EARTHQUAKE RESISTANT BUILDING CONSTRUCTION
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Elements of Engineering Seismology

- Earthquake: the ground vibrations both feeble and strong produced on the surface of the Earth due to any reason whatsoever are described as earthquakes.
  1. Anti centre
  2. Seismic waves
  3. Seismograph
CAUSES OF EARTHQUAKES

1. Superficial or surface causes
2. Volcanic causes
3. Tectonic causes
Classification of earthquakes

- On the basis of location
- On the basis of their cause
- On the basis of focal depth
- On the basis of intensity/magnitude

**Types of Earthquakes**

- **Tectonic Earthquakes** -- occur when rocks in the earth’s crust break due to geological forces created by movement of tectonic plates.
- **Volcanic Earthquakes** occur in conjunction with volcanic activity.
- **Explosive Earthquakes** result from the explosion of nuclear and chemical devices.
- **Collapse Earthquakes** are small earthquakes in underground caverns and mines.
INDIAN SEISMIC ZONE MAP
Introduction

Traditionally built constructions of India include small structures constructed in brickstone, a word for combination, therefore the masonry buildings which are brittle structures have proved to be the most vulnerable to strong seismic forces.

Major casualties which occurred during earthquakes such as the Bhuj earthquake in 2001.
**SEISMIC PERFORMANCE OF MASONRY BUILDINGS**

1. Failure of connection between walls
2. Absence of proper bonding between perpendicular walls at the junction
3. Large size of openings
COMMON MODES OF FAILURE

1. Out of plain failure
2. In-plain failure
3. Diaphragm failure
4. Connection failure
5. Non-structural components failure
Available Seismic Resistance (ASR)

**Condition:**

(ASR) < (MSR) → Seismically Weak Structure Liable to be Damaged During Earthquake
COMMON MODES OF REINFORCED CONCRETE BUILDINGS

1. Horizontal and vertical irregularities
2. Identification of Seismic damages in building components
3. Columns beams slabs infill walls foundations
TYPES OF IRREGULARITIES

- Vertical irregularities
  1. Change in geometry
  2. Change in strength
  3. Change in stiffness
  4. Concentration of mass

- Horizontal irregularities
  1. Excessive lateral deflection
  2. Non parallel shear walls
  3. Large openings in diaphragm
  4. Lack of separation
DAMAGES IN COLUMNS

Figure 5: Two distinct designs of buildings that result in different earthquake performances – columns should be stronger than beams.

Repair of Concrete Columns for Cracks and Damages
TYPES OF FOUNDATION

- Shallow Foundation
- Combined footing
- Mat foundation
- Pile foundation
TYPES OF FOUNDATIONS

SET 5: ISOMETRIC

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7.5 Design Lateral Force

7.5.1 Buildings and portions thereof shall be designed and constructed, to resist the effects of design lateral force specified in 7.5.2 as a minimum.

7.5.2 The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragms action.

7.5.3 Design Seismic Base Shear

The total design lateral force or design seismic base shear \( V_0 \) along any principal direction, shall be determined by the following expression:

\[
V_0 = A_a \cdot \frac{H}{W} \cdot T_e
\]

where:
- \( A_a \) = Design horizontal acceleration spectrum value as per 6.4.3, using the fundamental natural period of vibration \( T_e \) as per 7.4.2 and the Seismic weight of the building as per 7.4.2.

7.6 Fundamental Natural Period

7.6.1 The approximate fundamental natural period of vibration \( T_e \), in seconds, of a moment-resisting frame building without brick infill panels may be estimated by the empirical expression:

\[
T_e = 0.185 \sqrt{H} \text{ for RC frame building}
\]

\[
T_e = 0.079 \sqrt{H} \text{ for steel frame building}
\]

where:
- \( H \) = Height of building, in m. This excludes the basement stories, where basement walls are connected with the ground floor deck or fitted between the building columns. But, it includes the basement stories, when they are not so connected.

7.6.2 The approximate fundamental natural period of vibration \( T_e \), in seconds, of all other buildings, including moment-resisting frame buildings with brick infill panels, may be estimated by the empirical expression:

\[
T_e = 0.197 \sqrt{H} \text{ for RC frame building}
\]

\[
T_e = 0.093 \sqrt{H} \text{ for steel frame building}
\]

where:
- \( H \) = Height of building, in m, as defined in 7.6.1.
- \( d \) = Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.
TYPES OF DISASTERS

- Major natural Disasters
  1. Earthquake
  2. Cyclone
  3. Drought
  4. flood
- Minor natural Disasters
  1. Setting of fires
  2. epidemics
  3. deforestation
  4. pollution