AHMEDABAD MANAGEMENT ASSOCIATION

Seminar on Managing Construction Projects (Trends - Present & Future)

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Construction Management – Post Earthquake

By

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RESMA **R**EAL **E**STATE **S**TUDIES AND **M**ANAGEMENT **A**CADEMY

The scene during 1990s

REAL ESTATE CONSTRUCTIONS

- Violations in Buildings
- No Permissions
- No .construction quality assurance
- No Role of Institute such as Builders forum/ Educational Institute/ Professional institute like GICEA.
- No Transparency.
- All quasi legal construction.
- ULC also promoted such scenario
- By-laws also age old and not with development pace.

Role of Real estate players

- Violations like pent house were common
- Parking violation were 7 out of 10 complexes
- No procurement of BU for basic services
- Cantilever Projections/ Entry passages/ open to sky/ chowks were covered
- Salable FSI 3.5 for low rise and 4.5 for high rise.
- Major Violation of C.P., Margin, etc by small time builders. (night flyers)

The quake effect

Bhuj Earthquake
Numbers as reported by the Govt. of India

Total death toll: 19,727
Total Injured: 166,000.
People left homeless: 600,000
Total number of houses destroyed: 3,48,000
Additional Houses damaged : 8,44,000
Direct Economic loss: $1.3 billion
Indirect Economic loss: $ 5 Billion

The quake effect

- Earthquakes are hazards with a low probability of occurrence, but with major consequences.
- Our response to them is a case of "being wise after the event".
- Most constructions in India are non-engineered types, consisting of walls of clay, stone, brick, and the like, built without hazard provisions.
- Earthquake damage can be mitigated by using earthquake-resistant designs for new buildings and retrofitting existing ones for acceptable levels of risk

The quake effect

An earthquake is marked by two types of simultaneous motion: a **lateral, push-pull motion** and an **undulating or pitching motion** which moves surface structures up and down.

The damage to a building depends on how much and on **how long** the ground motion lasts —that is, how the shock waves travel through the soil, on the nature of the soil and on the nature of the structure itself.

The quake effect

- How the structure responds depends in turn on its properties as well as on its damping characteristics, that is, its capacity to absorb the forces acting upon it.
- Concrete has better damping properties than steel. Brick buildings suffer during earthquakes because the roofs tend to separate from the supports due to the shaking; the walls tend to tear apart, moving diagonally

Avoiding the Collapse

- ✓ It is not the earthquake but the collapse of buildings that causes destruction and loss of human lives.
- ✓ Earthquakes will do least harm to us if the collapse of buildings is avoided.
- ✓ The main criteria in design of buildings should be to prevent loss of human lives.
- ✓ The buildings may deform, sway, crack or distort but must not collapse!

Avoiding the Collapse

- New materials: Of late, materials like rubber, lead, stainless steel, fibre-reinforced plastic and shape-memory alloys have been used to offer earthquake resistance to earthquakes.

Gujarat Quake

- Earthquakes have visited district of Kutch repeatedly over the centuries. The last great earthquake was in 1819, but smaller ones have damaged and destroyed buildings a number of times in the 20th century.

- The construction near the earthquake's epicenter in Kutch contrasted with that found in nearby Ahmedabad, where the construction tradition more closely resembled that found in Turkey & Kashmir

Gujarat Quake

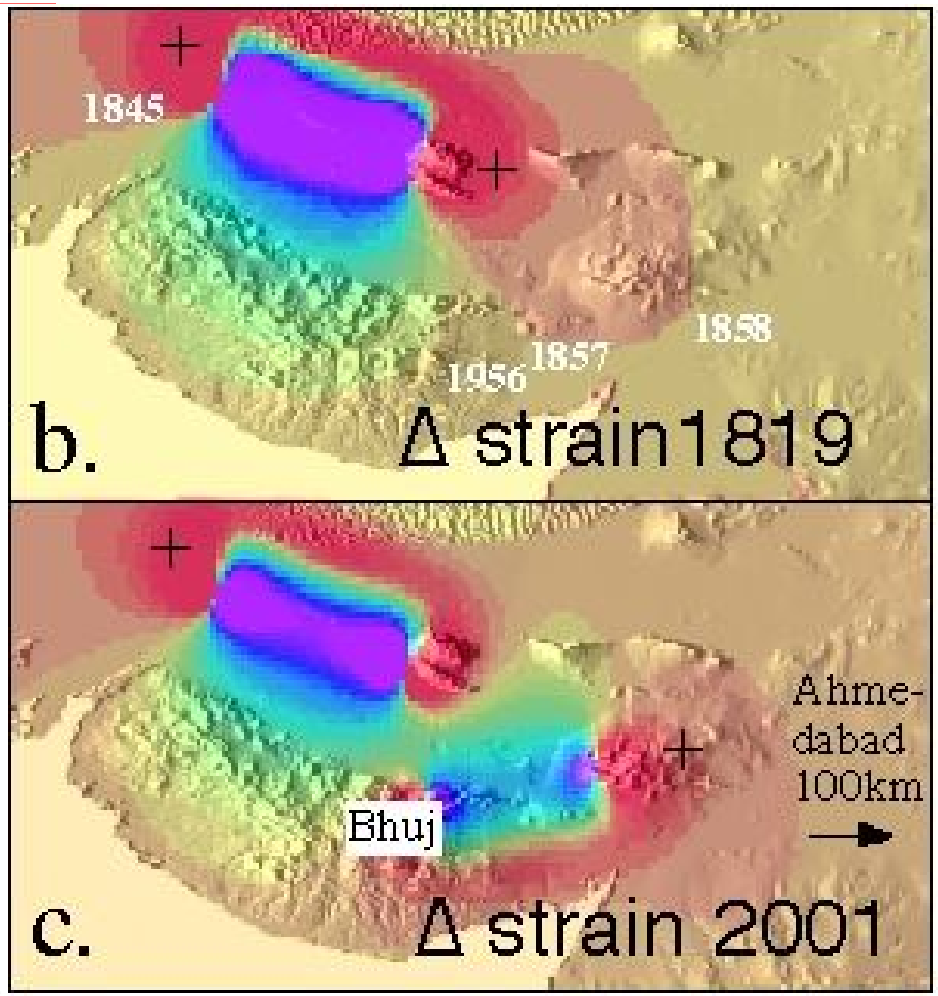
- Bhuj was originally an ancient walled city, and it still has both part of its original fortifications and many historical buildings within the city core. Some of the fort walls had survived the vicissitudes of time, only to now be heavily damaged by the earthquake

Gujarat Quake

- In Ahmedabad, many of the traditional buildings within the Old Walled City area had timber lacing in the walls, and exhibited other elements that have proven to make them more resistant to earthquake damage than the stone construction found in Kutch.

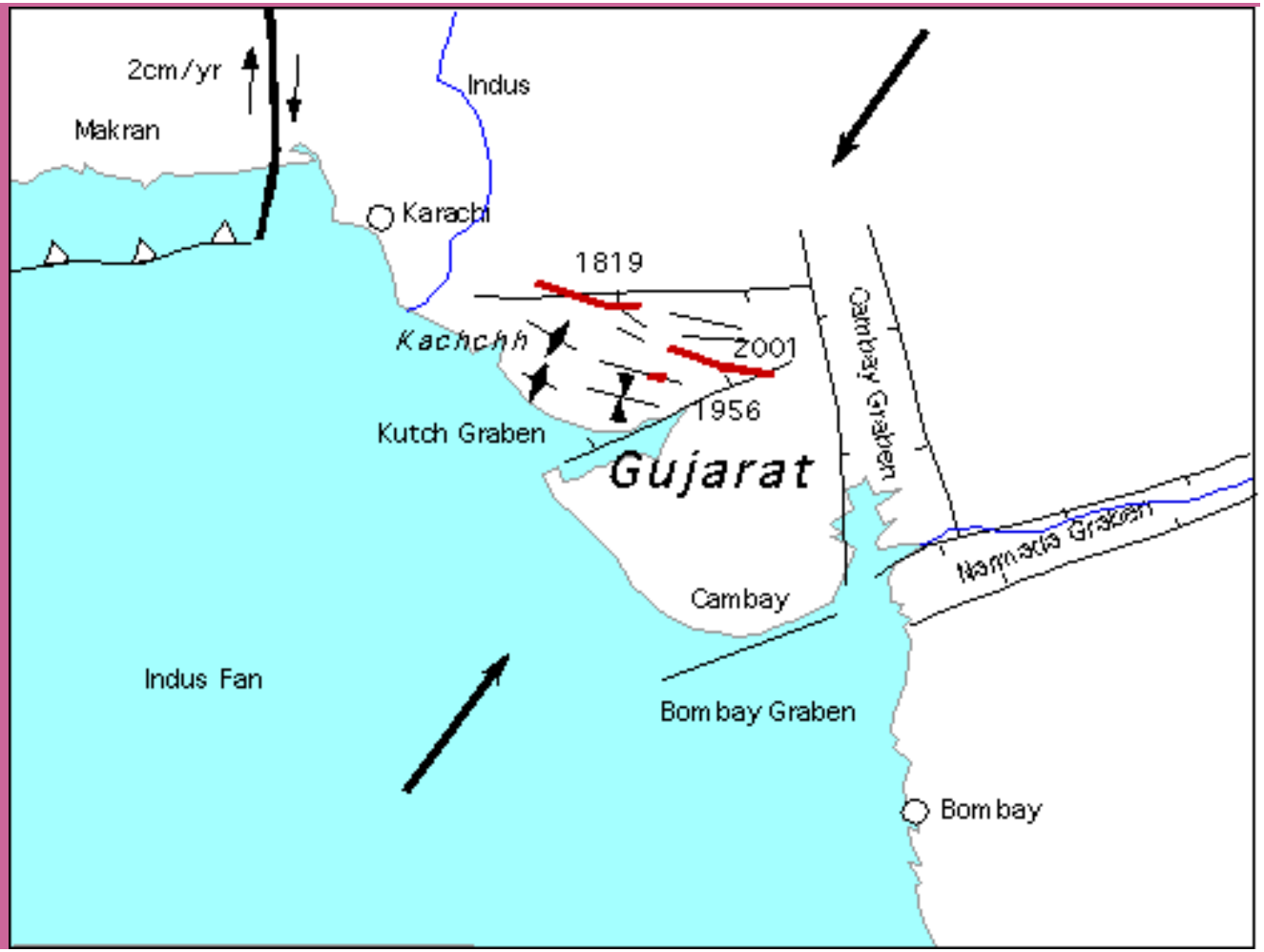
- As a result, only one building is reported to have collapsed n the Old City of Ahmedabad, and the damage there was far less (although the shaking of the earthquake was significantly less than in Kutch, but nonetheless strong enough to collapse a number of reinforced-concrete high rise apartment buildings of recent construction, with high rates of casualties).

Future quakes
Marching towards Ahmedabad

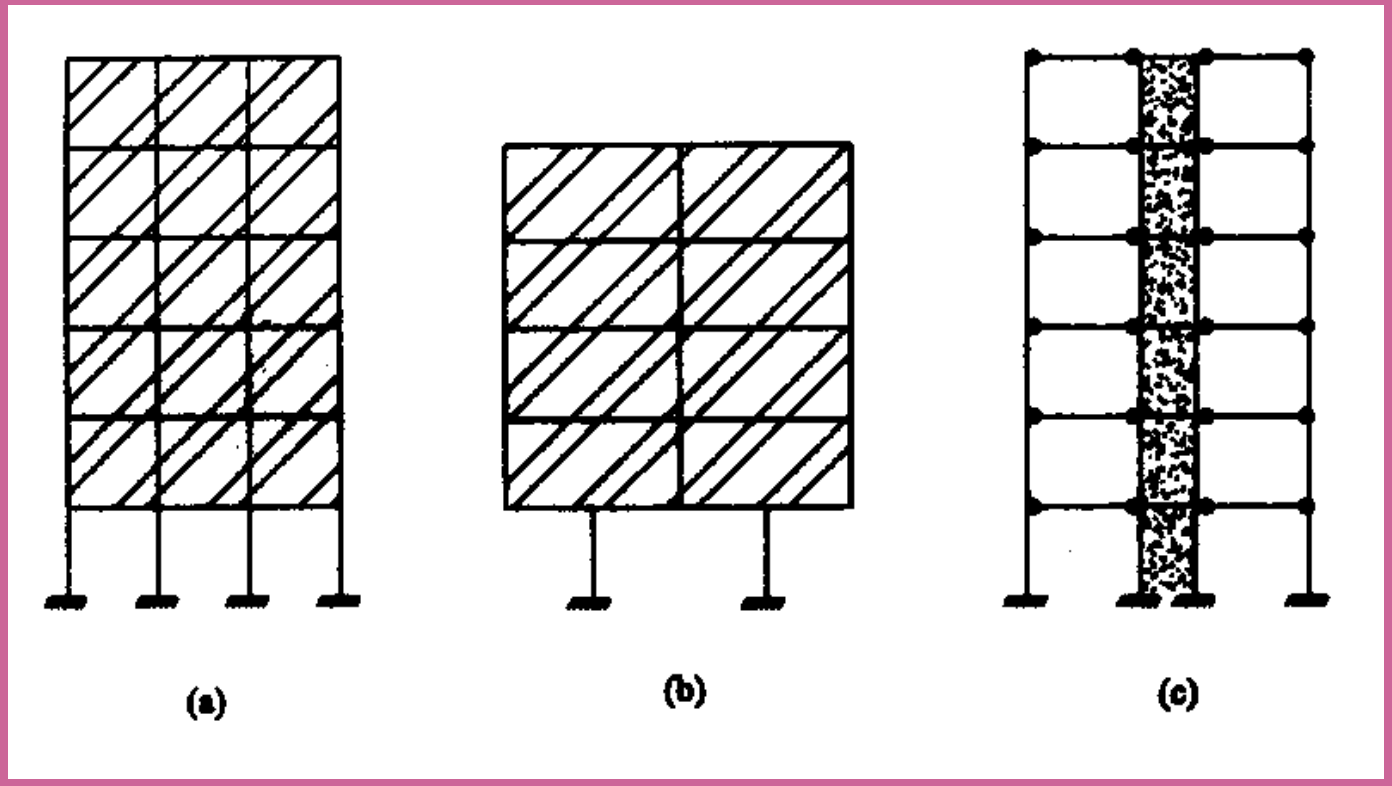


Faults mapped by Malik et al. (2000) and by Rajendran and Rajendran (2001) with mainshock and one large aftershock mechanism from USGS/NEIC

Future quakes
Marching towards Ahmedabad



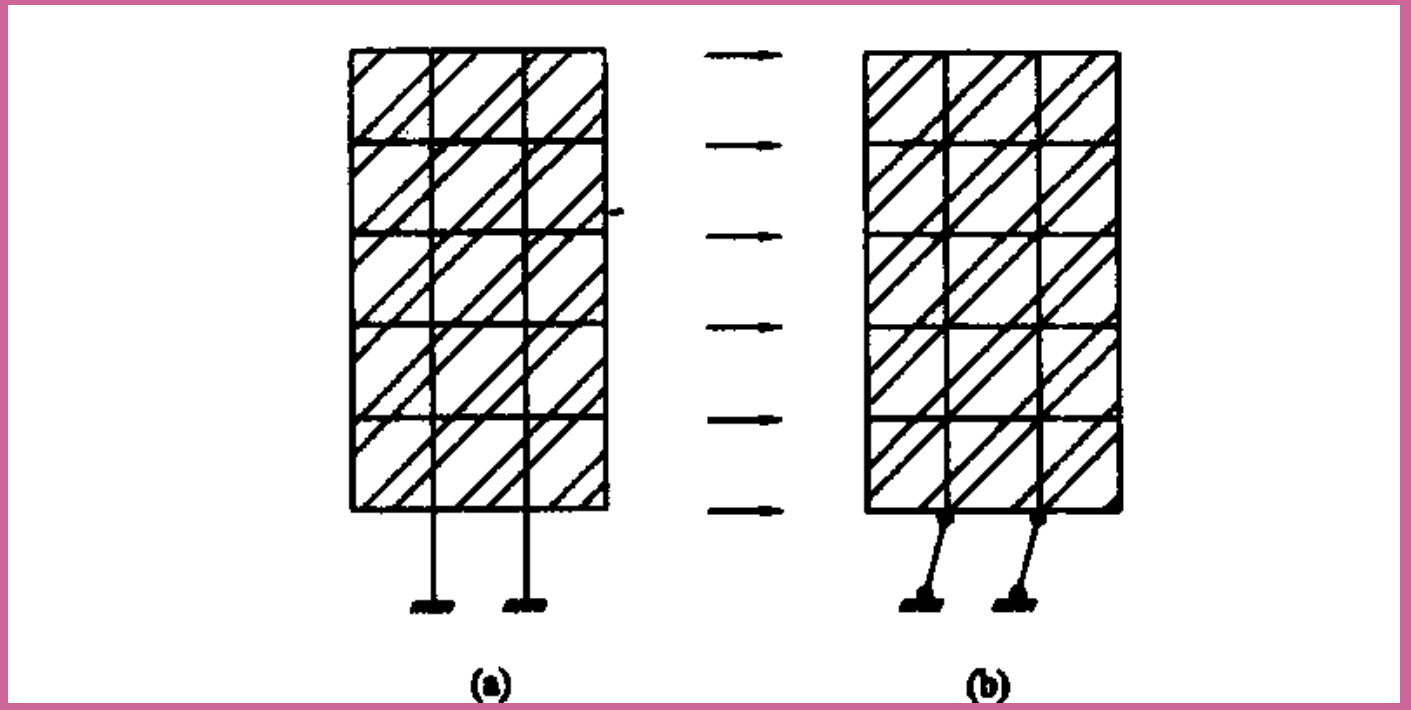
Ahmedabad Building Collapse Assessment



- Improper Structural Systems Employed in Ahmedabad (Outer bays are simple supported in Fig. c)

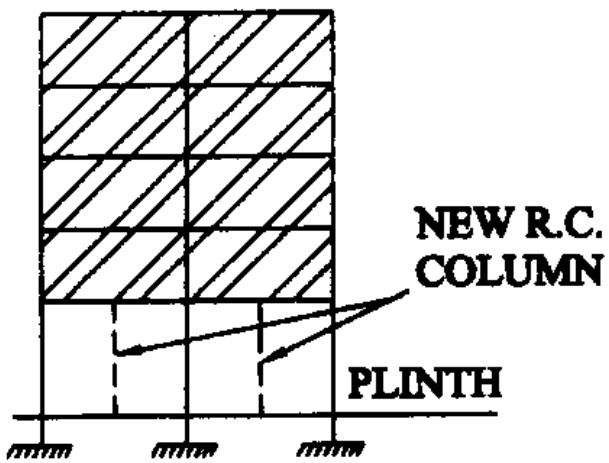
Ahmedabad Building Collapse Assessment

- **Soft Storey (hollow Plinth) Failure Mechanism**

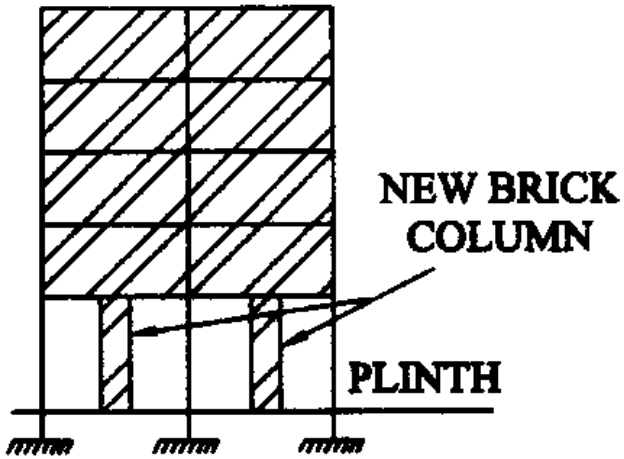


Ahmedabad Building Collapse Assessment

Use of Stub columns without beams and foundations



(a)



(b)

Ahmedabad Building Collapse Assessment

- About 65 buildings collapsed
- Only 2 were High rise bldgs (Mansi and Shikhar)
- Out of remaining 63 only 13 were built prior to 1990.
- All the 13 such buildings collapsed due to non-maintenance & major alterations after they were built.
- Only 2 buildings which collapsed had basements
- 50 buildings collapsed having hollow plinth (soft storey)
- Buildings having E, C and F shapes as Plans suffered more damage
- Major collapse took place at the staircase joint which was the weakest of all structural members.
- Tie beam was absent in majority of buildings which collapsed.

Ahmedabad Damage Assessment

’Mansi’,

Collapsed from stair joint

Ahmedabad Damage Assessment

A split building.

Weak structural joint.

Pictures of Taiwan Quake

Hollow
Plinth
Collapse
in Highrise

Collapse Analysis

- A significant number of the midrise buildings suffered dramatic failure generally from loss of stability due to the hollow plinth storey during the January 26, 2001 earthquake.
- Many buildings had only two to four columns at the ground floor. The size of columns in the ground floor varied from 230 mm x 230 mm to 230 mm x 900 mm depending upon the storey height.
- The frames had weak column-strong girder proportions.

Collapse Analysis

- Deficiencies included insufficient column ties, lack of cross ties, 90-degree rather than 135-degree hooks on the ties, splices with inadequate length and confinement, and no staggering.
- Even the G + 10 storey buildings had isolated floorings without interconnecting foundation beams. Some of the buildings were located on in-filled soil without carrying out detailed geotechnical investigations.
- The quality of concreting was poor and there was no control on water cement ratio
- Concrete compaction was poor
- Little curing was done

Building Design Philosophy

- No Standard can lay down regulations so that no structure shall ever suffer any damage during earthquakes of all magnitudes.
- The design approach adopted in the bylaws is to ensure :
  - A structure possess maximum strength to withstand minor earthquakes, which occur frequently, with some non-structural damage,
  - Resist moderate earthquakes, which occur once in twenty five years or so, with minor structural damage and some non structural damage and,
  - Withstand a major earthquake, which is likely to occur once in a life time of the structure, without complete collapse.

Earthquake resistant buildings Classification

- **Level 1:**

  No Structural Damage, minor non structural damage, No need to vacate
- **Level 2:**

  Minor Structural Damage, No need to vacate, can live while ongoing repairs
- **Level 3:**

  Major Structural Damage, unsafe, Need to vacate, can only live after the repairs are complete.
- **Level 4**

  Major Structural Damage, Building Useless but no collapse. Have to demolish and rebuild

Guidelines for Earthquake Resistant buildings

- For buildings taller than 30 metres, model analysis should be carried out to study the behaviour of the building under random motion of ground.
- For buildings taller than 75 metres dynamic behaviour of the structures should be studied to evolve their design.
- For all buildings taller than 30 metres, effect of positive torsion should be taken into account.
- Natural frequency of buildings should be mistuned with that of earthquakes. There are a number of empirical formulae available to find the natural frequency of buildings. The vibration period of earthquakes is normally 1.5 to 2.5 seconds.

Guidelines for Earthquake Resistant buildings

- Higher factor of safety should be used in design of tall structures such as chimneys, towers and tanks.
- Intensity of shocks due to earthquakes may vary with variation in soil conditions. Soil conditions should, therefore, be studied to work out seismic coefficients for hard, medium or soft soils.
- Stiff buildings are more prone to earthquakes. In earthquake prone areas, buildings should be ductile and flexible.
- Circular buildings are least affected by earthquakes as compared to other buildings. Buildings should be symmetrical and having minimum corners.
- Slenderness ratio of buildings should be limited.

Guidelines for Earthquake Resistant buildings

- A large damage occurs due to breakout of fires on occurrence of an earthquake. No time may be available to operate fire fighting equipment when an earthquake occurs. The structures should, therefore, be built by designing them to be safe against fire.
- The vibrations due to earthquake rise in buildings from foundation upwards. The buildings should therefore be provided with bearings that are able to absorb shock waves. Many kinds of effective and useful bearings have been developed by engineers for use in other structures bearing dynamic loads such as bridges. So there is no dearth on this account.
- A multi-storeyed building having a tube structure proves highly effective in resisting seismic loads. Such a structure was first suggested by Owings and Merril, Chicago. In such a structure, the core of the building is kept stiff while columns are provided along its periphery and are connected by spandrel beams.
- Wherever possible, a flat slab design should be preferred for ceilings as it does away with the beams.

Guidelines for Earthquake Resistant buildings

- Mass of the buildings should be kept as low as possible. Light weight materials should be brought under use. Lesser is the self weight of buildings, lesser will be the earthquake force affecting it.
- Joints of a building should be so designed that cumulative effect of deflection does not occur in any member. Deflection diagram of the buildings should be well studied.
- The structural framework should be kept highly redundant or indeterminate during design. Such a structure will provide better resistance to earthquake

Government Initiatives

- Political Motive with shorter vision
- Court criminal cases with wrong Sec 304 A
- Such situation hampers the rebuilding of collapsed structures
- Most of the government aid was un-used for reconstruction
- Long and complicated litigations
- Resulted into ramification of all govt. initiatives

Post Earthquake Scenario

Building Bylaws

- Simple without loopholes
- Equal FSI for both High rise and low rise
- No cantilever projections allowed
- Calculation of FSI simplified using volumetric method
- FSI exemption for basement not permitted if used as storage.
- No apartment projects allowed on road narrower than 7.5 mt.
- Setup of an appeal committee.

Post Earthquake Scenario

Professionals

- Registration mandatory for developers/builders
- Developers are required to be enrolled with their associations
- Affidavit required for Quality control and byelaws from the developer for every project
- Registration of : structural engineer and clerk of works, architect and consulting engineers.
- Importance of GICEA and GIHED (in the appeal committee)
- Affidavit on completion of the project required along with approval
- Soil Investigation Report mandatory

Post Earthquake Scenario

Institutional Changes

- Excellent database
- Registration of Laboratories
- GSDMA setup and many programmes
- Educational initiatives
- Training initiatives
- Progress report during construction
- Requirement of completed building photographs before issuing B.U. Permission
- IS Codes are modified and implemented

Post Earthquake Scenario

Construction Industry

- Branded TMT Steel used in Construction
  (material selection given careful review)
- M20 grade of concrete
- No major alteration in the specified design during construction
- Adherence to structural stability.
- stub columns no longer used in buildings.
- Quality testing of all materials
- Emphasis on curing
- Use of Ready mix concrete (RMC) prevalent
  (For consistent quality mix)

Post Earthquake Scenario

Legal Awareness by Industry

- Emphasis on titles of the property
- Planning Proposals
- Emphasis on EARTHQUAKE RESISTANT DESIGN
- BU permission
- Marketing with appropriate tag lines such as GIHED member, good quality, earthquake resistant design, etc.

Post Earthquake Scenario

Customer Preferences

- Few prefer to stay in high-rise buildings
- Few prefer to live in houses which were constructed prior to earthquake
- Majority of MIG population prefer locations of Bopal-Ghuma having individual units.
- Members are more conscious regarding the maintenance of the building they live in.

Post Earthquake Scenario

Code of Conduct

- Exemplified by GIHED and FREDAG
- Change in mindset of developers
- Insistence on BU and legal permissions
- Maintaining records of past projects.
- Bad reputation of builders yet to be repaired
- Today majority of leading builders are technocrats and highly qualified civil engineers and planners.

Post Earthquake Scenario

- EWS HOUSING
  - AUDA has set an example in EWS Housing.
  - Mascot technology of G+3 houses built by AUDA
  - Total houses supplied- 5000 units of 25 sq. mts. @ Rs. 85,000
  - Excellent quality of construction
  - All buildings are earthquake resistant having RCC Shear walls
  - Residents/occupants do not have any option to modify any structural member of the house due to its unique design.

Post Earthquake Scenario Future Trends

- Ratings for Builders
- Registration of Builders by government agencies (Evaluation criteria to practice)
- Technically qualified agents and liasoning personnel with AMC/AUDA.
- Real time quality checks
- City level consumer awareness cell
- Construction R&D for display, development and feedback of new and up coming technologies
- Training for all.

THANK YOU !

On behalf of

GICEA, GIHED and RESMA