UNIT - V

DESIGN FOR ABNORMAL LOADS

Progressive Collapse - Code Provisions - Equivalent design loads for Considering abnormal effects such as earthquakes, cyclones, etc - Importance of avoidance of Progressive Collapse.

Introduction

Throughout history, there have been many significant structural failures. While many of these failures have resulted in negative consequences (i.e, death, injury, Property loss, etc) these events present on opportunity to evaluate the validity of Engineering design approaches and procedures.

In an attempt to improve structural design and prevent structural disasters, Engineers continue to refine design guidlines.

World wide, there are several building that directly address the type of Progressive Collapse, while some regulations. While Some regulations do a better job of Conveying Progressive Collapse requirements than others. Currently there is no explict Engineering design method available Pertaining to this Potential Structural Problems.

Progressive Collapse

Typically, Progressive (disproportionate) Collapse is the result of an abnormal loading event. Four general classes of abnormal loads are:

1) Accident impact
2) Faulty Construction
3) Foundation failure
4) Vollent Change in Air Pressure

Accidental Impact

Several Cases of Progressive Collapse have been caused by accidental impact. An Example of this form of abnormal loading is an automabe striking a key member (s) in a structure i.e, buildings, bridges etc.

Faulty Construction

There have been several instances throughout history where poor Construction practices have lead to Progressive collapse. A notable eg of this was the skyline plaza apartments in building in Fair fax County Virgina. This feulure was attributed to Premature removal of supporting forms. This led to localized feulure.

Foundation failure:

Failure of a small portion of a structure foundation can result in a loss of primary support. This failure could be the result of problems with erosion, geology, catering due to explosion etc. If the remainder of the structure is unable to redistribute this change in load caused by the loss in support, extensive damage to the structure, could be much greater.

Violent change in Air Pressure:

An extreme change in Air pressure can stem from any source such as explosion caused by gas, high explosives etc. An example of a progressive collapse in air pressure was the 1995 terrorist bombing of the A.P murrah Fedral building

Code Provisions

Codes And Standards.

Since the Progressive Collapse of the Ronan Point apartment tower in 1968, many Codes and Standards have attempted to address, the revise of this type of Collapse. Complex Survey of these effort is beyond the Scope of this Paper, but a Small Sampling of current Paper, but a Small Sampling of current and recent Provisions related to Progressive Collapse.

ASCET - 02:

The american Society of Civil Engineering minimum Design loads for building and other Structures (ASCE - 2002). has a Section on general Structural Integrity" that reads thus:

Building and other structure shall be designed to sustain local damage with the structural system as a whole remaining stable and not being damaged to an extent disappropriate to the original local damage. Degree of redundancy is not specified and the requirements are entirely threat independent.

ACI 318 - 02

The american Concrete Institute Building Code requirement for Structural Concrete ACI 2002 include extensive "Requirements for structureal integrety" in the chapter on reinforcing steel details. Though the Commentary states that it "is the intent of these section to improve redundancy". There is no explict mention of redundanky or alternate load paths in the Code.

GSA PBS Facilities Standards 2003

The 2003 Edition of the GSA's facilities Standards for the Public Building Service retained the Progressive Collapse heading from the 2000 Edition, but replaced all of the words reproduced above with this short statement. "Security Design".

GSA PBS Progressive Collapse Guidelines 2003

The GSA Progressive Collapse Analysis and design Guidelines for new Federal office.

Buildings and major modernizations Projects (GSA - 2003 b) begins with process for determining whether a building is Exempt from Progressive Collapse considerations. Exempt is based on the type and size of the Structure, and is unrelated to the level of threat.

8

Equivalent design loads for effects such as Earthquake cyclones.

In this section, we will review loads, typically considered in building design. These are:

1) Earthquake Loads
2) Wind loads

Earthquake Loads:

Earthquake are catastrophic events that occur mostly at the boundaries of portions of the earth's crust called tectonic plates, when movement occurs in these regions, along faults waves are generated at the Earth surface that can produce very destructive effects. After shocks are smaller quakes that occur after all large eq. They are usually most intense in size and number within the first week

They can cause very significant re-shaking of damaged structures, which makes earthquake induced disasters more hazardous.

A number of moderate quake. They can cause very significant re-shaking of damaged structures, which makes earthquake - induced disasters more hazardous.

Design Concept:

Earthquakes, we must contend with appreciable that failures will occur in the near future. otherwise, all the wealth of the world prove insufficient to fill our needs. the most modest structures would be fortress. we must also face uncertainties on a large scale while designing Engineering systems whose; pertinent properties are still debated to resist future earthquake.

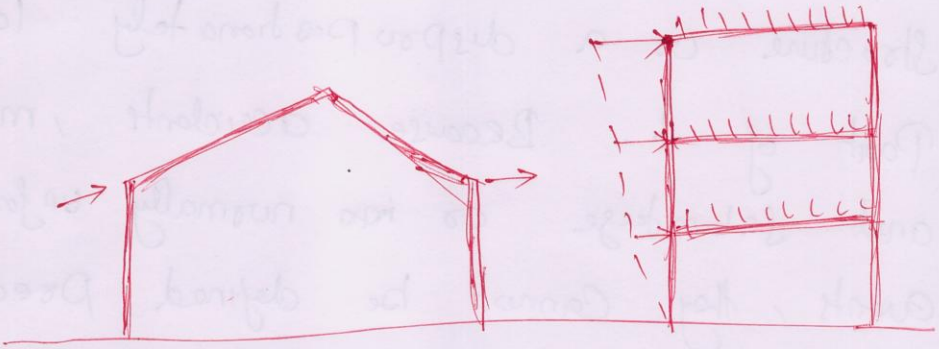
above whose characteristics we know even less.

Although over the years, experience and research have diminished our uncertainty and concerns regarding the characteristics and occurance regarding, though that there will be such a change in the nature of knowledge to relieve us of the necessity of dealing openly with random variables.

Wind Loads:

Wind is a term used to describe horizontal motion of air. Motion in a vertical direction is called current. Winds are produced by differences in atmospheric pressure that are primarily attributable are caused by unequal distribution of heat from the sun, and the difference in thermal properties of land and ocean surfaces, when temperature of adjacent regions

become unequal, the warmer, lighter air rises and flows over the colder, heavier air. winds initiated in this way are modified by rotation of earth.



Earthquake loading.

Abnormal loading.

Thorough accident misuse or sabotage, properly designed structures may be subjected to conditions that could lead to either general or local collapse. It is usually impractical for a structure to be designed to resist general collapse caused by gross misuse of a large part of the system or severe abnormal loads.

12

Progressive Collapse. Progressive Collapse is defined as a spread of an initial local failure from element to element, eventually resulting in the collapse of an entire structure or a disproportionately large part of it. Because accidents, misuse and sabotage are normally unforseeable events, they cannot be defined precisely. Likewise, general structural integrity is a quality that cannot be state in case local collapse.

Collapse Patterns

It is discussed in the following Patterns

(1) Earthquake collapse patterns

(2) Design alternative for reducing Progressive collapse

(3) Guidelines for achieving structural integrity.

Earthquake Collapse Patterns

We typically accept higher risks of damage under seismic design forces than under other comparable extreme roads, such as maximum live load or wind forces. The corresponding seismic design forces are generally too high to resisted within the elastic range of material response, and it is common to design for strengths, which are a fraction of that corresponding to elastic response, and to expect the structures to survive large earthquakes by in elastic deformation and energy dissipation corresponding to material distress, Earthquake shaking cause damage to structure but it is the gravity that causes collapse. Redundancy and ductile behaviour can prevent or reduce extent of collapse.

Design Alternatives for Reducing Progressive Collapse

There are number of ways to obtain resistance to Progressive Collapse and the important among them are the following :-

1. During the design process, Consider resistance to Progressive Collapse through the Provision of minimum levels of Strength, Continuity & ductility.
2. Provide alternate load paths so that the damage is obtained and major Collapse is averted.
3. Provide sufficient Strength to resist failure from accidents or misuse.
4. Provide Specific local resistance in regions of high risk to have sufficient Strength to resist abnormal load in order

for the structure as a whole to develop alternate paths.

Guidelines for Achieving Structural Integrity

1. Generally connections between structural components should be ductile and have a capacity for relatively large deformation and energy absorption under the effect of abnormal conditions.
2. Good plan layout. An important factor in achieving integrity is the proper plan layout of walls & columns
3. Provide an integrated system of ties among the principal elements of structural systems. These ties may be designed specifically as components of secondary load - carrying

16

4. Returns on walls. Returns on interior and exterior walls will make them more stable.

Cyclone effects

Improving wind / cyclone :: Resistance of Building - Guidelines :

The Coastal areas of India receive a number of cyclonic wind storms practically every year. Causing devastation over large due to.

(i) high speed winds, which destroy traditional homes and uproot trees and electric line supports

(ii) Floods, caused by heavy rains

(iii) Storm surge waters, first flowing toward the land then receding back towards the sea, drowning people & Destroying homes, agriculture trees etc. whatever comes in the path of the following flowing waters

Scope:

These guidelines deal with the Construction of wind / cyclone resistance to buildings of both Engineered and non-Engineered types. The Proposed measures are generally applicable to wind resistant Construction, but have Particularly been framed keeping in view the regions having wind velocity greater than or equal to 39m/sec.

Wind Pressure on Building And Storm Surge Heights:

(a) Basic wind Speed zones:

The marco-level wind Speed zone of India have been formulated and published in IS: 875 Indian Standard Code of Practice for wind loads.

55 m/s (198 km/h) - Very high damage Risk - zone A

50 m/s (180 km/h) - Very high damage Risk Zone - B

47 m/s (162.2 km/h) - High Damage Risk Zone

44 m/s (158.4 km/h) - Moderate damage - A

39 m/s (140.4 km/h) - moderate damage - B

33 m/s (118. km/s) - Low damage.

The basic wind speed height are applicable to 10m height above mean ~~sea~~ ground level in an open terrain with a return Period of 50 years.

Design wind speed and Pressure:

The basic wind speed is reduced or enhanced for design of buildings and Structures and due to factors like

(1) The risk level of the structure measured in terms of adopted return Period and life of Structures (5/25, 50 or 100 years)

(ii) Terrain roughness determined by the surrounding building or trees, height, size of the structure.

(iii) Local topography like hills, valleys, cliffs or ridges etc. Thus general basic wind speed being the same in a given zone, structures in different site Connections would have appreciable modification and must be considered determining design wind velocity.

The design wind pressure at height z above ground level on a surface normal to the wind streams is given by

$$P_z = 0.0006 V_z^2$$

where V_z = design wind velocity m/s

These factors play an important role in determining the vulnerability of given building types in given wind speed zones. By changing the cladding areas, different pressure co-efficient will be these.

c Coastal Areas

The Coastal areas are subjected to severe wind storms and cyclonic storms. It is known that in certain events, the wind gusts could appreciably exceed the specific basic wind speed (55 m/s). But for design structure the above macro level zoning stated is considered as sufficient.

d) Storm Surge

Besides the very high velocity winds, the coastal areas suffer from the onstaught of sea water over the coast due to storm surge generate cyclones. A storm surge is the sudden abnormal rise in sea level caused by the cyclone. The surge is generated due to interaction of air, sea, land. Sea water flows across the coast as well as inland.

Design Consideration Roofs :

Depending upon the construction material used and the geometrical aspects the roof can be broadly classified into two main types.

(a) Flat roofs of various types
(b) Pitched roof with various covering materials

Flat Roofs

Flat roofs may consist of

(i) R.C. Slabs
(ii) wooden or R.C Joists, inverted T-irons placed usely spaced and carrying brick tiles, stone slabs or seeds with clay
(iii) Prefabricated R.C elements of various designs placed side by side
(iv) Where of R.C slabs are rigid in their own planes, the other types will require their integration through diagonal bracing

or topping R.C Screed.

b) Structural deck concrete of grade not leaner than M15 shall be provided over precast components to act monolithic with them

Pitched Roofs:

(a) The main load bearing structural members are timber or steel trusses, purlins and bracings. The cladding may be of GI or AC sheeting, tiles, timber planks or prefabricated R.C or ferrocement elements. It will be preferable to use sheeting with adequate fixtures than tiles or cyclone areas.

(b) Analysis and designed of Pitch roof is carried out as per provisions of relevant Codes of practice. IS - 800 - 1984 for steel trusses and IS - 883 - 1970 for timber trusses

Framed building

As an alternative to vertical load bearing walls, reinforced concrete, steel or timber framing can be used.

In RC constructions, the frame comprises of rigidly connected beams and columns or posts.

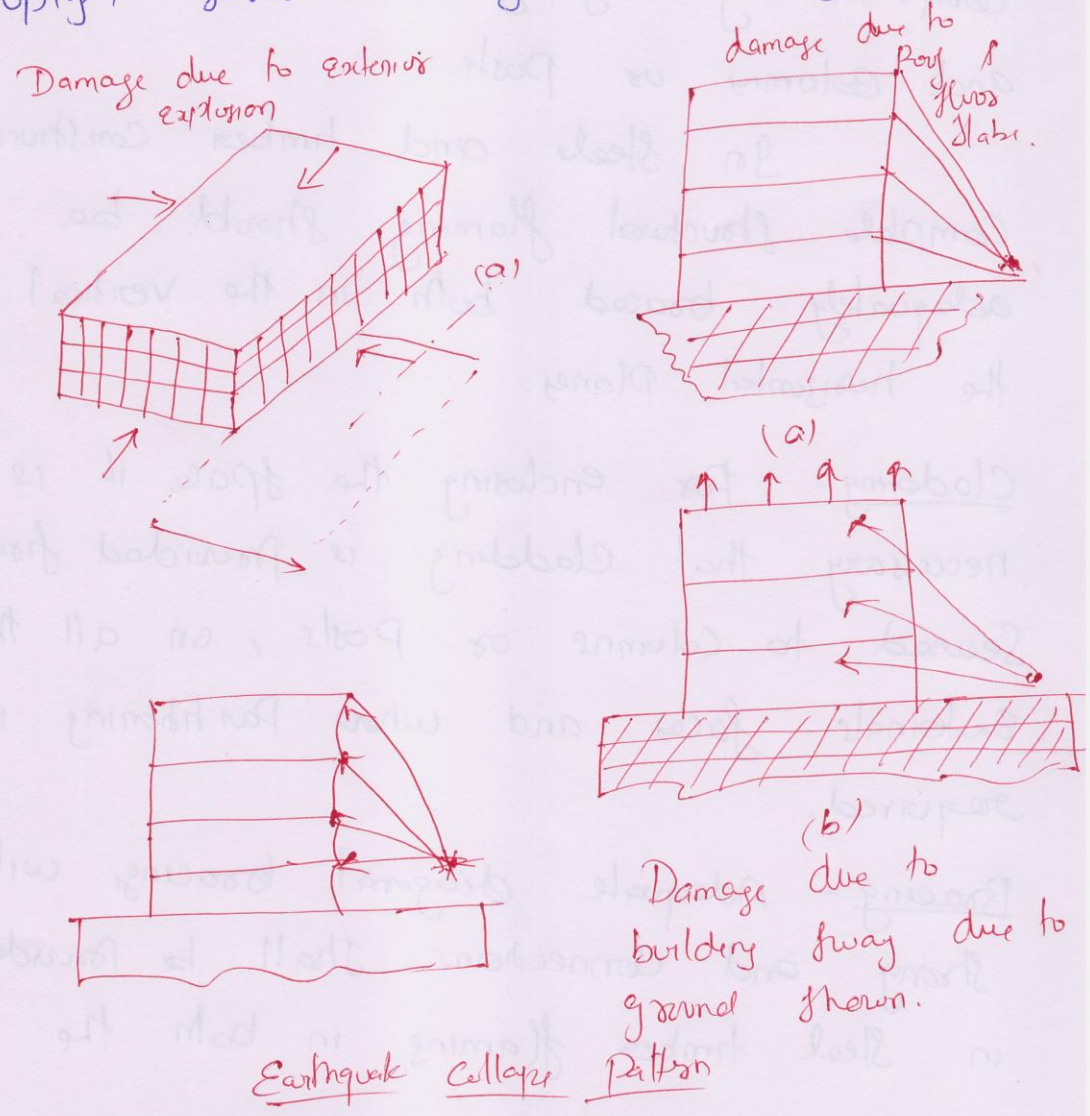
In steel and timber construction complete structural framing should be adequately braced both in the vertical and the horizontal planes.

Cladding - For enclosing the space it is necessary that cladding is provided firmly secured to columns or posts, on all the external faces and where partitioning is required.

Bracing - Adequate diagonal bracing with strong and connections shall be provided in steel timber framing in both the

horizontal and vertical planes to improve their lateral load resistance.

Anchoring - The flame columns and shear walls where used shall be properly anchored into the foundation against uplift forces, as found necessary.



Earthquake collapse Pattern