

## Structure Repairs & Rehabilitation In Low Strength Masonry Buildings

- Structure Repairs &

Rehabilitation Low Strength Masonry

Building is Laid in

- Fired brick work in clay & mud mortar
- Random rubble ; Uncoursed, Undressed stone masonry in weak mortars made of cement-sand, lime-sand & clay-mud.
- Structure Repairs & Rehabilitation

Component Of Low Strength Masonry

Building:

- Foundation
- Flooring
- Brick/ Stone Columns
- Brick Work
- Stone Masonry
- Wood Work
- Slab
- Slopping Wooden frame Roof
- Plaster
- Structure Repairs &

Rehabilitation Life Of Structure Depend

Upon:

- A. Geography Of Location
  - B. Building Material
  - C. Technology
  - D. Workmanship
- Structure Repairs & Rehabilitation

#### A . Geography Of Location:

- Type of Strata
- Water Table
- Earth Quack, Wind, Cyclone, Flood, Snow
- Pollutant
- Land Slide
- Tree location w.r.t. building
- Structure Repairs &

#### Rehabilitation B . Building Materials

- Cement
- Lime
- Fine Sand
- Coarse Sand
- Coarse Aggregate
- Quality of Water
- Bamboo/Wood
- Brick
- Structure Repairs & Rehabilitation

#### C. Technology

- Architectural Design
- Structural Design Based On Load Bearing Wall
- Construction Methods
- Quality Practices
- Construction Management
- Structure Repairs & Rehabilitation

## D Workmanship

- Structural Work
- Finishing Work
- Water Proofing Work
- Development of Drainage (Internal & External)
- Maintenance Of Building
- Structure Repairs & Rehabilitation

### Building Needs Repairs &

### Retrofitting

- Crack & Spalling In Structural Members
- Crack & Settlement In Flooring
- Crack & Spalling in Non Structural Members
- Leakage In Water Supply & Drainage System
- Redesigning existing structure for nature forces
- Changed functional requirements
- Structure Repairs &

## Rehabilitation Crack & Spalling In

### Structural Members

- Cracks Occur Due To Settlement In Foundation
- Cracks Due To Earth Quack ,Wind
- Crack Due To Overloading Of Structure
- Crack Due To Reduction in Load Carrying Capacity of Structure Due To Weathering
- Crack Due To Improper Design Of Structure
- Crack due to Poor connection Of Structural Members Resulted From Poor Workmanship
- Structure Repairs &

## Rehabilitation Crack & Settlement In

### Flooring

- Due To Improper Plinth Filling

- In case of black cotton soil in foundation not replaced up to sufficient depth by Good Soil under plinth (For generating enough Counter weight upon black cotton soil)
- Water Table vary within the Plinth Sub base (this occur in frequent flooding area & near sea soar)
- Improper curing, Improper laying, Poor Quality of workmanship.
- Improper design for loading i.e. thickness & type of flooring.
- Structure Repairs & Rehabilitation

#### Crack & Spalling in Non Structural

##### Members

- Crack In Plaster
- Crack In Finishing
- Crack In Water Proofing Work
- Vertical cracks in long boundary wall due to thermal movement Or Shrinkage.
- Crack Induced due to thermal changes, change in moisture content in building material, Chemical Reactions
- Structure Repairs &

#### Rehabilitation Leakage In Water Supply

##### & Drainage

- It may result from structural cracks & settlement
- Improper selection of pipe thickness
- Improper selection of Supports & its spacing to Pipe
- Improper making Of joints
- Non Provision for contraction & expansion (Particularly when pipe is passing over different type of long structures)
- Non Testing of Pipe before & after laying
- Insufficient soil cover over pipe
- Structure Repairs & Rehabilitation

Redesigning existing structure to meet functional requirement as well as forces generated by Nature It is a comprehensive task & require planning which include following Information gathering.

- Field investigations including details of sub strata, foundation details
- Type of Existing structure & its members stability
- Design Data Collection
- Identification of components required to be strengthened, replaced.
- Cost Estimates (it is feasible up to 60% of new construction)
- Method or Procedure to be followed.
- Structure Repairs &

#### Rehabilitation Crack Investigation

- Location
- Profile (vertical, Horizontal, Diagonal)
- Crack Size throughout length (Width,Depth &

length) Thin crack < 1mm

Medium Crack >1 to 2

mm Wide Crack > 2 mm

Crack may be non-uniform width. i.e. Tapper in width(narrow at one end & wider at other end. )

- Static or Live cracks
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- Cracks are static or live, is monitored & recorded by “Tell-Tale” method
- Structure Repairs & Rehabilitation
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#### Construction Details Of Bearing Of R.C.C. Roof Slab Over a Masonry Wall

- Structure Repairs & Rehabilitation

- Structure Repairs & Rehabilitation
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- Structure Repairs & Rehabilitation  
When two adjacent walls shake in different directions, their joint at corners comes under a lot of stress. This causes crack at the junction of two walls.
- Structure Repairs & Rehabilitation  
When the long wall bends outward or inwards vertically in the middle of its length, this stretching causes tension and causes vertical cracks in the walls.
- Structure Repairs & Rehabilitation  
Similarly when the walls bends outward or inwards horizontally in the middle of its height, this stretching causes tension and causes horizontal cracks in the walls. This happens at the base of gable wall.
- Structure Repairs & Rehabilitation  
Many times the wall gets pulled from its corners. This results in to tearing of wall in diagonal direction. In the wall if there is a window or a door, then the diagonal crack occur at their corners.
- Structure Repairs & Rehabilitation  
Flexural Tension Cracks At Lintel Level Due to Shrinkage & contraction of R.C.C. Slab
- Structure Repairs & Rehabilitation  
If the window is very large or if there are many doors and windows in a wall, then it tears even more easily in an earthquake.
- Structure Repairs & Rehabilitation Many times the roof slides on top of the walls on which it is sitting on
- Structure Repairs & Rehabilitation

#### Structural Repairs

#### Load Bearing Walls: PROCEDURE IN NEXT SLIDE

- Structure Repairs & Rehabilitation

#### Repairing Of Crack Due To Structural

#### Cause

- Replace all cracked bricks
- Use R.C.C. Stitching Block In Vertical Spacing In Every 5<sup>th</sup> or 6<sup>th</sup> Course ( 0.5 meter apart ).

- Stitching block

Width=equal to wall width,

Length = 1.5 to 2 bricks,

Thick =1 or 2 bricks as per severity of cracks

- Mortar For Repairs 1:1:6 (1 Cement :1 lime: 6 sand)
- Structure Repairs & Rehabilitation

load bearing walls(May be Brick or Stone) have inbuilt deficiency.

- Each Brick have different strength
- Thickness of Mortar Joints are not also uniform.
- Bricks are not perfectly laid horizontally & vertically
- Opening in walls
- Improper staggered joints
- Use of unwanted Brick bats

1. These resulted in cumulative effect & concentration of stress in particular section of wall is more than other section.

- Structure Repairs & Rehabilitation

Corrective Measures For Load Bearing Wall

Building

- Therefore Shifting of Window, Door ,Inbuilt construction of Almirah should be carried out with due consideration to IS code 13828:1993
- Proper Bearing to lintel over brick work to avoid diagonal cracks & it can be done in retrofitting work.
- It is advisable to keep window width as less as feasible while height can be increased with fixed glass pans on top portion as per slide 41.
- Structure Repairs &

Rehabilitation Importance Factor(I)

Depend Upon

- Functional Use Of Structures
- Hazardous Consequences Of Its Failure

- Post Earthquake Personal needs
- Historical Value
- Economic Importance
- School Building Have “T” value=1.5
- Structure Repairs & Rehabilitation

Elevation : Distance b1 to b8 changes as per Building

Retrofitting Need

- Structure Repairs & Rehabilitation
- Structure Repairs & Rehabilitation
- Strengthening Of Window When Its Position Is Not As Per Table Above Slide No 42.
- Structure Repairs & Rehabilitation

Strengthening Arrangements Recommended For low Strength Masonry Building

b = Lintel Bend

C = Roof Bend, Gable bend

d = Vertical steel at corners & junctions of wall

f = Bracing in plan at tie level of Pitched Roofs

g = Plinth band

For Building of Category ‘B’ in two storey constructed with stone masonry in weak mortar, provide vertical steel of 10 mm dia in both storey.

- Structure Repairs & Rehabilitation

Strengthening Arrangements Recommended For Elements of low Strength Masonry Building

- Structure Repairs & Rehabilitation
- Seismic wave propagation increases as height of wall/structure increases.
- Seismic wave expansion pushes bricks of corner of wall out of building.



- Movement of Seismic wave through joints of similar or dissimilar component of building ,makes joint open, resulting in falling of component of the building.
- Structure Repairs & Rehabilitation

#### Possibility For Old Masonry Structures

##### Strength

- Plinth Belt in lieu of plinth band
- Lintel level belt in lieu of band
- Roof level/ gable level band
- Corner steel
- Shape, Size & location of Window In Wall
- Wall length to Height Ratio
- Cross wall/ Brick Pillar/counter fort
- Structure Repairs & Rehabilitation Reinforced band on top of gable wall  
It will reduce bending of gable wall
- Structure Repairs & Rehabilitation In long walls  
introduce buttress  
to strengthen it.
- Structure Repairs & Rehabilitation

#### Low Strength Masonry Building

##### Retrofitting For Brick Masonry Structure

- Height of the building in B.W. shall be restricted to the following.
  1. For retrofitting category of building A,B,C up to 3 storey with flat roof or 2 storey plus Attic for pitched roof.
  2. For category D up to 2 storey with flat roof or one storey plus Attic for pitched roof.

where each storey height shall not exceed 3.0 m. Cross wall spacing should not be more than 16 times the wall thickness

CONTD.

- Structure Repairs & Rehabilitation

3. Minimum wall thickness in brick masonry shall be one brick for one & two storey construction, while in case of three storey, the bottom storey wall thickness is one & half brick.

4. Use brick from kiln only after 2 weeks when work is in summer & 3 week when work in winter.

5. Use leaner mortar preferably also adding lime for repairing cracks in particular & in masonry in general. It can be 1:1:6, 1:2:9, 1:3:12 as per need.

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Rehabilitation For Stone

Masonry

- Height of the building in Stone Masonry shall be restricted to the following

1. For retrofitting category of building A,B,—2 storey with flat roof or 1 storey plus Attic for pitched roof .In case cement sand mortar 1:6, the building up to 2 storey plus Attic for pitched roof.

2. 2. For category C,D– 2 storey with flat roof or 2 storey plus Attic for pitched roof with Cement sand mortar or 1 storey plus Attic for pitched roof with lime- sand or mud mortar.

CONTD.

- Structure Repairs & Rehabilitation

3. Maximum wall thickness in stone masonry shall be 450 mm & preferably 350 mm. ,

- Each storey height shall not exceed 3.0 m and span of walls between cross wall is limited to 5.0m

- Structure Repairs & Rehabilitation

- Cross wall connection In steps

- Structure Repairs & Rehabilitation

Wall to wall joints are to be made by building wall ends in steps form

- Structure Repairs & Rehabilitation Vertical reinforcement within the masonry in corners increases wall's capacity to withstand Horizontal cracks due to bending.

- Structure Repairs & Rehabilitation In

Each Layer Staggered Toothed Joint

- Structure Repairs & Rehabilitation  
Recommended Longitudinal steel in Reinforcement Concrete Bends
- Structure Repairs & Rehabilitation
- Steel Profile In Band At Corner & Junction
- Structure Repairs & Rehabilitation

#### Bonding Elements

##### A. Wood Plank

( 38x38x450 mm)

##### B. R.C.C. Block

(50x50x450 & 8

mm)

##### C. 8 or 10 mm Hook

or “S” shape bent Bar

#### Plan showing Through Stone

Through stone = Bonding Element

- Structure Repairs & Rehabilitation  
“S” shaped steel rod placed in a through hole in random rubble wall and fully encased in concrete
- Structure Repairs & Rehabilitation

Casing in every 0.6 m is lifted & M15 or Mortar 1:3 is Compacted around bar.

- Structure Repairs & Rehabilitation
- Half Split Bamboo Ties To Rafter
- Brace the Rafter to 50 mm Dia Bamboo (B)
- Seismic Bend & Rafter should be tied Properly
- Structure Repairs & Rehabilitation Diagonal tying on the upper or underside of the roof Prevents roof from getting distorted and damaged
- Structure Repairs & Rehabilitation Installing multiple strands of galvanized iron wires pulled and twisted to pretension
- Structure Repairs & Rehabilitation  
Vertical steel at corners and junction of walls up to 350 mm thick should be embedded in plinth

masonry of foundations, bands, roof slab as per table

- Structure Repairs &

Rehabilitation One Brick Thick      One

& Half Brick Thick

----- Contain One Bar At Centre

- Structure Repairs & Rehabilitation  
Seismic Belts & closing a opening with pockets made in jams of masonry.
- Structure Repairs & Rehabilitation  
Encasing masonry column in cage of steel rods and encased in micro concrete.
- Structure Repairs & Rehabilitation Anchoring the roof rafters and trusses with steel angles or other means
- Structure Repairs & Rehabilitation  
Weld mesh belt approximately 220mm wide all around the openings and anchored to masonry wall and encased in cement mortar
- Structure Repairs & Rehabilitation  
Vertical deformed steel encased in concrete bar from foundation to roof, anchored to both masonry walls at wall junctions with special connectors.
- Structure Repairs & Rehabilitation  
Seismic belt in lieu of Seismic Band is made of weld mesh approximately 220mm wide anchored to masonry wall and encased in cement mortar.
- Structure Repairs & Rehabilitation  
Use smaller glass panes for windows Prevents the shattering of glass in earthquake and cyclone
- Structure Repairs & Rehabilitation Anchoring roof to wall &, reducing roof overhangs, prevent the roof from getting blown off
- Structure Repairs & Rehabilitation Prolonged flooding can weaken the mortar, especially if it is mud mortar, and hence, the wall, causing cracking in walls or collapse.
- Structure Repairs & Rehabilitation  
If the ground is sandy in which the foundation is sitting, then high speed flood/surge water can scour the land around and under the foundation of your school, leading to settlement and/or cracking of the wall.
- Structure Repairs & Rehabilitation  
Simple erosion of wall near its bottom, or cracking, plaster peeling off and settlement in floor.
- Structure Repairs & Rehabilitation
- Structure Repairs & Rehabilitation  
Extensive cracking of walls caused by differential settlement due to flood
- Structure Repairs & Rehabilitation  
High plinth level to avoid entering flood
- Structure Repairs & Rehabilitation

Use of pilasters strengthens walls against flowing water

- Structure Repairs & Rehabilitation
- This Presentation was focused on Low Strength Masonry Buildings therefore for framed structures & rich cement mortar building ,certain slides are in-valid. In next Presentation this balance portion will be highlighted.
- This Presentation was aiming to provide some technical input to site peoples so that we could point out any doubtful detailing in drawings to Structural/Architectural Designer.
- It is possible that features of Flood, Heavy Rain fall, Cyclone, earth quack may collide but We have to look priority of our geographical requirement.