



Nilachal Polytechnic

Bhubaneswar

Sem: 6th Subject :ACT

Branch: Civil Engineering

Name of the Faculty : Sweta Sarangi

Text Book to be followed by Student / Faculty

Book- : B.L.Gupta & Amit Gupta

Chapter-3 : Earthquake resistant Construction

Learning Objective

Students will learn -

About Earthquake

About the lateral loads

About damping

About scaffolding

About foundation

2.Essential Questions

- i) What is foundation?
- ii) what is earthquake resistant construction?
- iii) what is damping?
- iv) What is scaffolding?
- v) what is lateral loads?

3. Hours Required

Theory	3 hours
Problems	nil
Question & Answer Theory	2 hours
Total	5 hours

4. Question for Teaching / Assignment / Self Practice

	02 Marks	05 Marks	10Marks
Teaching	4 no.s	3no.s	3no.s
Assignment	3 no.s	2no.s	2no.s
Self Practice	3 no.s	2no.s	2no.s
Total	10 no.s	7 no.s	7 no.s

Lesson Description

Earthquake is a natural phenomenon occurring with all uncertainties.

Engineering design aims to link economics, social, environmental and safety factor to produce the best solution.

India is a large country. Nearly two thirds of its area is earthquake prone.

A large part of rural and urban buildings are low-rise buildings of one two three storeys.

Many of them may not be adequately designed from engineers trained in earthquake engineering.

Most loss of life and property due to earthquakes occur due to collapse of buildings.

Enclosed :

Course Material.

CHAPTER -3 **Earthquake Resistant Structure**

Lateral loads on the building

Lateral loads are loads that act on a structure in a horizontal direction.

Earthquake forces on a structure are generally lateral loads.

Lateral load resisting structure.

The first step in architectural planning of a building is to select the lateral load resisting system.

The load resisting system must be of closed loops, so that it is able to transfer all the forces acting either vertically or horizontally to the ground.

BIS(Bureau of Indian Standard) has approved 3 major types of lateral forces resisting system. These consists of moment resisting building frame system , bearing wall system and dual system.

Response reduction factor R is basically an indicator of the performance of the structures in earthquakes.

A lower value of $R = 1.5$ indicates an extremely earthquake prone building and high value of $R = 5$ indicates an earthquake resistant type building.

Irregularities of structure

A building that does not have symmetry and plan elevation, geometry, mass or load resisting elements is called a irregular structure.

There are 2 types:-

Vertical irregularity

Horizontal irregularity

Damping

Damping is the ability of a structure to absorb the vibration energy due to earthquakes.

Building response is inversely proportional to the damping of the building structure.

Seismic weight

- (i) Seismic forces are proportional to the building weight and the building height.
- (ii) It means the weight of the building increases with height of the building.

Scaffolding.

When a construction is done above the 1.5m height then a temporary structure is needed to support the labours to continue the construction process. These structures are called scaffoldings and this can be made up of steel or timber.

Building configuration

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

Gable band

A gable band is horizontal member which is placed at the top of the ridge of the sloping slab to support the ends and transferring loads to gable end walls.

Earthquake

The shaking of earthcrust due to the movement of collision of the tectonic plates is called earthquake.

They are the natural disasters of a generally unpredictable nature.

A sudden rapid shaking of the earth caused by the breaking and shifting of rocks beneath the earth surface.

Building configuration

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

In earthquake resistant construction, we use IS Code 1893:2002 part1 and important feature in building configuration is its regularity and symmetry.

To perform well in an earthquake e, a building should possess four main attributes namely simple and regular configuration and adequate lateral strength, stiffness and ductility.

Buildings have simple regular geometry uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than buildings with irregular configuration.

Size of the buildings

In tall buildings with large weight to base size ratio the horizontal movement of the floors during ground shaking is large. In tall buildings, the damaging effects during earthquake is more.

Horizontal Layout of Buildings

In general, buildings with simple geometry in plan have performed well during strong earthquakes.

Buildings with re-entrant corners, like those U, V, H and + shaped in plan have sustained significant damage.

Many times, the bad effects of these interior corners in the plan of buildings are avoided by making the buildings in two parts.

Often, the plan is simple, but the columns/walls are not equally distributed in plan. Buildings with such features tend to twist during earthquake shaking.

Vertical Layout of Buildings

The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building.

Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity.

Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in the storey.

Adjacency of Buildings

When two buildings are too close to each other, they may pound on each other during strong shaking.

With increase in building height, this collision can be a greater problem. When building heights do not match the roof of the shorter building may pound at the mid-height of the column of the taller one; this can be very dangerous.

Ductility

Under normal conditions, a building experiences elastic deformations, deforming as force is applied and returning to its original shape when removed.

However, extreme earthquake forces may generate inelastic deformations in which the element does not return to its original shape after the force is removed.

Ductility is the property of certain elements that have inelastic deformation before failing.

Building elements constructed with ductile materials have a "reserve capacity" to resist earthquake overloads.

Therefore, buildings constructed of ductile elements, such as steel and adequately reinforced concrete, tend to withstand earthquakes much better than those constructed of brittle materials such as unreinforced masonry.

Strength and Stiffness.

Strength is the property of an element to resist force.

Stiffness is the property of an element to resist displacement.

When two elements of different stiffnesses are forced to deflect the same amount, the stiffer element will carry more of the total force because it takes more force to deflect it.

When stiff concrete and masonry elements are combined with more flexible steel or wood elements, the concrete and masonry take more of the total force.

Damping

When a tuning fork strikes a surface, it vibrates back and forth at a certain rate - this rate is known as its fundamental period.

Ground shaking from an earthquake will cause vibrations in a building. If the ground shaking matches the fundamental period of the building, the building will resonate with the earthquake, causing the building vibrations to greatly increase. This can lead to extensive building damage. Damping is imparted to a building by the cracking and inelastic movement of its structural elements.

Weight Distribution

Buildings that are wide at their base and have most of their weight distributed to their lowest floors generally fare better in earthquakes than tall, top-heavy buildings.

Building Configuration

Square or rectangular buildings with floor plans with symmetrically placed lateral force resisting elements tend to perform better in earthquakes than buildings composed of irregular shapes.

Buildings with irregular shapes cannot distribute lateral forces evenly, resulting in torsional response that can increase damage at the points in the building.

Foundation / Soil Characteristics.

The underlying geology of the site can also have a significant effect on the amplitude of the ground motion there.

Soft, loose soils tend to amplify the ground motion and in many cases a resonance effect can make it last longer.

Resonance

Resonance was a major problem in the 1940 earthquake, in which the total collapse of many mid-rise buildings caused many fatalities.

Tall buildings at large distances from the earthquake source have a small, but finite, probability of being subjected to ground motions containing frequencies that can cause resonance.

Redundancy

It is very beneficial for a rehabilitated lateral-force-resisting system to have an appropriate level of redundancy, so that any localized failure of a few elements of the system will not result in local collapse or instability.

Safety considerations are-

Excavation and foundation work

The type and design of the foundation adopted shall ensure safety to workmen during construction and residents of the neighboring property.

Sufficient care shall be taken in areas, where withdrawal of ground water from surrounding areas could result in damages to such foundations.

During the construction of the foundation, it shall be ensured that the adjoining properties are not affected by any harmful effects.

The process of excavation, filling in, pumping etc. shall avoid endangering the strength or stability of the partially completed structure. The partially completed structure shall be capable of carrying loads previously taken by temporary works which, as part of the construction procedure, have to be transferred before the completion of the work.

Excavation with intervals on any site shall be avoided. If such excavation is unavoidable, the excavated site shall be properly fenced and warning signals. Excavation of interrupted or temporarily suspended construction shall be either backfilled or barricaded.

Arrangements for safe movement of workers and inspectors in the trench have to be planned and provided.

Scaffolding

Properly designed and constructed scaffolding built by competent workmen shall be provided during the construction of the walls to ensure the safety of workers.

The scaffolding shall be of timber, metal or bamboo sections and the materials in scaffolding shall be inspected for soundness, strength, etc,

The scaffold has to check after every 15 days in rainy season and 30 days in dry season. In the erection or maintenance of tall buildings, scaffoldings shall be of noncombustible material especially when the work is being done on any building in occupation.

After initial construction of the scaffolding, frequent inspections of scaffolding shall be made by the Engineer-in-charge. The platforms, gangways and runways provided on the scaffoldings shall be of sufficient strength and width to ensure safe passage for the workmen working on the scaffolding.

Ladders

Setting of Ladders: Rails of ladders shall extend at least 1m above the landing and shall be secured at the upper end.

there shall be adequate handhold at landing or side guys with anchorage at the bottom.

To prevent slipping, a ladder shall be secured at the bottom end or held by a person at the time of use.

Use of Ladders: All ladders shall be constructed of sound material, and shall be capable of carrying the design loads.

Stacking of materials

No materials at worksite shall be so stacked or placed as to cause danger or inconvenience to any worker or the public.

Necessary lights to protect the public from accidents are to be provided.

The different bands used in additional strengthening measures in masonry buildings

- (i) Gable Band
- (ii)Roof Band
- (iii)Lintel Band
- (iv) Plinth Band

Plinth Band

This type of horizontal bands is essential in those areas where the soil on which the building has to be constructed is weak. The soil will be soft with uneven properties. This problem is mainly found in soils found in hilly areas. This band is hence not necessary if we have a stronger soil and substructure.

Lintel Band

These are horizontal bands provided at the lintel level. And it is provided in almost all buildings. Under the action of earthquake ground motion, the lintel band is subjected to constant bending. Hence the construction of lintel band has to done with special care and supervision.

Roof Band

These bands are mainly employed in buildings with roofs made of flat timber or CGI sheets. If the building roof is made of reinforced concrete slabs or brick roofs as mentioned before, there is no need of these bands. As R.C slabs itself behave as a horizontal band.

Gable Band

Those buildings that have sloped roof i.e. truss construction, gable bands are necessary. Now the incorporation of Gable band is not shown in the figure as the building have a flat roof. When the roof construction is by using a truss, the requirement of gable band comes into play.

Question Set.

Classroom Teaching

Group A

What do you mean by lateral loads on the building? [2015(w) 2012(s)]

Short notes on lateral load resisting structure. 2015(w)

What do you mean by irregularities of structure?

What is Damping?

Group B

What are the safety considerations to be followed during additional construction and alteration of existing buildings ? 2015(w)

Describe any five structural irregularities in buildings. 2014s,2014(w) [2014s]

Describe the assumptions made in the earthquake resistant design of structures. 2016(s)

Group C

Discuss the building characteristics in earthquake resistant construction. 2015(w), 2014(s)

Describe the structural irregularities in buildings. [2016(s),2015(w)][2014s,2014(w)]

Define underpinning & describe the methods of underpinning

Assignment Questions

Group-A

Define seismic weight. [2015(w)]

What do you mean by liquefaction? [2014s]

Define scaffolding. [2018S]

Group-B

State different plan configuration problems. [2015(w)]

Explain building configuration briefly. [2014s]

Group-C

What do you mean by Shoring? Describe its types.

What are the different bands used in additional strengthening measures in masonry buildings?

3. Self Practice

Group-A

What do you mean by building configuration?

What do you mean by Gable band?

What do you mean by earthquake?

Group-B

What are the vertical irregularities in structural building?

What are the additional strengthening measures in masonry buildings for earthquake resistance?

Group C

Write down the general principles for Earthquake Resistant Building.

Describe different building characteristics from seismic performance point of view.

Faculty

HOD

Principal