KUPPAM ENGINEERING COLLEGE

DEPARTMENT OF CIVIL ENGINEERING

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EARTHQUAKE RETROFITTING OF BUILDING

SEISMIC RETROFITTING

- 240 million houses stock according to 2000 census
- 85 –90% houses are masonry houses
- Stone masonry, Block masonry, Brick masonry
- No standardized procedure
- Differs from structure to structure
- Depends upon seismic zone

CONCERN ABOUT EARTHQUAKE SAFETY

- Houses not designed to resist earthquakes
- People don't know what to do ?
- Whether their houses are earthquake safe ?
- How strong they are ?
- How to make them earthquake safe ?
- Buildings can be upgraded by minor interventions –Seismic Retrofitting
- What level of Seismic Retrofitting ?

SEISMIC EVALUATION OF BUILDINGS

- Earthquake intensity
- Structural configuration and components
- Structural condition
- Geological condition
- Foundation capability
- Non-structural components

DIFFICULTIES IN SEISMIC EVALUATION

- Difficulty in estimating the earthquake parameters, intensity.
- Influence of site condition –microzonation.
- Difficulty in estimation of insitu strength of materials.
- Analytical methods are either unreliable or too complex.

EVALUATION OF A BUILDING

- Before the retrofitting –to identify the deficiency

- After the retrofitting –to estimate the adequacy and effectiveness

SEISMIC SAFETY OF EXISING BUILDINGS

- Detailed layout (plan and elevation)
- Detail of foundation and soil
- Structural drawings
- Detail of codes used/ design calculations
- Vulnerability assessment
- If found deficient -retrofitting is done

VULNERABILITY ASSESSMENT

- Natural frequencies of vibration of the structure
- Frequency content of ground motion
- Type of local soil and type of foundation
- Strength of building material used
- Care taken in its detailing for energy absorption
- Care taken in construction

Damage to a traditional house

MASONRY BUILDINGS

Damage on masonry buildings start from corner separation

CAUSES OF UNSAFE BUILDINGS

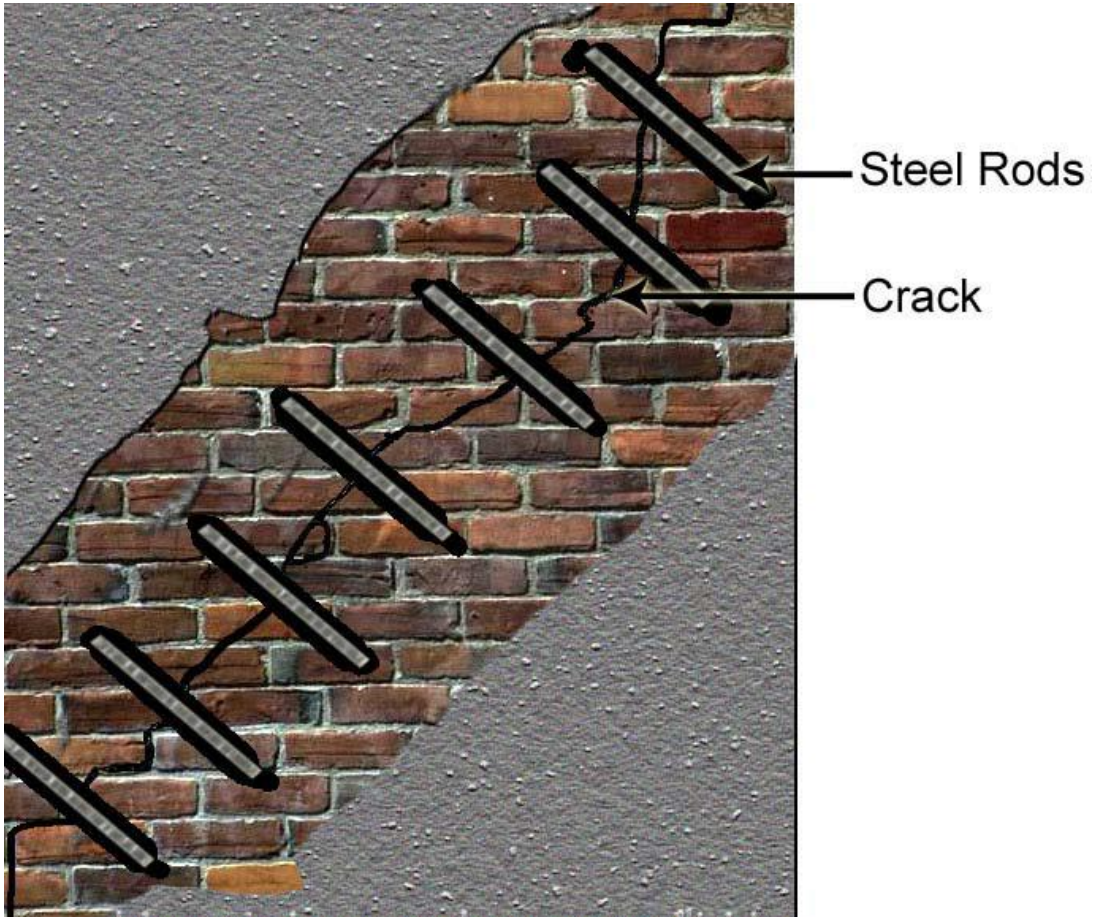
Number of unsafe buildings is alarming

- Non-engineered buildings
- Faulty original design –lack of lateral resisting elements: frames, shear walls
- Changes in Codal practices
- Inadequate detailing of reinforcement
- Extensions, Alterations and Encroachment
- Increase in load due to usage
- Poor and deficient construction
- Lack of regular maintenance
- Degradation of building material/ Corrosion

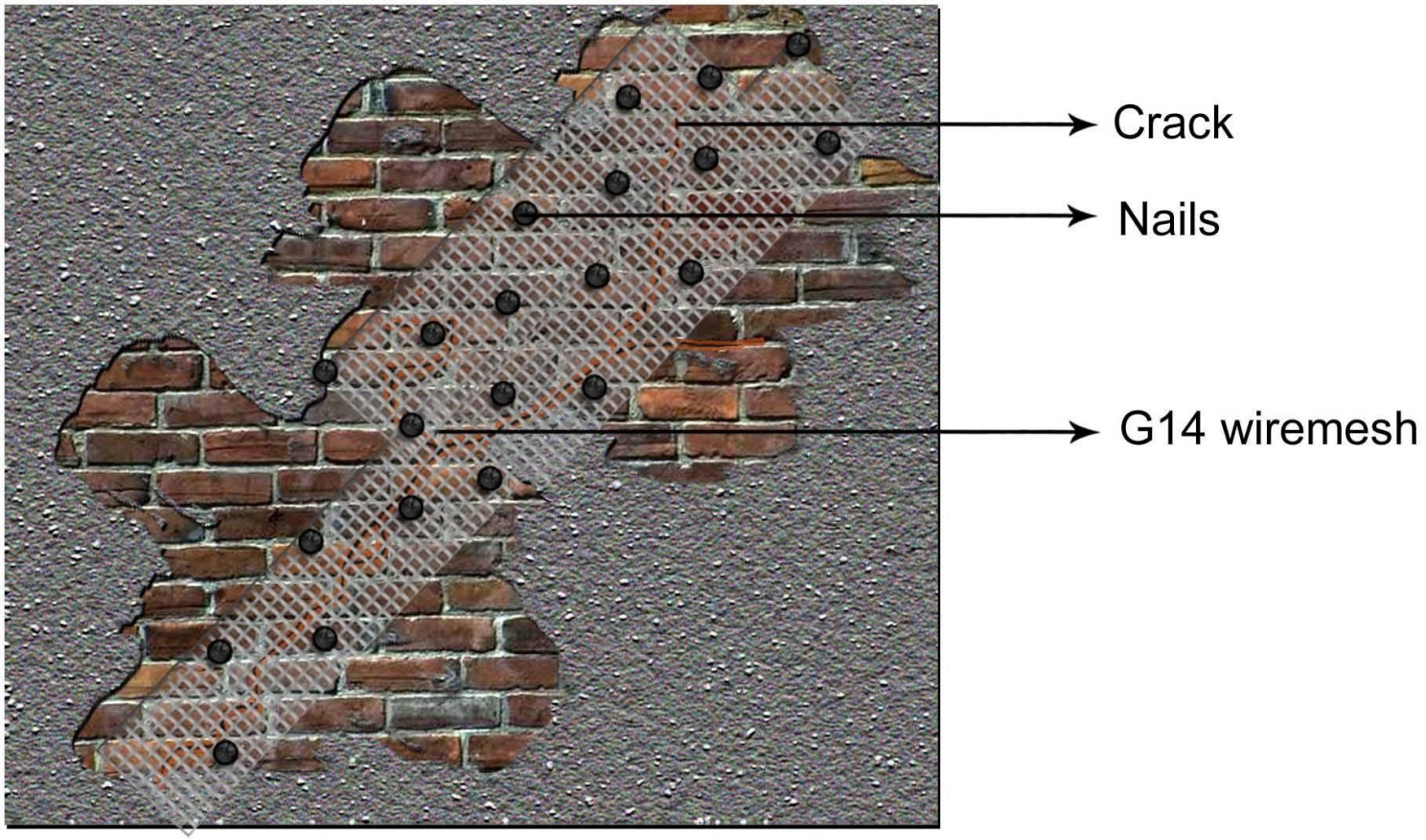
PRINCIPLE OF SEISMIC SAFETY OF MASONRY BUILDINGS

- Integral box action
- Integrity of various components Roof to wall
- Wall to wall at corners
- Wall to foundation
- Limit on openings

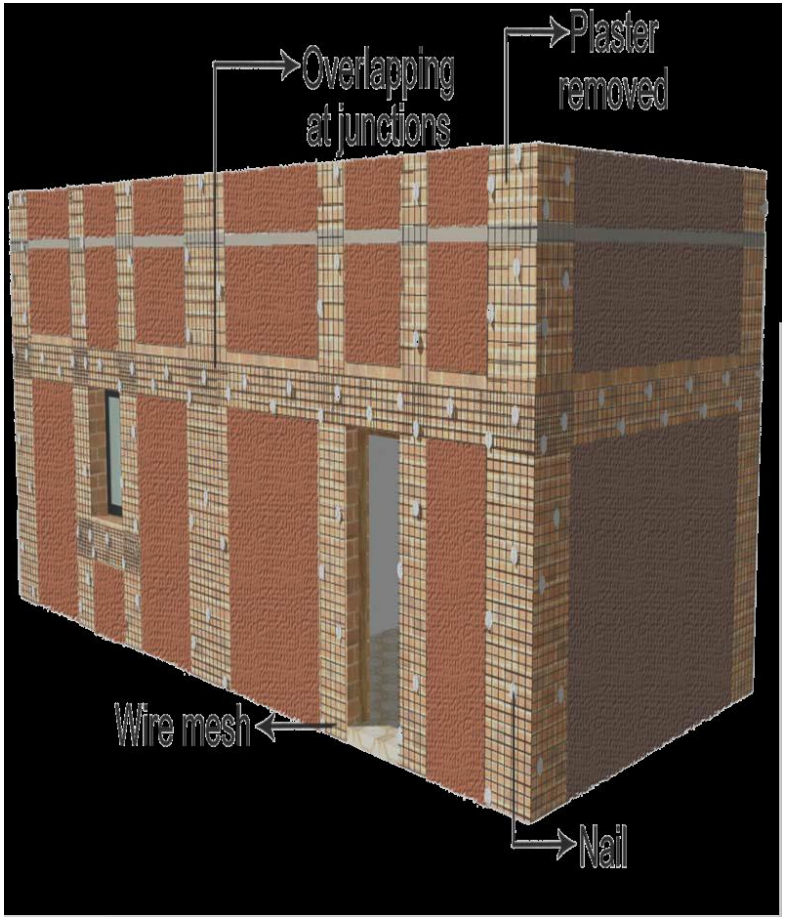
STITCHING OF CRACKS



REPAIR OF DAMAGED MEMBERS



INTEGRAL BOX ACTION THROUGH SPLINT AND BANDAGE



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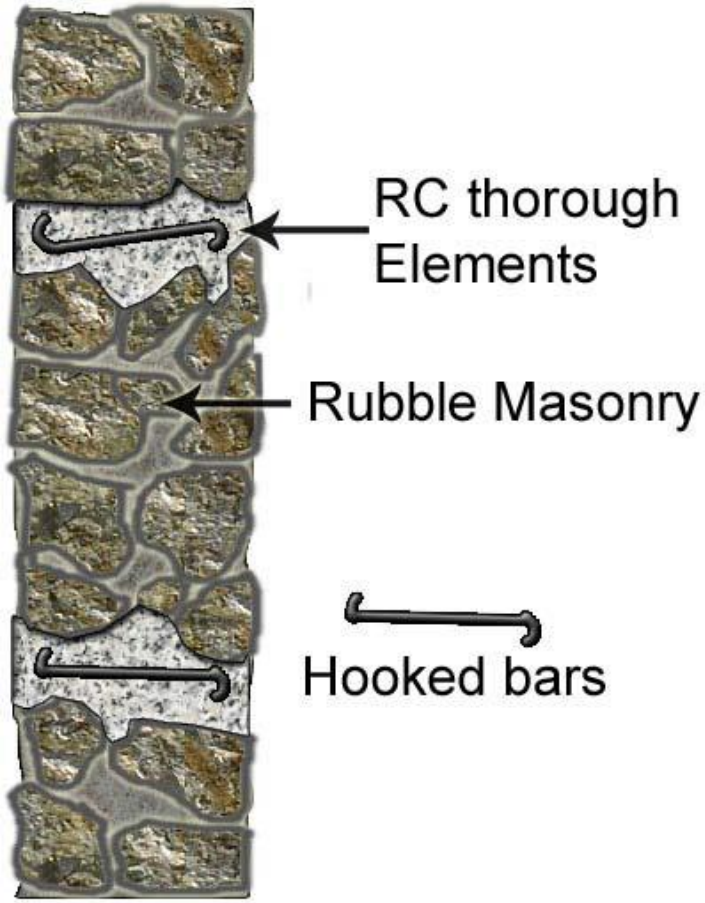
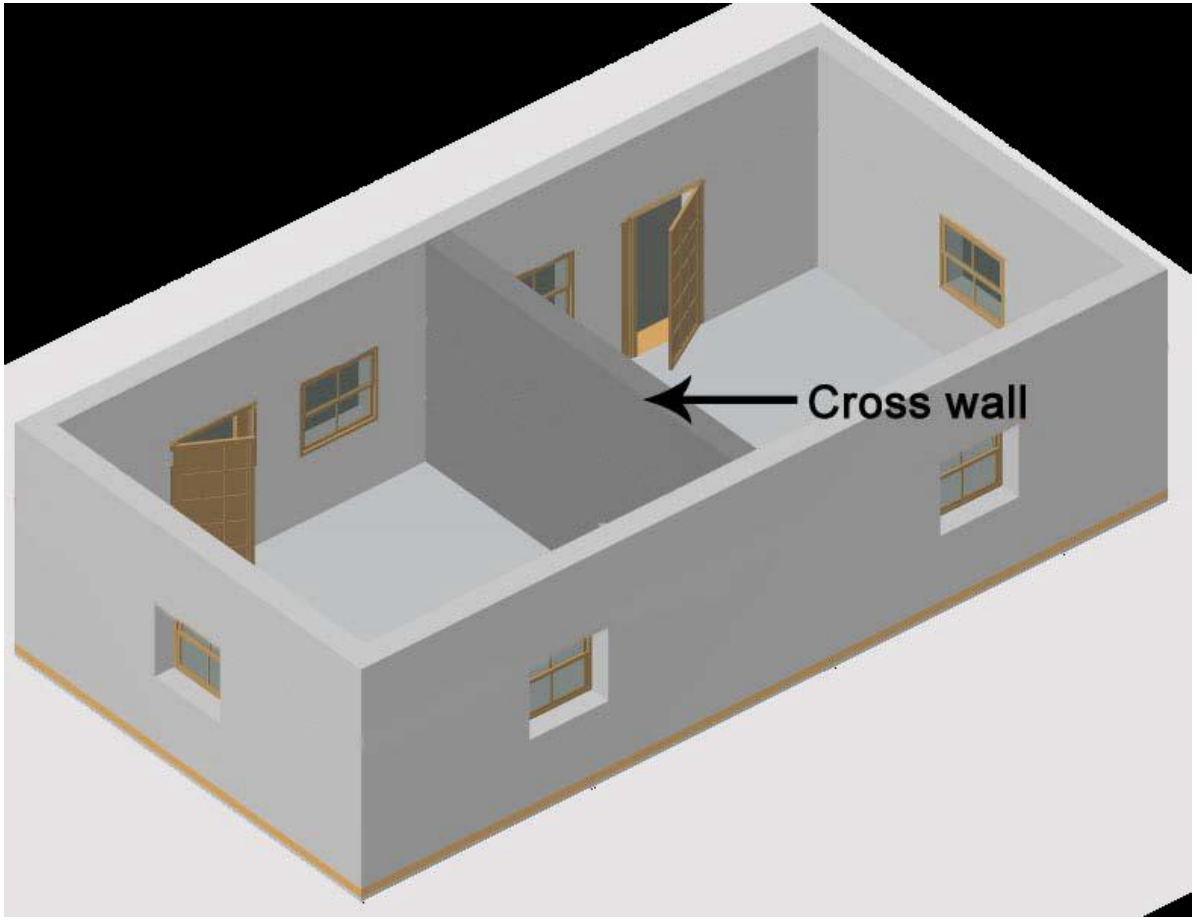
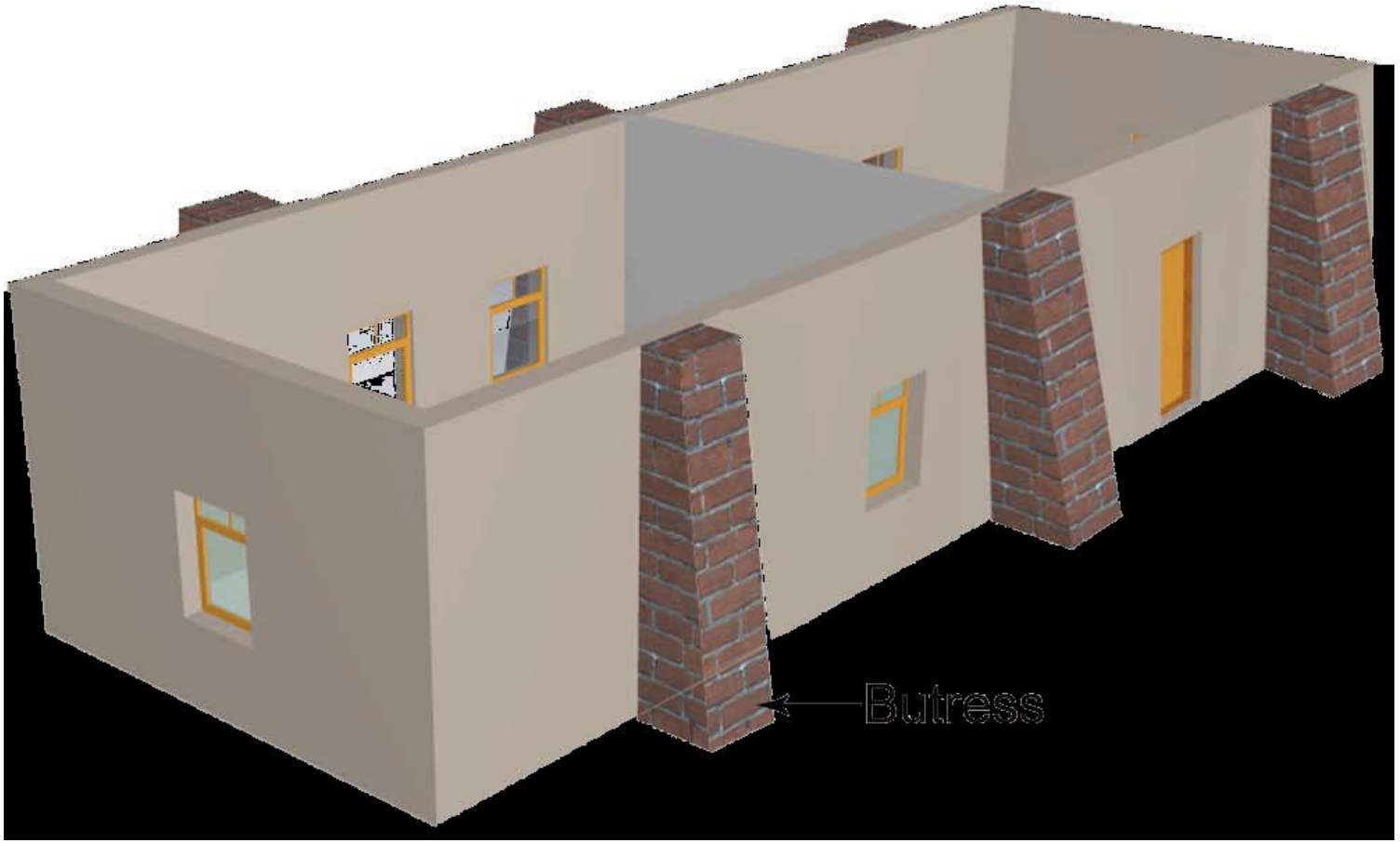
WALL INTEGRITY USING THROUGH ELEMENTS



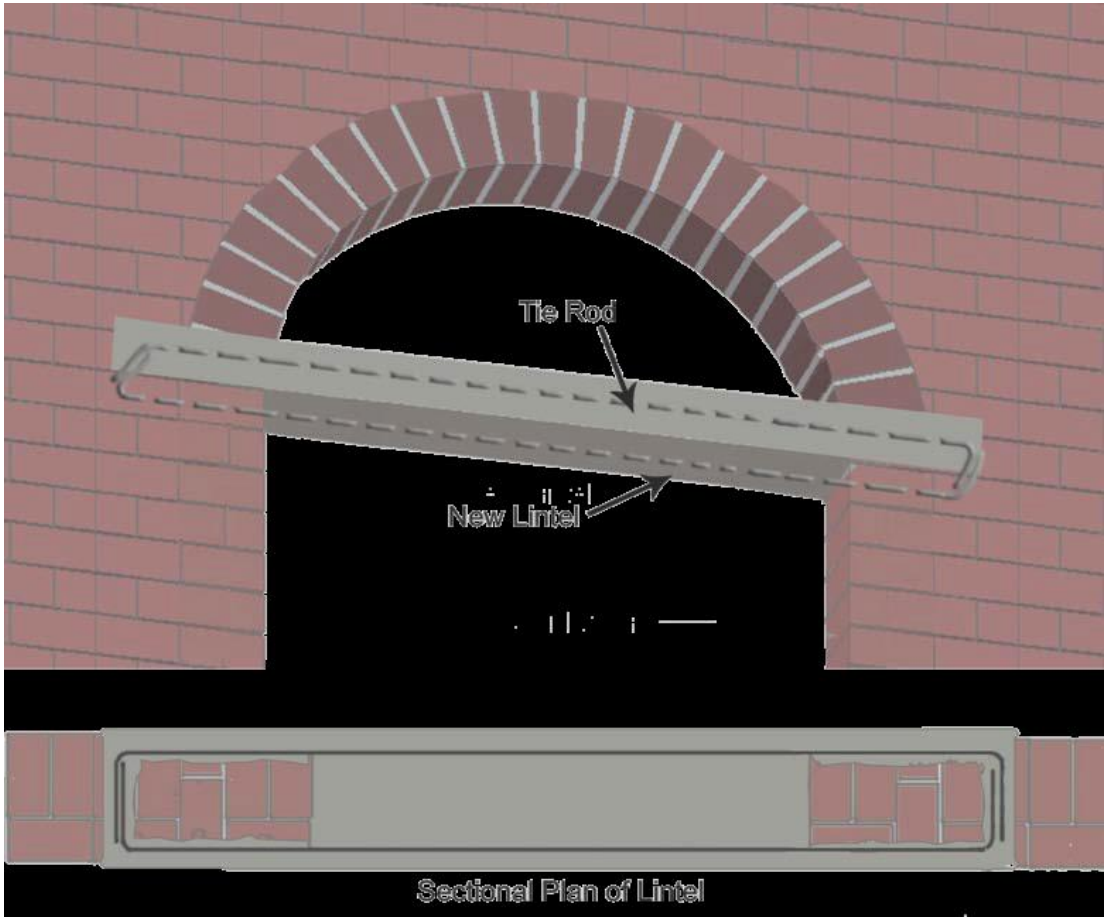
STRENGTHENING BY CROSS WALLS



STRENGTHENING BY BUTTRESSES



STRENGTHENING OF ARCHES



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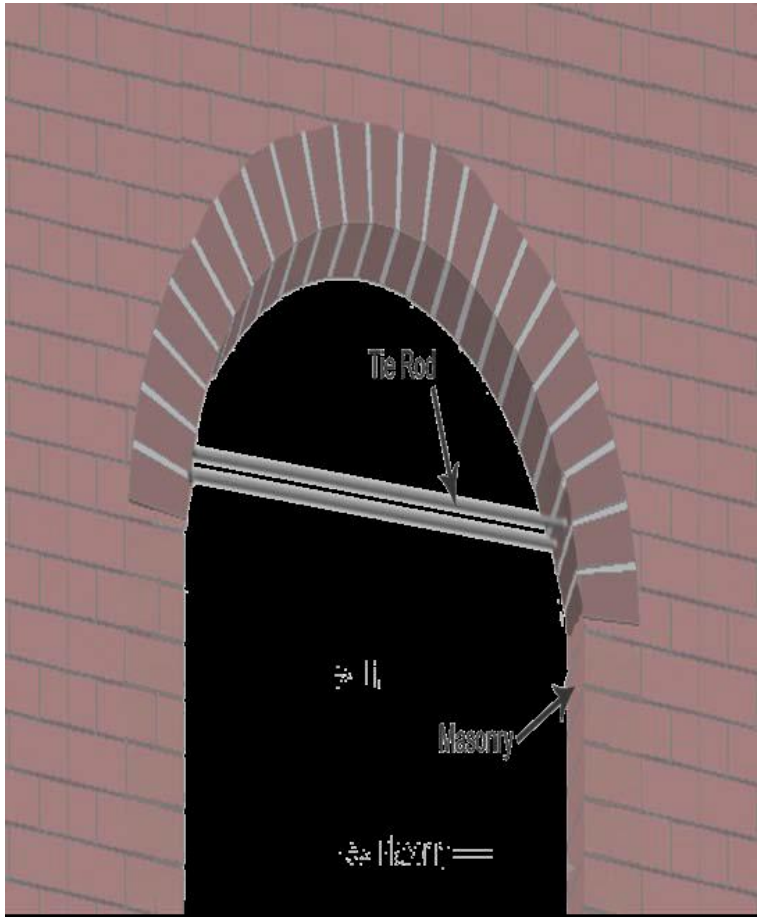
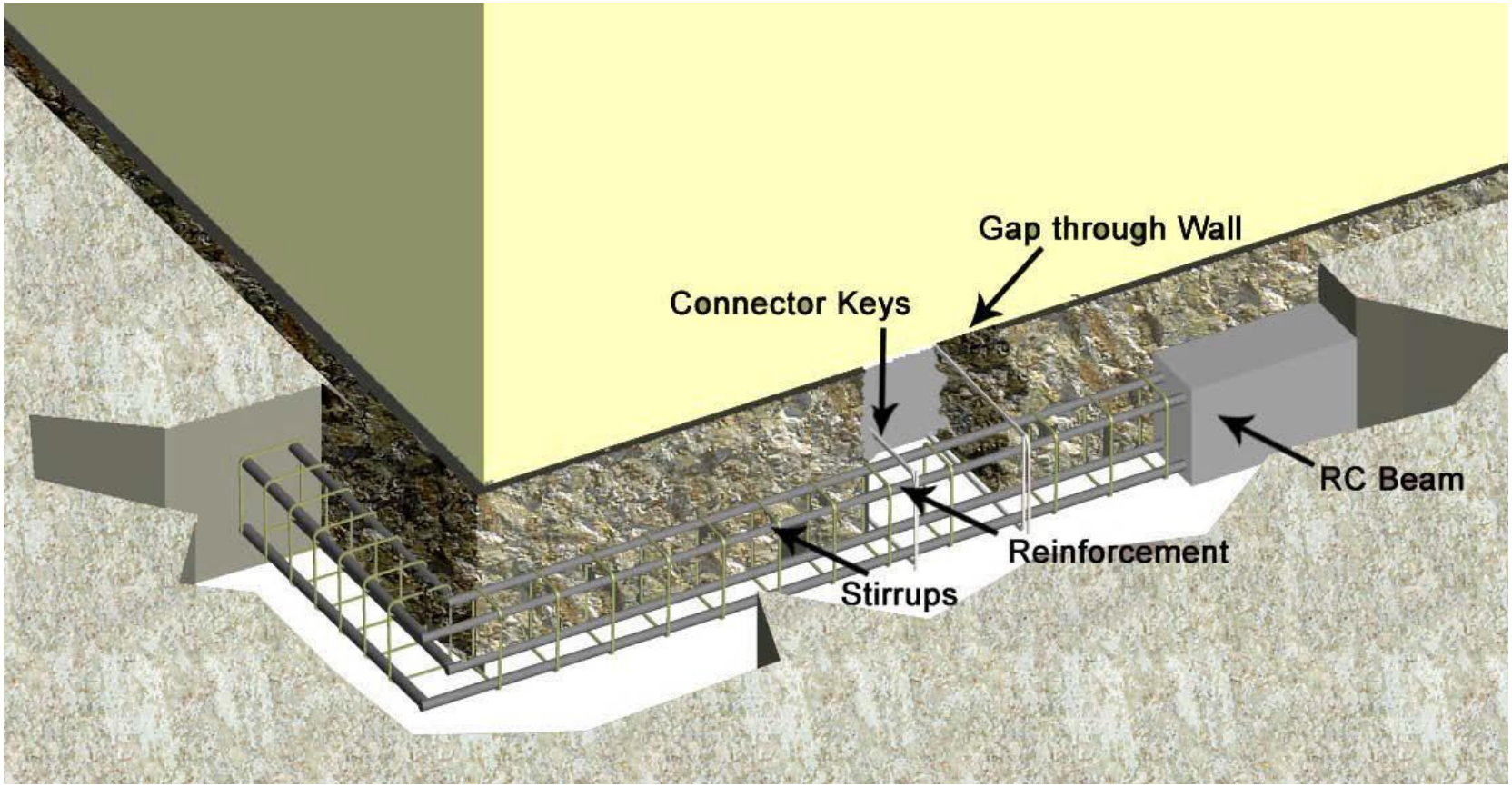


STRENGTHENING OF FOUNDATIONS



LESSONS FROM PAST EQ.

- Many buildings with soft storey collapsed due to failure of columns at joints in soft storey
- The failure occurred due toLack of strength & stiffness of soft storey
- strong beam-weak column behaviour of moment resisting frame
- lack of ductility due to poor detailing

REMOVAL OF IRREGULARITY

- Soft storey
- Floating columns
- In-plane and out-of-plane irregularity
- Asymmetric configuration

STRENGTHENING OF STRUCTURE

- Strengthening Existing MembersReinforcedConcrete Jacketing, Overlay & UnderlaySteel Plate Bonding and Jacketing, Steel section caging; FRP Plate Bonding and Jacketing

- Adding New Members, Shear walls, Frames, Bracings, Buttresses

MATERIALS FOR RETROFITTING

- Conventional cast-in-place concrete
- High-strength concrete using shrinkage
- compensating admixture
- Ferro-cement
- Shotcrete (gunite)
- Polymer concrete

MATERIALS FOR RETROFITTING

- Resins
- Resin concrete
- Grouts
- Gluing metal sheets on concrete
- Welding of new reinforcement
- Gluing fibre-reinforced plastic (FRP) sheets on concrete
- Composite reinforcing bars

ADVANCE COMPOSITE MATERIALS

- Fibre reinforced composite
- Latest technique in structural réhabilitation
- ACS comprises of uni-directional or bi-directional woven reinforcing fabric saturated with specially formulated epoxy matrix

ADVANCE COMPOSITE SYSTEM

- Quick and easy application procedure results in time and cost saving
- Flexibility of application makes it suitable for application on member with any shape or profile
- Causes no destruction or disturbance to existing concrete
- It can be used in space constrained areas
- No heavy machinery or equipment is required

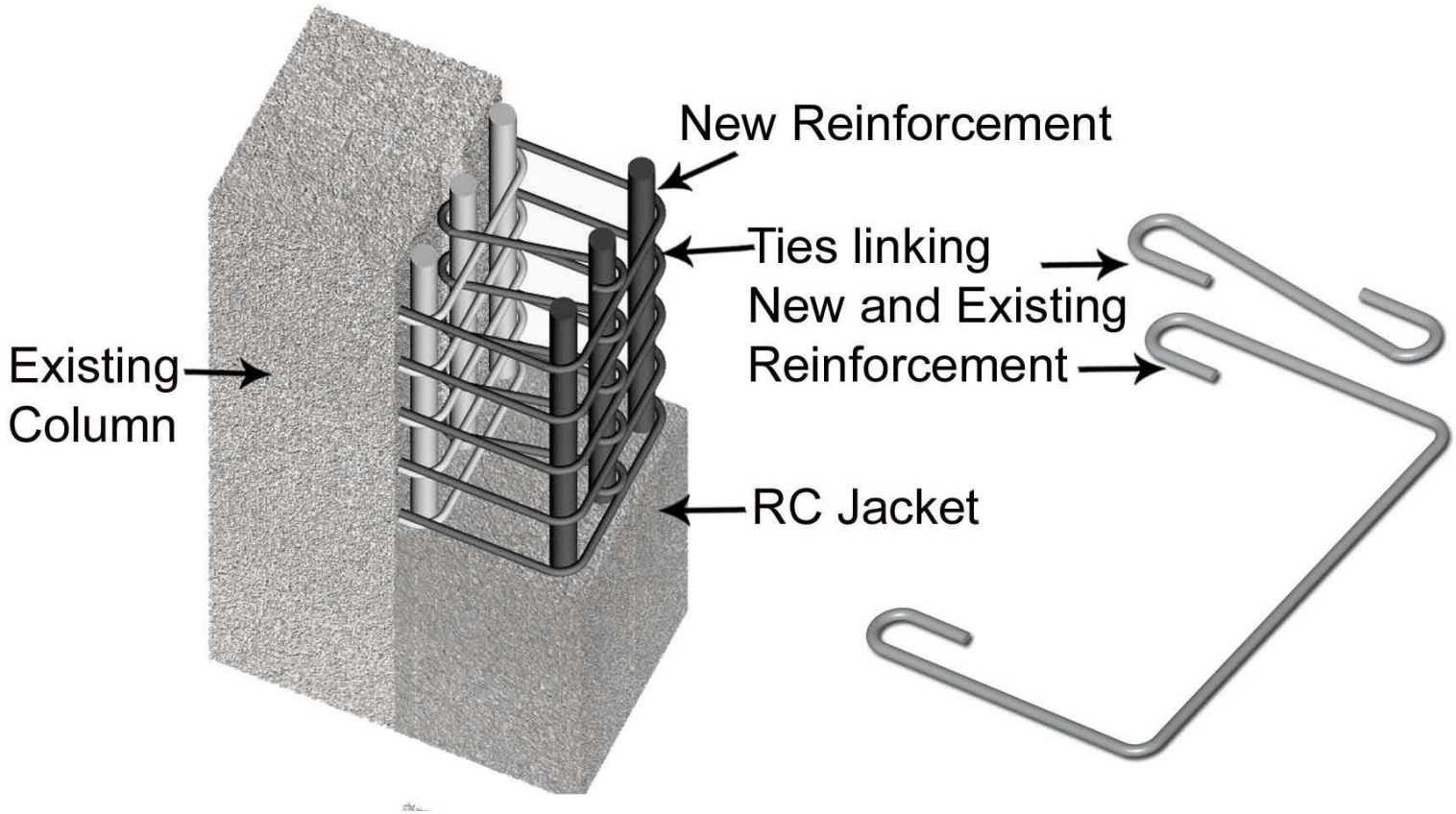
ADVANCE COMPOSITE SYSTEM

- It is light weight and easy to install causing no distress to the member being strengthened
- It increases the strength and ductility; enhances axial, shear, flexural and tensile capacities
- No appreciable increase in member size or dead load
- It does not corrode and inhibits further corrosion

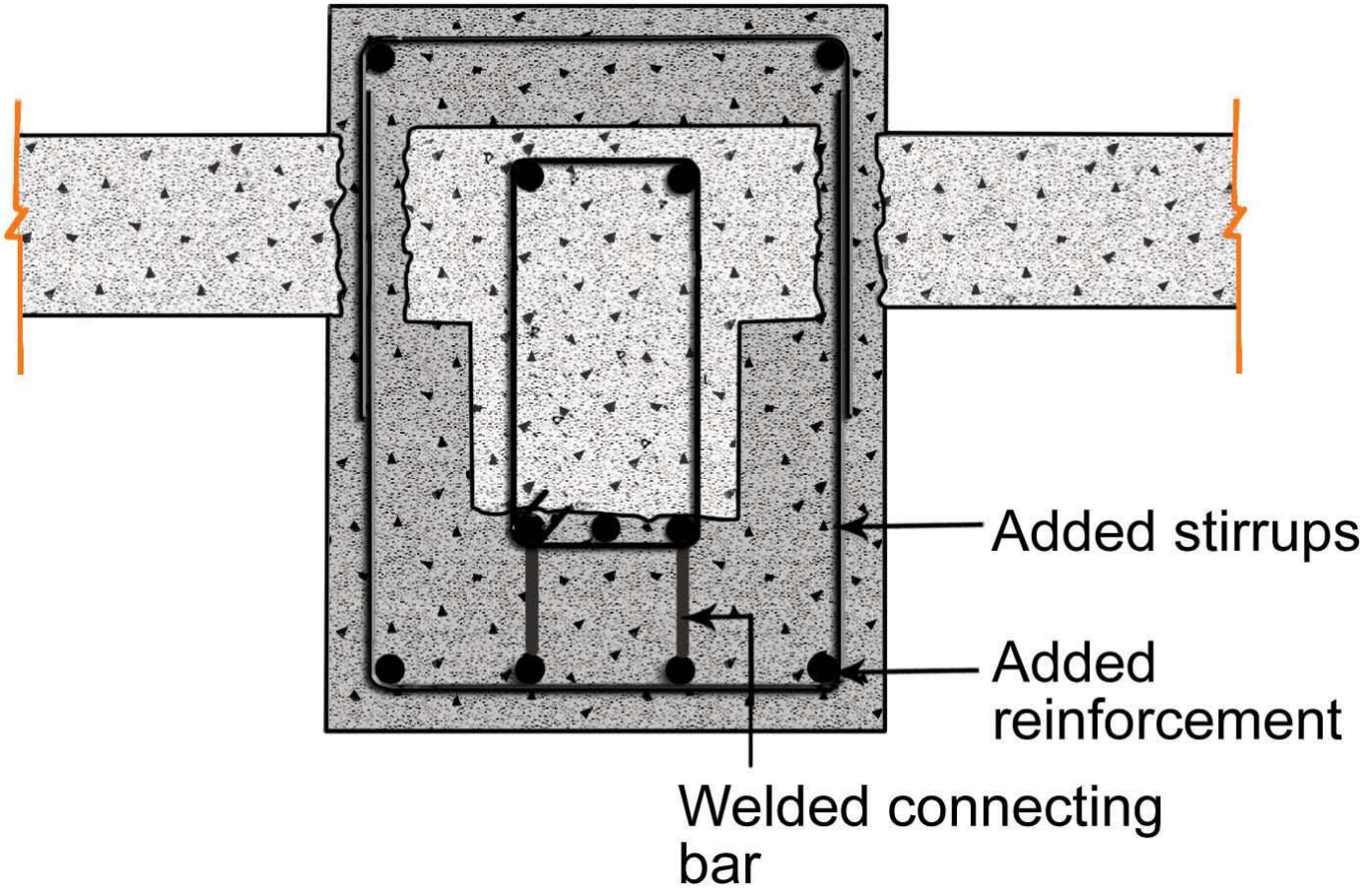
RETROFITTING OF EXISTING BUILDINGS

- Increasing the size of ground storey columns by jacketing
- Addition of RC walls at ground floor
- Steel bracings at ground storey
- Use of energy dissipating devices such as yielding bracing or viscous dampers

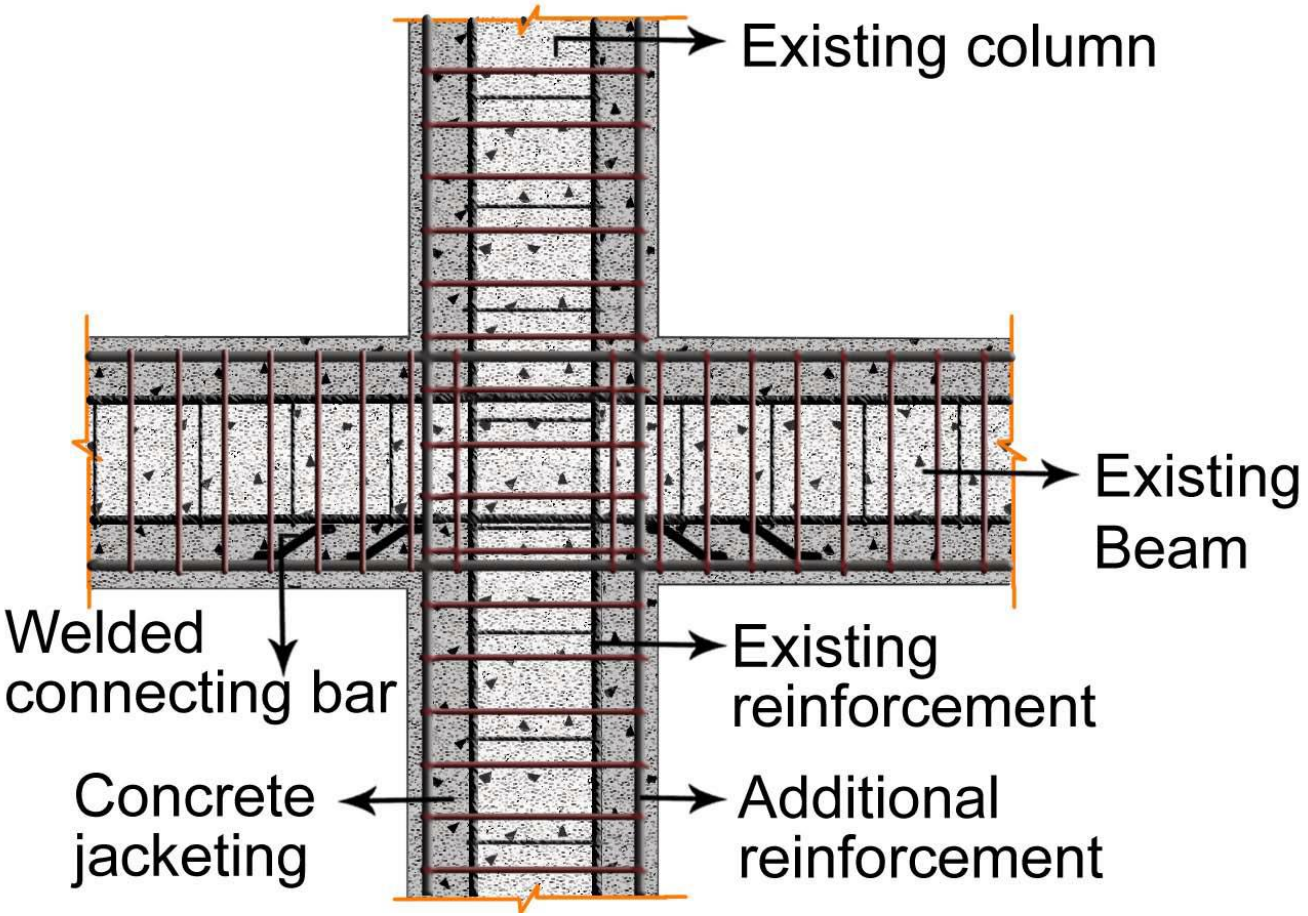
RC JACKETING



RC JACKETING

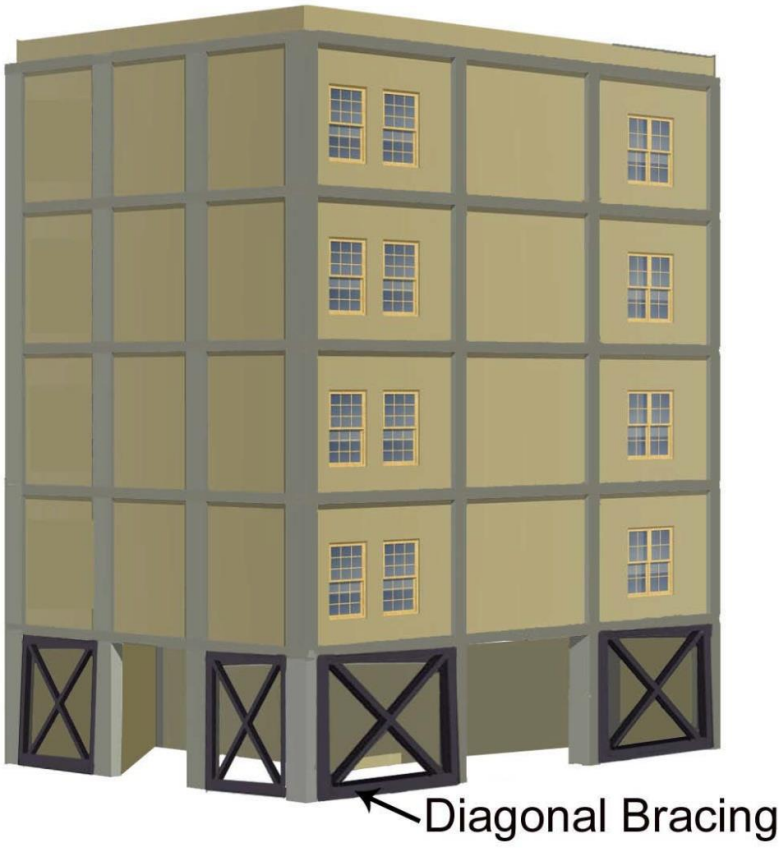


RC JACKETING



SHEAR WALLS IN SOFT STOREY

STEEL BRACING IN SOFT STOREY



SHUTTERING FOR SHEAR WALLS

ADDING STEEL BRACING

CONNECTION WITH EXISTING MEMBERS

STEEL SHEAR WALLS

DESIGN OF SOFT GROUND STOREY BUILDINGS

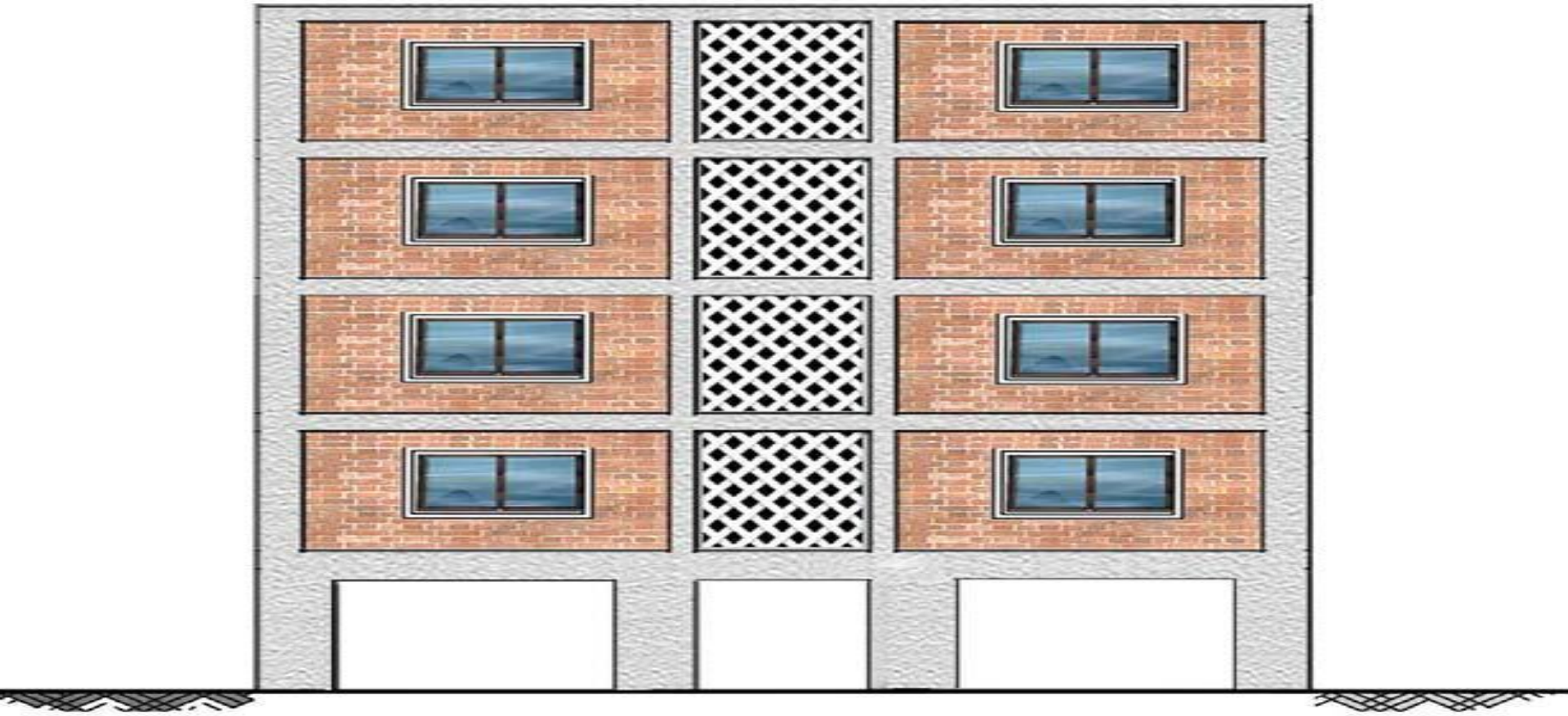
- Option 1:

  Detailed non-linear dynamic analysis to ensure the deflection of the ground storey columns to be within safe limits

- Option 2:

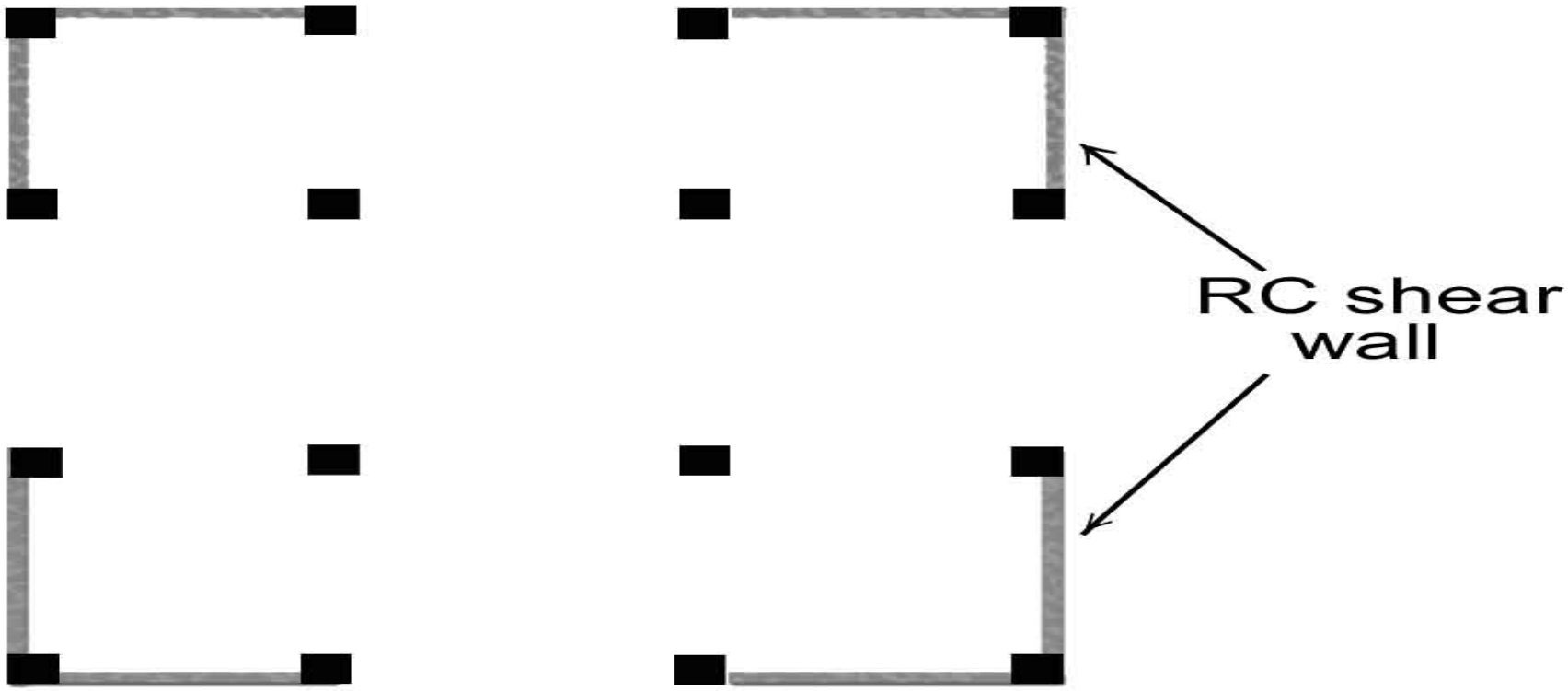
  Increased lateral stiffness of the ground storey to avoid soft storey effect

INCREASED BEAM-COLUMN SIZE



The size of the ground storey beams and columns is increased to have the stiffness of the ground storey comparable with upper storeys

SHEAR WALLS AT GROUND STOREY



The ground storey should be provided with shear walls to increase the stiffness at ground storey

EARTHQUAKE DEMAND REDUCTION

- THE RESPONSE OF THE STRUCTURE IS MODIFIED TO REDUCE THE EARTHQUAKE FORCES AND DISPLACEMENTS
- STRATEGIES ARE:

1. REDUCTION OF MASS

2. BASE ISOLATION

3. ENERGY DISSIPATION

BASE ISOLATION

- Generally required for large masonry buildings, excavations are made around the foundations of the building and the building (in piecemeal fashion) is separated from the foundations

- Steel or reinforced concrete beams replace the connections to the foundations, while under these, layered rubber and metal isolating pads replace the material removed, these in turn are attached below to new or existing foundations.

- These allow the ground to move while the building, restrained by its inertial mass, remains relatively static.

Base Isolation Devices

Lead rubber bearing

ENERGY DISSIPATION SYSTEM

- Directly Increases The Structure Damping

  Large relative displacements are required for effective damping.

- More effective in frame structures with large window openings, than in shear wall buildings.

- Sometimes braced frames are required for mounting.

SPECIAL BRACES

ENERGY DISSIPATING UNITS

CONCLUSIONS

- Large Number Seismically Deficient Buildings -Quick Assessment Method
- Upgradationof existing buildings is huge job and should be taken up on buildings' importance basis
- Government alone cannot do it
- Techniques of retrofitting and strengthening should be applied
- Techo-financing -tax exemption incentives

THANK YOU !