Strength and Stability Enhancement of Reinforced Concrete Buildings by constructing them Earthquake Resistant

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ABSTRACT: Earthquakes are very serious problems since they affect human life in various ways. The Earthquakes are mainly prevented by two methods namely Base Isolation Methods and Seismic Dampers. There are structural requirements which a building should have in order to resist earthquakes. There are various designs of structures which cause damages during earthquake and the most important one is the "short column effect". The various solutions which can be applied in order to overcome these effects and to strengthen the structural elements are briefly explained. The retrofitting and special confinement reinforcement is the methods applied. The present paper deals with Base Isolation and Seismic Damper Methods in brief manner. This paper explains the methods and their preventive measures about Earthquakes. The present paper deals with structures which resist Earthquakes. It explains the frames which help in resisting Earthquakes.

I. STRUCTURAL FRAMING

There are basically two types structural framing possible to withstand gravity and seismic loads viz bearing wall construction and framed construction. The framed construction may again consist of:

a. Light framing members which must have diagonal bracing such as wood frames or infill walls for lateral load resistance.

b. Substantial rigid jointed beams and columns capable of resisting the lateral loads by themselves. The framed constructions can be used for a greater number of storeys compared to bearing wall construction. The strength and ductility can be better controlled in framed construction through design. The strength of the framed construction is not affected by the size and number of openings.

II. REQUIREMENTS OF STRUCTURAL SAFETY

The following main requirements of structural safety of buildings can be arrived at:

a) A free-standing wall must be designed to be safe as a vertical cantilever. This requirement will be difficult to achieve in unreinforced masonry in Zone A. Therefore, all partitions inside the buildings must be held on the sides as well as top. Parapets of category I and II buildings must be reinforced and held to the main structural slabs or frames.

b) Horizontal reinforcement in walls is required for transferring their own out-of-plane inertia load horizontally to the shear walls.

c) The walls must be effectively tied together to avoid separation at vertical joints due to ground shaking.

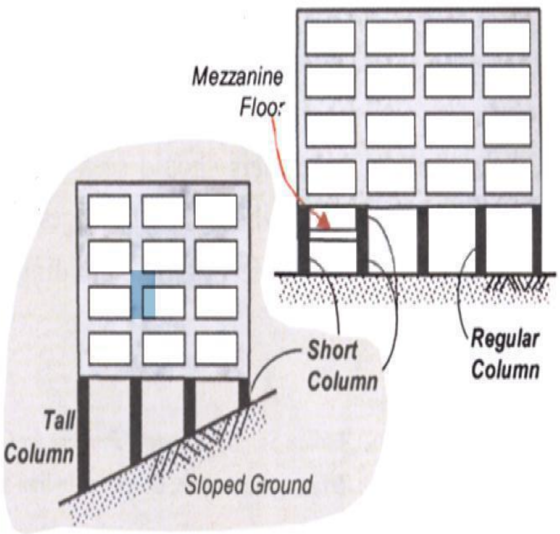
d) Shear walls must be present along both axes of the building.

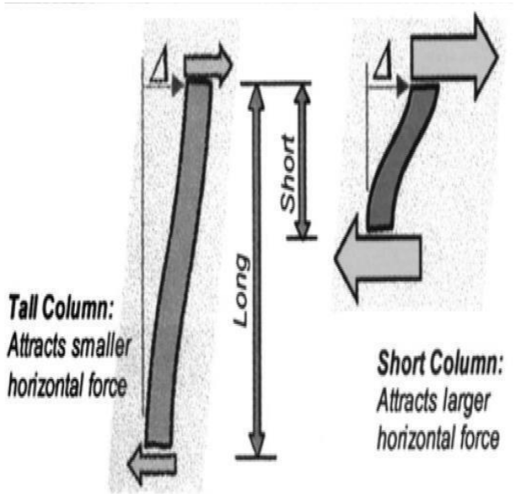
e) A shear wall must be capable of resisting all horizontal forces due to its own mass and those transmitted to it.

f) Roof or floor elements must be tied together and be capable of exhibiting diaphragm action.

g) Trusses must be anchored to the supporting walls and have an arrangement for transferring their inertia force to the end walls.

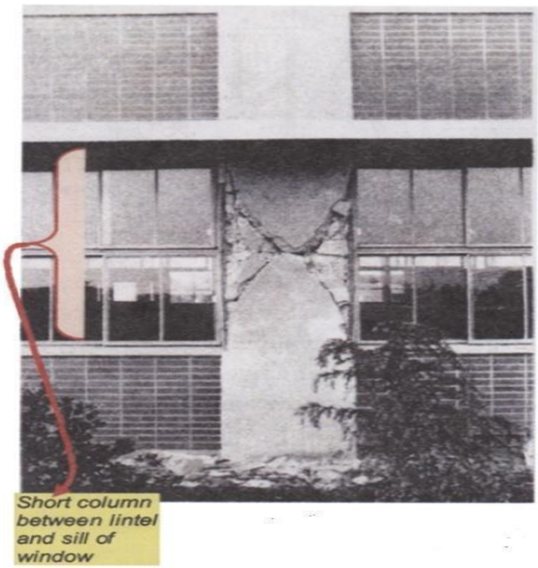
During past earthquakes, reinforced concrete (RC) frame buildings that have columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey. Two examples of buildings with short columns in buildings on a sloping ground and buildings with a mezzanine floor can be seen in the figure given below.

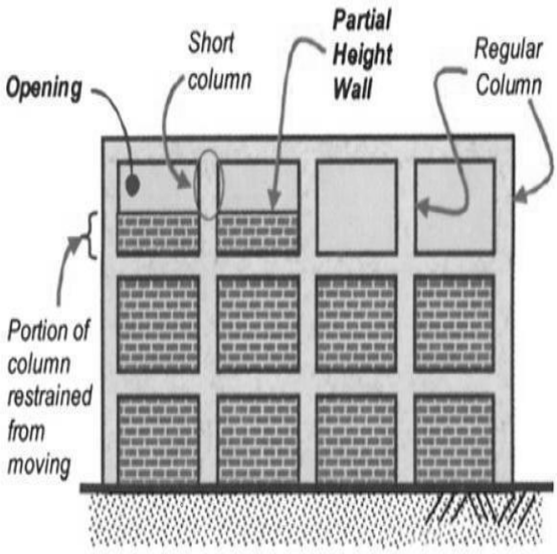




Poor behavior of short columns is due to the fact that in an earthquake, a tall column and a short column of same cross section move horizontally by same amount which can be seen from the given figure.

However, the short column is stiffer as compared to the tall column, and it attracts larger earthquake force. Stiffness of a column means resistance to deformation- the larger is the stiffness, larger is the force required to deform it. If a short column is not adequately designed for such a large force, it can suffer significant damage during an earthquake. This behavior is called short column effect. The damage in these short columns is often in the form of X-shaped cracking – this type of damage of columns is due to shear failure.

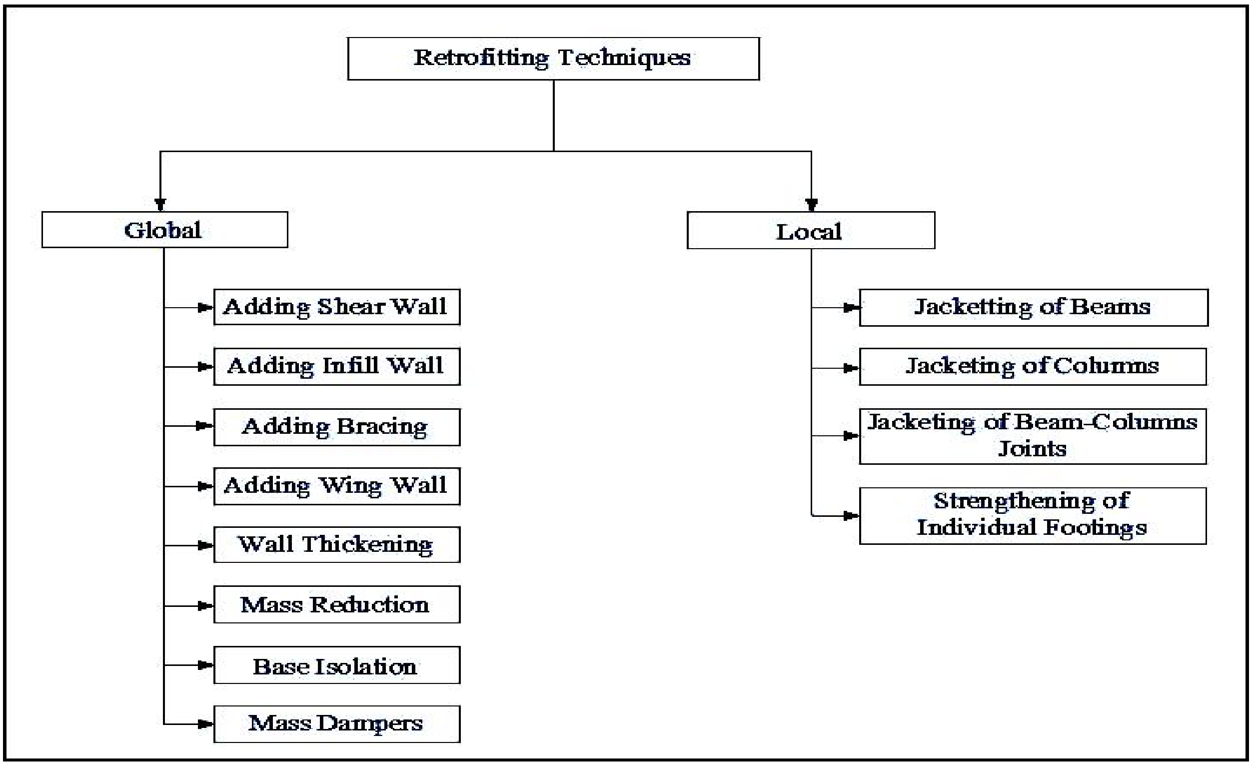




Many situations with short column effect arise in buildings. When a building is rested on sloped ground, during earthquake shaking all columns move horizontally by the same amount along with the floor slab at a particular level (this is called ***rigid floor diaphragm action***). If short and tall columns exist within the same storey level, then the short columns attract several times larger earthquake force and suffer more damage as compared to taller ones. The short column effect also occurs in columns that support mezzanine floors or loft slabs that are added in between two regular floors.

There is another special situation in buildings when short-column effect occurs. Consider a wall *(masonry* or RC) of partial height built to fit a window over the remaining height. The adjacent columns behave as short columns due to presence of these walls. In many cases, other columns in the same storey are of regular height, as there are no walls adjoining them. When the floor slab moves horizontally during an earthquake, the upper ends of these columns undergo the same displacement. However, the stiff walls restrict horizontal movement of the lower portion of a short column, and it deforms by the full amount over *the short height* adjacent to the window opening. on the other hand, regular columns deform over the *full height.* Since the effective height over which a short column can freely bend is small, it offers more resistance to horizontal motion and thereby attracts a larger force as compared to the regular column. As a result, short column sustains more damage. X-cracking in a column adjacent to the walls of partial height. In new buildings, *short column effect* should be avoided to the extent possible during architectural design stage itself. When it is not possible to avoid short columns, this effect must be addressed in structural design. The Indian Standard IS: 13920-1993 for ductile detailing of RC structures requires special confining reinforcement to be provided over the full height of columns that are likely to sustain short column effect.

III. RETROFITTING TECHNIQUES



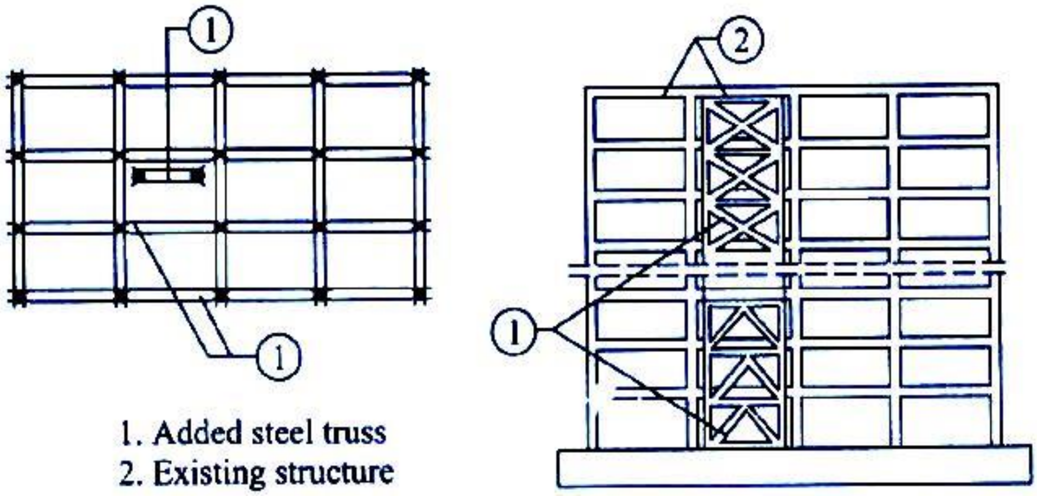
SOMEE CONVENTIONAL APPROACHES:

Adding new shear walls

- Frequently used for retrofitting of non-ductile reinforced concrete frame buildings.
- The added elements can be either cast-in-place or precast concrete elements.
- New elements preferably be placed at the exterior of the building.
- Not preferred in the interior of the structure to avoid interior moldings.

Adding steel bracings

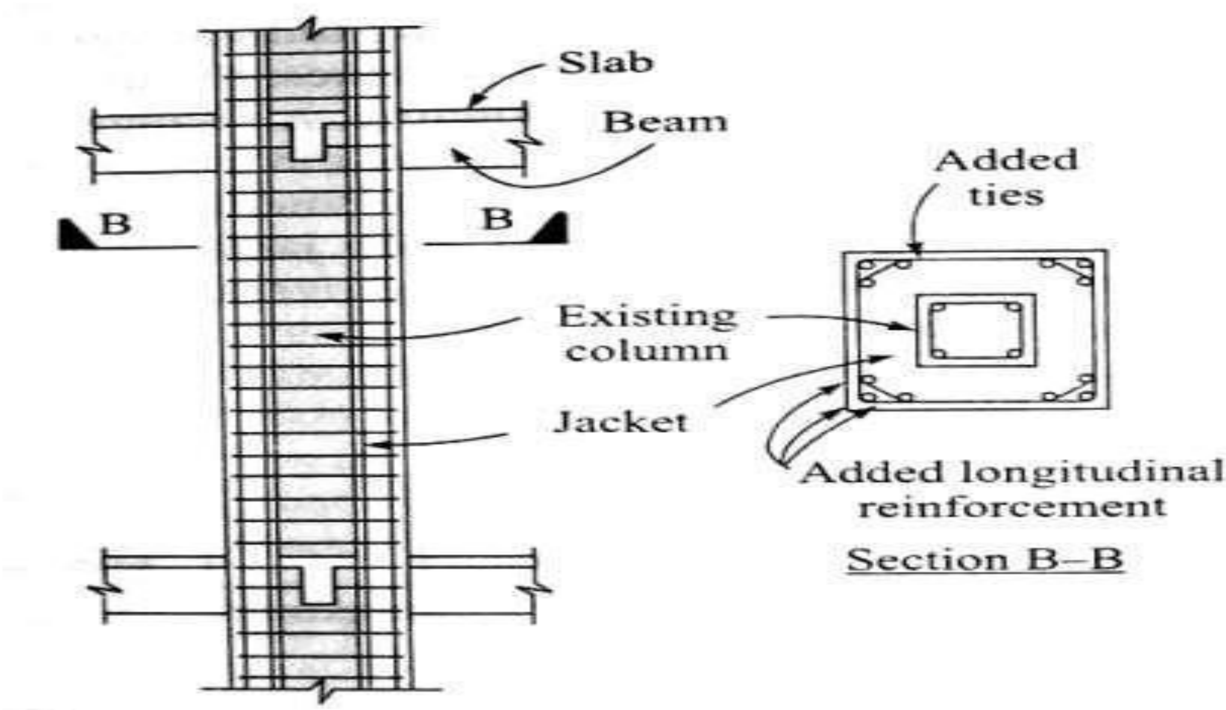
- An effective solution when large openings are required.
- Potential advantages for the following reasons
- higher strength and stiffness,
- opening for natural light,
- amount of work is less since foundation cost may be minimized
- adds much less weight to the existing structure



RC Building retrofitted by steel bracing

Jacketing (Local Retrofitting Technique)

- Most popular method for strengthening of building columns
- Types-1. Steel jacket, 2. Reinforced Concrete jacket, 3.
- Fiber Reinforced Polymer Composite (FRPC) jacket
- Purpose for jacketing:
  - To increase concrete confinement to increase shear strength
  - To increase flexural strength



RETROFIT OF STRUCTURES USING INNOVATIVE MATERIALS:

a) Current research on advanced materials has mainly concentrated on FRP composites.
b) Studies have shown that **externally bonded FRP composites** can be applied to **various structural members** including columns, beams, slabs, and walls to **improve** their structural performance such as **stiffness, load carrying capacity, and ductility.**

PURPOSE OF TRANSVERSE REINFORCEMENT:

Transverse reinforcement is specified in design codes for beams and columns to serve the following four functions:

a) to prevent buckling of longitudinal reinforcing bars,
b) to resist shear forces and to avoid shear failure,
c) to connect the concrete core to provide sufficient deformability (ductility),
d) to clamp together lap splices-after splitting cracks form parallel to the splices, ties or spirals restrain slip between the spliced bars. Note that none of these functions are effective till the concrete cracks or spalls; All are critical for the column to maintain vertical or lateral capacities under earthquake displacements in the post-yield range.

EARTHQUAKE RESISTANT DESIGN:

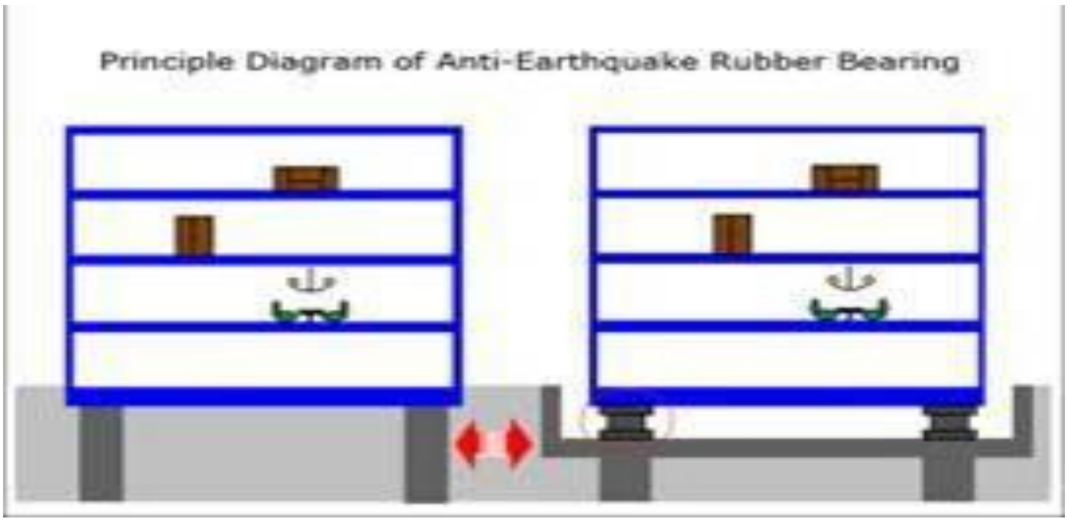
a) Design is nothing but calculation of loads on to structure and to make structure to resist them.
b) If such design is to make such that it resists EQ, then such design is called Earthquake Resistant Designs.

POPULAR EARTHQUAKE RESISTANT DESIGN:

a) The most popular EQ resistant Designs are:
    a. **Base Isolation Devices**
    b. **Seismic Dampers.**
b) The above methods are widely used and commonly used in different constructions to resist EQ loads.

EVOLUTION OF TECHNIQUES:

a) Earthquakes mainly happen in surface of Earth, so if we separate the structure from surface, then we can build EQ resistant Designs.
b) The main thought behind Base Isolation Devices is to separate buildings from surface of Earth.



The above diagram shows the Base Isolation Devices in a diagrammatic manner. In the above diagram, we can see how the structure is separated with help of rubber bearings from surface of Earth, and it became an EQ resistant Buildings.
Earthquakes are resisted not only by means of BID, but it is also resisted by Cross Bracings, Shear Walls and Shear Cores which resists EQ's. The cross bracings resist the movement of columns due to EQ, and it resists damage of structure in Vertical Direction. Shear Walls and Shear cores are used to resist structure during Earthquake in Horizontal Direction. This is most efficient technique and it is advancement in Base Isolation Devices.

ADVANTAGES OF BASE ISOLATION

a) Isolates Building from ground motion
   a. Lesser seismic loads, hence lesser damage to the structure.
   b. Minimal repair of superstructure.
b) Building can remain serviceable throughout construction.
c) Does not involve major intrusion upon existing superstructure.

DISADVANTAGES OF BASE ISOLATION:

a) Expensive
b) Cannot be applied partially to structures unlike other retrofitting
c) Challenging to implement in an efficient manner
d) Allowance for building displacements
e) Inefficient for high rise buildings
f) Not suitable for buildings rested on soft soil.

SEISMIC DAMPERS:

Seismic Dampers are used in place of structural elements, like diagonal braces, for controlling seismic damage in structures. It partly absorbs the seismic energy and reduces the motion of buildings.

Types:-

a) **Viscous Dampers** (energy is absorbed by silicone-based fluid passing between piston-cylinder arrangement),
b) **Friction Dampers** (energy is absorbed by surfaces with friction between them rubbing against each other), and
c) **Yielding Dampers** (energy is absorbed by metallic components that yield).

IV. CONCLUTION

The tasks of providing full seismic safety for the residents inhabiting the most earthquake-prone regions are far from being solved. However, in present time we have new regulations in place for construction that greatly contribute to earthquake disaster mitigation and are being in applied in accordance with world practice. In the regulations adopted for implementation in India the following factors have been found to be critically important in the design and construction of seismic resistant buildings:

a) sites selection for construction that are the most favorable in terms of the frequency of occurrence and the likely severity of ground shaking and ground failure;
b) high quality of construction to be provided conforming to related IS codes such as IS 1893, IS 13920 to ensure good performance during future earthquakes.
c) To implement the design of building elements and joints between them in accordance with analysis. ductility design should be done.
d) Whereas such the situations demand irregularity maximum effort should be given to done away with the harmful effects like that of "SH0RT C0LUMN EFFECT"

The modernized techniques of special confinement reinforcement and retro fitting methods help to increase the strength of columns and thereby increase the stability of the buildings. These modifications in construction and design can be introduced which as a result has increase seismic reliability of the buildings and seismic safety for human life.

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