant construction techniques to meet the aftermath of disasters. It examines the issue of damage to Reinforced Concrete Cement (RCC) buildings by underlying the necessity of adherence to building codes and standards. Some recent advances in housing technology are also highlighted.

The reasons for intensifying the impact of disaster are mainly

- • Improper location of the building
- • Faulty design and use of poor quality materials
- • Sub-standard construction practices
- • Non-compliance to building codes
- • Lack of awareness of:
    - Safe Construction practices
    - Disaster resistant practices

GUIDELINES FOR DISASTER RESISTANT CONSTRUCTION

The behaviour of a building during any disaster depends critically on its location, overall shape, size and geometry. Hence, at the planning stage, architects and structural engineers must work together to ensure that the unfavourable features are avoided and a good building configuration is chosen.

For safe site selection, the following broad points should be kept in mind:

• Safe site which is away from landslides, steep slopes, falling rocks, loose soil and polluted water

• Well-drained area to avoid risk of water-logging and vector borne diseases.

For earthquake resistant construction, it is better to avoid hillside slopes and areas having sensitive and clayey soil. It should be preferable to have several blocks on terraces rather than one large block with footings at different clusters. The building as a whole should be kept almost symmetrical. Simple

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rectangular shapes behave better in an earthquake than shapes with multiple projections. Separation of a large building into several blocks is required for symmetry and rectangularity of each block. Restricting the width of openings, using bond beams and taking recourse to steel or wooden dowels as well as RCC band at plinth, lintel and roof levels are good disaster resistant techniques for buildings.

In case of cyclones, structures should be erected in areas, which provide a protective shield from high winds with natural firm level foundation. Flat roof arrangement should be avoided. So should be the projecting elements like antennas and chimneys, eave projections, sunshades etc. The construction should have adequate diagonal bracing, reinforced machinery, thicker plate glass, and anchoring of purlins to gable ends.

As far as flood resistant housing is concerned, prohibited zones should be totally avoided. Layout of the buildings/ houses should be such that they do not block free flow of water. Construction should be done on raised mounds. Waterproofing treatment, adequate bracing, afforestation in catchment areas are required for flood- prone areas.

Model designs and application of hazard resistance in construction

The basic design consideration for increasing hazard resistance of houses should include the following:

Earthquake - • Frame, or bands at different places (plinth, lintel and roof) • Shear walls • Cross bracing • Base isolation (shock absorption) • Brick joinery

Flood - • Raised plinth / building on stilts • Strong plinth • Water proofing of houses

Cyclone - • Suitable location to minimize wind force • Roof tied to walls • Firm fixing of building components together (foundations, walls, roof structure and roof covering) • Improved aerodynamics of the structure • Long root bearing plant trees as wind breakers

Landslide - • Proper site selection • Design of retaining walls

TRADITIONAL DISASTER RESISTANT CONSTRUCTION TECHNIQUES

Several earthquake-prone regions in the country have traditionally built houses that minimize the damage to life and property and stand up well in the wake of the quake. The traditional wisdom and attention to detail can be applied to modern material as well. These techniques are based on the use of traditional material e.g., timber and bamboo for building houses.

Avoiding compression structures like domes, vaults and arches is another option. The structural system needs to be tensile and the material should be flexible, as is the case with timber, steel and bamboo. It also helps if the structure is constructed in a way that it vibrates as one unit and sways together.

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Most new constructions with heavy roofs (slate tiles or RCC) supported by weak walls (random rubble in mud mortar) have proven deadly. Older houses at higher elevations have timber roofs held together by timber and tie-bands, horizontal timber beams spanning across the entire building, connecting the entire structure and giving it the character of a cage. Such houses have suffered little damage despite the mud and stone masonry.

Quake resistant houses should have tie-bands just above the level of the floor, the level of the doors and windows, and another at the roof level. Corners are the most vulnerable and thus ought to be strengthened. Elasticity of the structure can be enhanced with flexible steel rods or wood batons at corners. Doors and windows should be few, small and symmetrically placed away from the corners. The house should be as light as possible.

The earth quake resistant structures adopted to the Rajput families of Rajasthan in India is “Sumers”.

'Chaukhats' or 'Kothi' is in the traditional building technology adopted in Himalayan region in India.

In North Peru, traditional 'Quincha' building technology results in a flexible structure with an inherent earthquake resistance.

These types of structures have proved to be quite resistant to earthquakes, and the design and technique behind them could be used in the present context

DAMAGE TO REINFORCED CONCRETE CEMENT BUILDINGS

No building can remain entirely free of damage during a high intensity earthquake. Nevertheless, all houses, big or small, can be made safer or quake resistant. Structures can be made to withstand earthquakes of a particular magnitude by taking certain precautions. Buildings generally collapse as a result of inertial forces. During an earthquake, the lower part of a building tends to vibrate, as it is in direct contact with the ground. The forces of inertia, however, keep the -upper portions static. This conflict of forces leads to collapse. The magnitude of these forces is directly proportional to the weight of the building, the heavier the structure the greater is the damage. If the structure is light, lesser number of people die in case of a collapse.

It is necessary to provide horizontal reinforcement in walls for imparting bending strength in the horizontal plane against plate action for out of plane inertia load, and for tying the perpendicular walls together. It is provided in the form of following bands:

Plinth band; Lintel band, Roof band and Gable band.

A band is a reinforced concrete beam provided continuously through all-load bearing longitudinal and transverse walls at a given level.

BUILDING CODES AND STANDARDS

Building codes are standards and guidelines for construction of buildings to ensure a minimum level of safety for the occupants. An appropriate building code incorporates a thorough understanding of the forces that natural hazards impose on the area governed by the code. Building codes are only one of the tools for increasing the resilience of the built-up environment in the face of natural hazards. Land use planning, emergency management, natural resource protection and infrastructure development policies play significant roles as well. Coordination of these activities can be achieved through comprehensive hazard mitigation planning. It is never possible through any building standard to lay down foolproof regulations for protection of infrastructure from earthquakes of all magnitudes. It is also not possible to build earthquake proof buildings. However, the design approach adopted in the building codes is to ensure that a building structure possesses:

- Minimum strength to withstand minor earthquakes, which occur frequently, with some nonstructural damage
- Resistance to moderate-earthquakes, which occur once in ten years or so, with minor structural damage and some non-structural damage; and
- Withstanding capacity to a major earthquake, which is likely to occur once in a lifetime of the structure, without complete collapse.

Actual forces that occur during earthquakes are much greater than those specified in any building code. However, ductility (capability to undergo deformation), arising from inelastic material behaviour and detailing of reinforcement and overstrength, arising from the additional reserve strength in structures over and above the design strength are relied upon to account for this difference in the actual and design loads. Critical facilities such as hospitals, telephone exchanges, powerhouses, schools, community centres, water tanks, airports etc., are designed for higher earthquake forces so that they must remain functional after the occurrence of :'earthquake.- It may be noted that the cost of incorporating earthquake resistance features in a new building may be merely about 15% to 25% of the civil costs of the building.

The Bureau of Indian Standards (BIS) has initiated several pre-disaster mitigation projects to reduce the impact of natural disasters on life and property as well as bring down social vulnerabilities. It has undertaken standardization efforts in the area of earthquake engineering.

IS 13935: 1993- Covers the selection of material and techniques to be used for repair and seismic strengthening of damaged buildings during earthquakes, and retrofitting for upgradation of seismic resistance of the existing buildings

The Himalayalan - Nagalushai region, Indo-Gangetic plain, Western India, Kutch and Kathiawar regions in Gujarat are geologically unstable parts of the country. Hence, some devastating earthquakes of the world have occurred here. Strong earthquakes have also visited a major part of peninsular India. But these have been relatively few in number and of considerably, lesser intensity. Taking cognizance of their frequency and intensity, it is, thus, all the more important to follow the building codes and earthquake resistant designs more rigorously.

RECENT ADVANCES IN HOUSING TECHNOLOGY

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Technologies that are innovative and quake resistant need to be made use of in order to cope with disasters like the earthquakes and cyclones:

1. **Base Isolation Technology**

Reducing the forces transmitted to the building from the ground by placing the building a top of a mechanical system of isolators, sliders and dampers is called 'base isolation technology'. This dampens the violent movements of the earth during a seismic event. By using isolators and dampers, the building is 'decoupled' from the ground motion of any earthquake and the transmission of seismic energy to the building is dampened. This is done by lowering the vibrational frequency, allowing the building to move or displace. It is also done by lowering the shock acceleration of the seismic event; thus reducing the tendency for the upper floors to move faster than the lower floors. In general, buildings that have been isolated in this way are subjected to 1/3rd to 1/5th of the horizontal acceleration to that of conventional structures during a seismic event. The isolator is a sandwich of alternating layers of 1/4th inch steel plate and 1/4th inch rubber, which are vulcanised to form a single integrated unit. It is able to displace horizontally in any direction by 24 inches from the centre.

2. **Insulating Concrete Forms (ICFs)**

These are able to resist natural hazards such as hurricanes, earthquakes, tornadoes, floods and fires. ICF construction is relatively new to the building codes and home building industry of the United States, ICFs are hollow foam blocks or panels that stack and interlock to create exterior walls of a building. Reinforced concrete is then placed inside the foam blocks, creating strong, insulated concrete walls. ICF construction is already noted for benefits such as energy efficiency and durability.

3. **Reinforcing Concrete**

The most widely accepted form of reinforcement is Welded Wire Fabric (WWF), It is a mesh of thick steel wires that is placed in concrete. However, synthetic fibre reinforcement avoids the increased labour costs and difficulty in placement that are associated with WWF Small diameter synthetic fibres (nylon and polypropylene) are now being added to concrete in order reduce shrinkage and cracking by more than 80%. Reducing the cracks lowers concrete permeability, increases its toughness and long-term exposure to weather. It also reduces callbacks in concrete slab floors, decks, driveways and walks. According to fibre manufacturers, the placement, curing or finishing characteristics of the concrete are not affected by the addition of fibrous reinforcement. Larger-diameter synthetic fibres (steel and polyolefin) added at higher content by volume (0.5% to 1.5% respectively) also enhance hardened flexural strength, but at an increased cost.

4. **Cyclone Resistant Dwelling Construction**

The new technology has been developed by the National Building Construction Corporation (NBCC). It involves the use of pyramidal roofs so that the thrust area is reduced and the tile use to give the roof the required shape is made possible. The walls and foundation have been well-spaced to allow for flexibility when a building is buffeted by strong winds. Such building techniques are commonly used in quake-prone areas in Japan and along the Californian coastline in the United States.

5. **Disaster Resistant Pier Systems**

In earthquake-prone zones, disaster resistant pier systems are generally considered to be more cost-effective than ground anchor systems, which do not always perform adequately. The anchors are usually located on the longer sides of the house, which bear the greatest wind loads. However, earthquake loads can occur in any direction and additional anchors on the short sides increase costs. Because the piers are usually separated from the soil by pads, rust and deterioration are not such big concerns, as they are for ground anchors.

CONCLUSION

The wrath of natural disasters could be reduced to a considerable degree with the adoption and implementation of improved design, siting and disaster resistant construction techniques practicable within the context of the cultural and socio-economic constraints prevailing in the given regions. When houses and buildings constructed through traditional methods, using conventional building materials, do not exhibit the necessary disaster resistant characteristics, new designs and nontraditional building materials and construction techniques need to be developed and put to use. Adoption of disaster resistant technology for construction is, therefore, an important consideration for the national programmes and projects on disaster mitigation and prevention. This Unit threw light on the different types of modern and traditional earthquake resistant construction techniques. It discussed the importance of adhering to the building codes

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