

PRESENTATION ON REPAIR AND REHABILITATION OF BUILDINGS DAMAGED IN EARTHQUAKE

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DIFFERENT TYPES OF DAMAGES

1. Minor cracks 0.5 to 5 mm wide in load or non-load bearing walls
2. Major cracks more than 5 mm wide in load or non-load bearing walls.
3. Loosening of
 - Stone blocks due to disintegration of mortar of Random Rubble
 - Masonry in the middle of the wall panel surrounded by
 - a. Plinth band, lintel band and cross walls.
 - b. Lintel band, roof level band (R.C.C. Slab) and cross walls, or
 - c. Plinth band, roof level band (R.C.C. Slab and cross walls)

CONTD

4. Dislocated and/ or side-bulged triangular portion of cracked wall between the two openings (door & window or window & window openings)
5. Collapsed random rubble masonry parapets at terrace level.
6. Collapsed staircase munties.
7. Collapsed Walls, whether these are load or non-load bearing walls.

TYPE 1 DAMAGE





FOR TYPE 1

Material / equipment required

- i. Plastic / Aluminium/GI nipples of 12mm dia (40 to 100 mm long)
- ii. Polyester putty for sealing of cracks.
- iii. Non-shrink cement (shrinkomp of ACC or equivalent)
- iv. Hand operated Slurry injection pump.

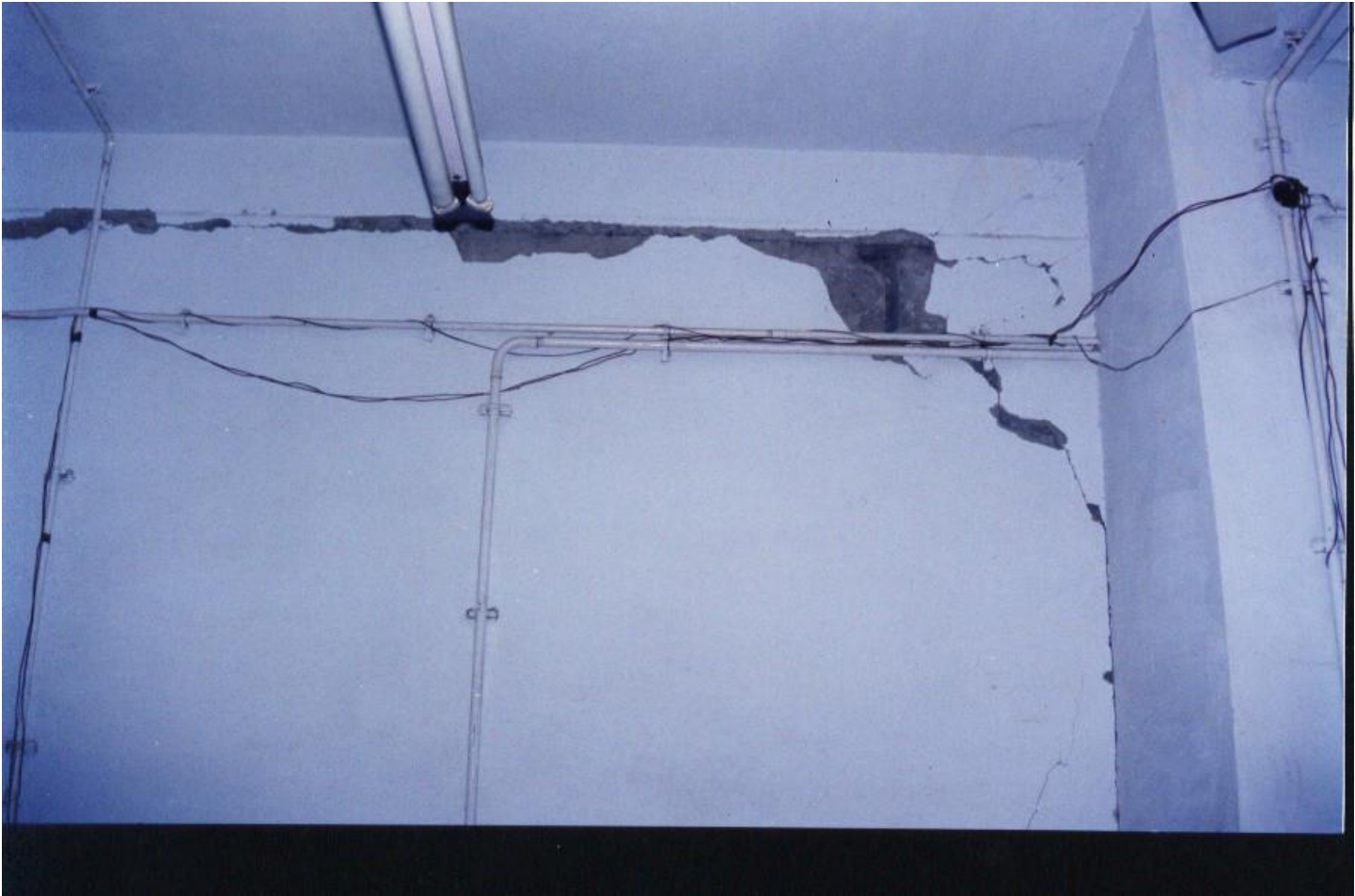
PROCEDURE

- Step 1 :- Remove the plaster in the vicinity of crack exposing the cracked bare masonry on both faces.
- Step 2 :- Make the shape of crack in the V-shape by chiselling out on both faces of the wall.
- Step 3 :- Clean the crack with compressed air.
- Step 4 :- Fix the grouting nipple at close spacing at 100mm c/c but not exceeding the thickness of wall on its both faces.

- Step 5 :- Clean the crack with the compressed air through nipples to ensure that the fine and loose material inside the cracked masonry has been removed.
- Step 6 :- This shall be followed by sealing the crack on both faces of the wall with polyester putty [or cement mortar 1:3 (1 cement : 3 coarse sand) and allowed to gain strength] and water injected starting with nipples fixed at higher level and moving down so that the dust inside the cracks is washed off and masonry is saturated with water.

- Step 7 :- Make cement slurry with 1:1 (1 non shrink cement : 1 water) and start injecting from lower most nipple till the cement slurry comes out from the next higher nipple and then move by plugging the lower nipple to the next higher nipple and so on till all nipples are plugged.
- Step 8 :- After injection grouting through all the nipple is completed, remove the nipples, carry out surface finishing including replastering the surface.

TYPE 2





Material / equipment required

The following material and equipment are required :-

- i. Plastic / Aluminium nipple of 12mm dia (30 to 40mm long)
- ii. Polyester putty for sealing of cracks.
- iii. Non-shrink cement (shrinkomp of ACC or equivalent)
- iv. Hand operated Slurry injection pump.
- v. Galvanised steel wire fabric 3.15 mm dia 50mm x 50mm mesh size.
- vi. Galvanised steel clamping rod of 3.15 mm dia and of length equal to thickness of wall to be repaired plus 60 mm.

Procedure

- Step 1 :- Remove the plaster in the vicinity of crack exposing the cracked bare masonry.
- Step 2 :- Make the shape of crack in the V-shape by chiselling out.
- Step 3 :- Clean the crack with compressed air.
- Step 4 :- Fix the grouting nipple at close spacing at 100 mm c/c but not exceeding the thickness of wall on its both faces.

- Step 5 :- Clean the crack with the compressed air through nipples to ensure that the fine and loose material inside the cracked masonry has been removed.
- Step 6 :- This shall be followed by sealing the crack on both faces of the wall with polyester putty [or cement mortar 1:3 (1 cement :3 coarse sand) and allowed to gain strength and water injected starting with nipples fixed at higher level and moving down so that the dust inside the cracks is washed off and masonry is saturated with water.
- Step 7 :- Make cement slurry with 1:3:1 (1 non shrink cement : 3 fine sand : 1 water) and start nipple and then move to next higher nipple.

- Step 8 :- After injection grouting through all the nipple is completed, replaster the surface and finish the same.
- Step 9 :- Also where it is found necessary wire mesh on both the face of wall may be provided after removal of plaster in the region of repair and these wire mesh may be clamped with each other by using clamps at the spacing of 400 mm c/c. The surface is replastered again with cement sand mortar of 1:3.

Type 3





Materials / equipments required

- i. Plastic / Aluminium nipple of 12 mm dia (40 to 100 mm long)
- ii. Non shrink cement (shrinkomp of ACC or equivalent)
- iii. Fine Sand and coarse sand.
- iv. Hand operated Slurry injection pump.
- v. Galvanised steel wire fabric 3.15mm dia 50mm x 50mm mesh size.
- vi. Galvanised clamping rod of 3.15mm dia and of length equal to 60mm + wall thickness

Procedure.

- Step 1 :- Wherever, loosened masonry has collapsed and come out, propping and supporting of the RCC band or slab above it shall be done.
- Step-2 :- Place and pack stone/masonry blocks with cement mortar 1:3 (1-cement: 3- coarse sand) in the hollow spaces to the extent possible by hand so as not to allow the stone blocks come out of the plane of the wall. So packed masonry shall be allowed to gain strength.
- Step 3 :- Fix the grouting nipples on both faces of the wall in loosened / opened up joints at close spacing of about 100mm but not exceeding thickness of wall.

- Step 4 :- Clean the joints of the stones of loosened random rubble masonry with compressed air starting from top towards the bottom. The compressed air shall be passed through the nipples and / or loosened joints. Thus all fine and loose material inside the masonry shall be ensured to have been removed.
- Step 5 :- Wherever, it is felt necessary, galvanised welded wire mesh of 50 x 50 mm with wires of 3.15 mm diameter of suitable size shall be provided on both faces of such loosened masonry connected with galvanised clamps hooked and clamped to tie the wire fabric on both faces of the wall

- Step 6:- This shall be followed by sealing the loosened stones / masonry block with polyester putty [or cement mortar 1:3 (1 cement : 3 coarse sand) and allowed to gain strength] and water injection starting with the nipples fixed at higher level and moving down so that the dust inside the loosened masonry is washed off and simultaneously the mortar and stones are saturated / wetted with water.
- Step 7 :- Prepare cement – sand injectable mortar [1:3:1 (1 cement : 3 fine sand : 1 water)] admixed with plasticiser to make it highly workable mortar and inject the same through nipples starting from the lower most nipples till the mortar comes out from the next higher nipple. Plug the lower nipple and start pumping from the next higher nipple and so on till all the nipples are sealed.
- Step 8:- After the injection grouting, remove the nipples and polyester putty used if any, and finish the surface, as may be required.

Type 4





- **Materials / equipments required.**
- (1) 10mm dia M.S. Rods of sufficient length to cover the full length of the masonry wall between the two door / window, window / window openings.
- (2) Pair of 8 mm thick steel bearing plates of 150 mm height (i.e. twice the course thickness) X (width of wall thickness) size for each of the parallel wall faces.
- (3) Two Pairs of M.S. angles (50 x 50 x 6mm) with height of each pair equal to the height of the opening in which the pair of angles is to be fixed.

- (4) Drill machine for drilling hole.
- (5) Welding machine.
- (6) Preferably a hydraulic jack with pressure gauge.
Alternatively, die for cutting threads
- in MS rods, spanner or turnbuckle as shall be specified.
- (7) Washers and nut for tightening.
- (8) All MS rods, plates, nuts and washers required to be embedded shall either be hot dip galvanised or coated with durable anti-corrosive coating like tar-epoxy or alike as shall be specified.

- **C. Procedure**

- Step 1 :- Prop and support the R.C.C. band through the door/window openings on the two sides of the damaged masonry wall to relieve the damaged masonry of loads coming over it.
- Step 2 :- Drill three holes at appropriate levels (one in middle and one on either end of the smaller openings) in the pair of MS angles of lengths equal to smaller of two openings. The MS rods shall be passed through these holes of appropriate lengths of damaged wall with extra lengths at their ends for tapping and receiving nuts.

- Step 3 :- Place the two pairs of M.S. angles together with the M.S. rods at the two corners of wall and weld them together connected with M.S. flats at three levels as shown in figure.
- Step 4 :- Tighten the nuts at the end of M.S. rods to bring it under tension such that the loose and sidewise-bulged masonry is brought back in its original position to the extent possible. Tightening shall be done at all the three levels simultaneously to ensure that all the rods are simultaneously having the same tensile force.
- Step 5 :- Thereafter, the cracked masonry shall be repaired by following the methods as specified in the preceding paragraphs

Strengthening / Upgrading of existing Brick Masonry buildings to make them seismic resistant by achieving integral box action.



- **Material / equipment required :**
- 1. All MS rods, plates, nuts and washers required to be embedded shall either be hot dip galvanised or coated with durable anti-corrosive coating like tar-epoxy or alike as shall be specified.
- 2. 10mm dia MS rods of sufficient length to cover the full length of straight length of wall plus 100mm.
- 3. Pair of 8 mm thick steel bearing plates of 150 mm height of width equal to wall thickness for each of the parallel wall faces.

- 4. Drill machine for drilling hole.
- 5. The drill bit of sufficient length to drill hole through the wall thickness in one operation and of nominal bore diameter equal to 3mm plus pre-stressing bar diameter.
- 6. Welding machine.
- 7. Preferably a hydraulic jack with pressure gauge. Alternatively, die for cutting threads in MS rods, spanner or turnbuckle as shall be specified.
- 8. Washers and nut for tightening.

- **Procedure :**
- **Step 1 :- Guidelines for fixing the level and location of Prestressing tendons**
- **1. Decide the levels of pre-stressing tendons**
- 1. Pre-stressing tendons are to be provided at levels away from the surface of restraint provided by R.C.C. floor level slabs wherever provided.
- 2. Though, it is desirable to provide pre-stressing tendons below the plinth level at ground floor in masonry buildings between the two cross – wall connections. But it may not be practicable in most of the cases due to inconvenience to users of buildings on account of much more time required for its finishing besides the extra cost involved.

- Hence, the pre-stressing tendons could be provided near above the plinth level between the two cross wall connections or between the jambs of two door openings, or between the jamb of one door opening and cross-wall connection.
- 3. Near above the soffit level of the lintels.
- 4. At such level that the H/B ratio of the panel wall between the two openings is less than or equal to 2.
- **2. Decide the location of prestressing tendons.**
- 1. These are to be provided symmetrically of either side and along the length of masonry wall.
- 2. These are to be provided on the face of the Random Rubble masonry wall.
- **Fig 2 (a): Alternative-I- Closely Spaced Prestressing Tendons**

- **Fig 1 : Strengthening / Upgrading Brick Masonry buildings by achieving integral box action**
- **Fig 2 (b): Alternative-II- Widely Spaced Prestressing Tendons**
- **Photo 9: Strengthening / Upgrading Brick Masonry buildings by achieving integral box action**
- **Photo 10 & 11: Strengthening / Upgrading Brick Masonry buildings by achieving integral box action**
- **Photo 12: Strengthening / Upgrading Brick Masonry buildings by achieving integral box action**

- 3. The anchoring bearing plate or the channel should be able to press the Random Rubble Masonry uniformly.
- 4. The minimum level difference of 50mm shall have to be provided between the two pairs of pre-stressing tendons running in orthogonal directions.
- **Step 2 :- Removal of plaster along the prestressing tendons as decided in Step 1.**
- 1. Remove the plaster of wall at the location and along the alignment of prestressing tendons without damaging the masonry where the prestressing tendon is to be accommodated.

- 2. Remove the plaster from the brickwork at location where the steel bearing plates are to be accommodated and level the same with rich cement mortar. The levelling plaster must have attained sufficient strength before pre-stressing the tendons.
- **Step 3 :- Drilling holes in cross masonry walls.**
- 1. Dia of hole shall be 3mm more than the dia of pre-stressing tendon.
- 2. The alignment of hole shall be truly in line with the outer face of the longitudinal wall.
- **Step 4 :- Bearing plate.**
- 1. Bearing plate shall be preferably 8 mm thick and shall be selected out of a number of shapes as shown in figure 2 depending on various factors like location of the bearing plate, vertical distance between the pre-tensioning tendons etc.

- **Step 5 :-Pre-tensioning the prestressing tendons.**
- 1. The pre-coated or galvanised MS rods (as shall be specified) of 10 mm dia, shall be placed with its end protruding out at both ends. The length of protrusion shall be enough for pre-tensioning with hydraulic jack or for receiving the threading and tightening nuts through the bearing plate.
- 2. The pre-tensioning force on each MS rod shall be calculated considering the effective area of end bearing plate and considering maximum permissible compressive stress as 0.1 Mpa (1 Kgf per sq. cm.)

- 3. The pre-determined tensile force is applied in each tendon (MS rod) by hydraulic jack. If specified. Otherwise, tightening the nuts against washers and the bearing plate could also do the required pre-tensioning.
- 4. Soon after the pre-tensioning is achieved, the stresses in the pre-tensioned rod shall be locked with a locking nut and the same shall be welded to prevent its subsequent opening at a later date.

THANKS