

Damage Categorization and Corrective Actions for Restoration

By

Rajendra & Rupal Desai

Hon. Jt. Directors

National Centre for Peoples'-Action in Disaster Preparedness

Ahmedabad, GUJ, India

Why Restore Damaged Building ?



It may be a lot cheaper to restore your existing damaged building instead of demolishing it.

Why restore ?

- Reconstruction means first demolition and removal of debris, and then reconstruction.
- Restoration means bringing the structure's strength to the pre-earthquake state and making it functional.
- Restoration would lower the vulnerability status back to pre-earthquake status
- Restoration implies touching only those portions of building that are damaged. Hence, is a lot cheaper than reconstruction.
- Restoration is faster and cheaper than full reconstruction.
- Restoration means most conveniences created in the house are not lost. Reconstruction means re-doing all that.
- Restoration permits a cheap option of long-term earthquake safety called retrofitting

Present Restoration Scenario...

Lightly damaged buildings are generally restored in technically faulty manner.

In recent disasters there has been little restoration of significantly damaged buildings. Instead the buildings were either abandoned or demolished and rebuilt.

Because...

- Engineers, Contractors/Masons are ignorant about **correct methods of restoration**
- People feel that rebuilding is the only way to ensure the long-term safety
- Often the government policies promote demolition and rebuilding rather than **restoration followed by retrofitting**

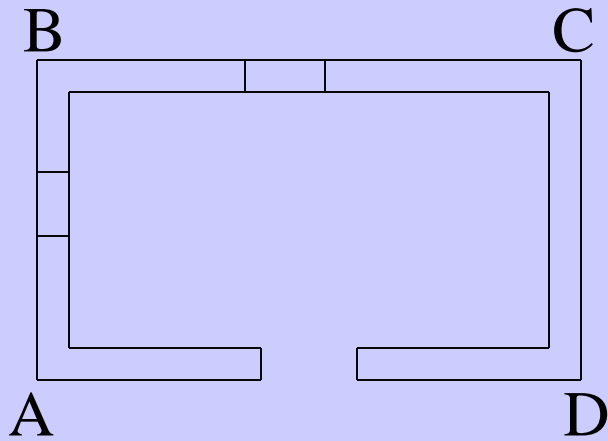
How to restore a damaged building ?

1. **Document** the structure with all the damage properly marked to fully understand the state of structure
2. **Categorize** the damage
3. **Demarcate the extent of damage** on the building and in the documentation
4. Determine the **Remedial action** for each damage and determine the materials required
5. **Procure** materials
6. **Restore** each damage portion one by one
7. Apply **finishing** to match the original finish on adjacent building elements

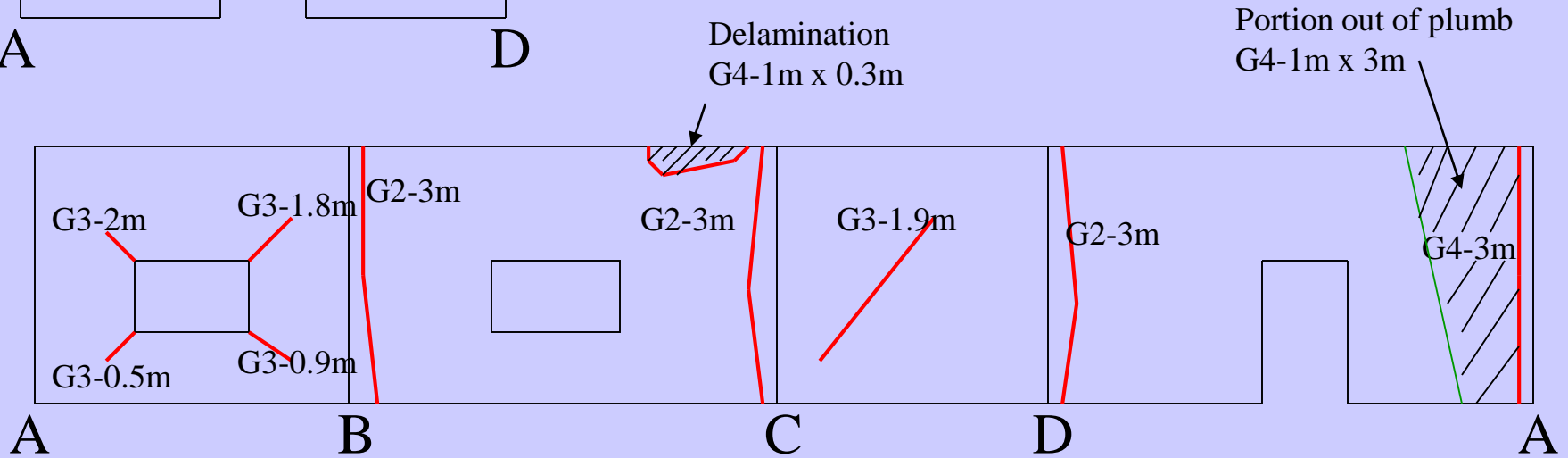
Damage Categorization

- G-1 : Hair line cracks in plaster (Single dimensional) – Non-structural
- G-2 : Cracks up to 5mm width (Two dimensional) - Structural
- G-3 : Cracks from 5mm to 10mm width (Three dimensional) - Structural
- G-4 : Portion of structural in the state of impending collapse - Structural
- G-5 : More than 50% structure in the state of impending collapse or collapse - Structural
- Typically an inexperienced person tends to overestimate the damage category

Document the damaged Bldg.



Bldg. Plan



Fold-out of Building showing damages

Repair of Damage

These are non-structural items including

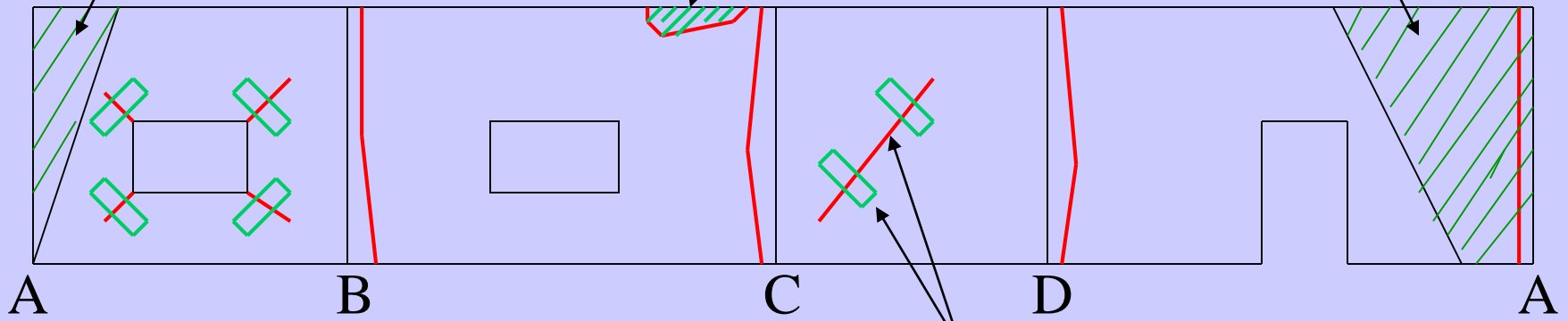
- Paint, plaster and tiles peeling off from walls
- Flooring disturbed
- Roofing disturbed – tiles, cement sheets etc.
- Plumbing damage
- Electrification damage
- Damage to doors and windows
- Damage to parapet

Show Restoration Measures

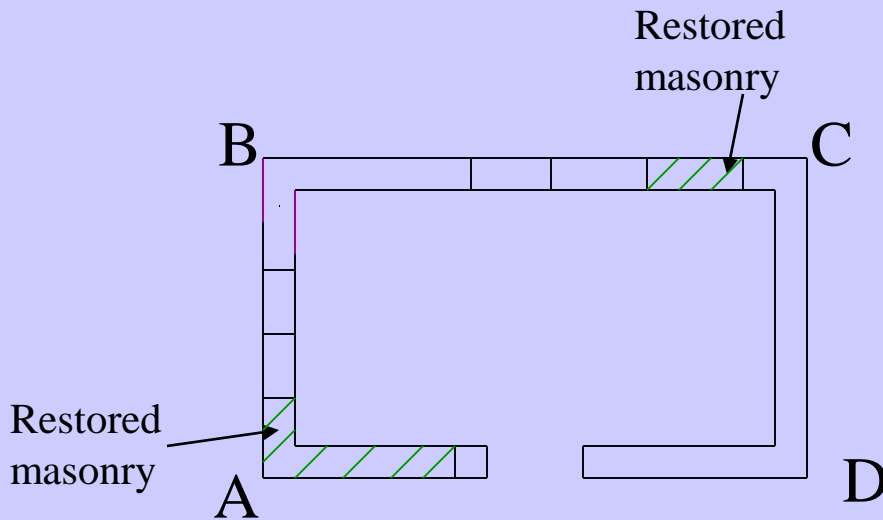
Dismantle masonry in stepped manner and construct both sides of corner

Dismantled and Recon. damaged masonry

Dismantle masonry in stepped manner and construct both sides of corner



Grout crack with non-shrink cement grout and install ferrocement bandages (Typ.)



Restoration of Original Strength

- Cracked walls (G2 to G3) – Require grouting with non-expansive grout and splicing across with ferrocement straps or ‘C’ clamps
- Bulged or delaminated UCR or extra thick brick walls (G4) – Requires removal of damaged portion and reconstruction using same or stronger mortar, and ensuring proper connection with the existing walls
- Walls out of plumb (G4) – Requires removal of leaning portion and reconstruction using same or stronger mortar, and ensuring proper connection with the existing walls
- Extensively damaged walls (G4-G5) – If the roof is intact and in original position, the damaged walls can be dismantled and rebuilt one by one with better quality

Masonry Wall Damage Category G-2



1. Make a 'V' notch along the crack.
2. Clean it with wire brush.
3. Fill up the gap with 1:3 Cement mortar.
4. Cure it for 1 day. .
6. Finish the restored parts to match the surrounding wall surface.

Masonry Wall Damage Category G2-3

Grouting of Cracks for Restoration of Original Strength



1. Make a 'V' notch along the crack, clean it with wire brush.
2. Fix grouting nipples, approximately 50mm long, in the 'V' groove sticking out of the crack, on both faces of wall at a spacing of 150mm to 200mm.
3. If compressed air is available, then use it through the nipples to remove the fine, loose particles from the crack,
4. Seal the crack along the surface with 1:3 cement mortar with nipples sticking out and allow it to harden for some time.

Grouting of Cracks for Restoration of Original Strength



5. Inject water in the crack through the topmost nipple, and then move downward to lower nipples one after another.

6. Make cement slurry with 1:1 (non-shrink cement : water) and begin injecting it into the nipple, starting from the lowest nipple upward, until the slurry comes out of the next higher nipple. Next inject it in the next higher nipple, following it till the end.

7. Cut off the protruding ends of the nipples, seal the holes with 1:3 cement mortar and finish the surface to match the adjacent surface.

Masonry Wall Damage Category G2-3

Grouting of Cracks for Restoration of Original Strength



Specially made drums for gravity fed grouting

Masonry Wall Damage Category G-3



Pump made from plastic pipes and nozzle



Sealing and Stitching of Cracks



- 1. Make a 'V' notch along the crack, clean it with wire brush.
- 2. Clean crack with water to remove the fine, loose particles inside the crack.
- 3. Prepare masonry surface on both, inside and outside, faces of the wall for fixing 200mm wide ferro-cement splices extending on both sides of the crack to a minimum of 450mm (18") length as shown in diagram by removing the plaster, raking the joints up to 12mm depth, and cleaning it with water,



4. Fill the crack with 1:3 cement mortar (non-shrink cement : fine sand) with just enough water to permit pushing mortar as far in as possible, from both faces of the wall.
5. Install the 150mm (6") wide 25x25 14 gauge galvanized welded wire mesh (WWM) (2.03mm dia.) with 100mm (4") long wire nails inserted at spacing no greater than 300mm (12") in a staggered manner.
6. A gap of 10mm must be maintained between the mesh and unplastered wall.
7. Plaster over the mesh with two 12mm coats of 1:3 cement plaster.
8. Cure it with water for 15 days.

Masonry Wall Damage Category G-3

**Crack
Splicing for
Restoration
of original
strength**



Options for restoration

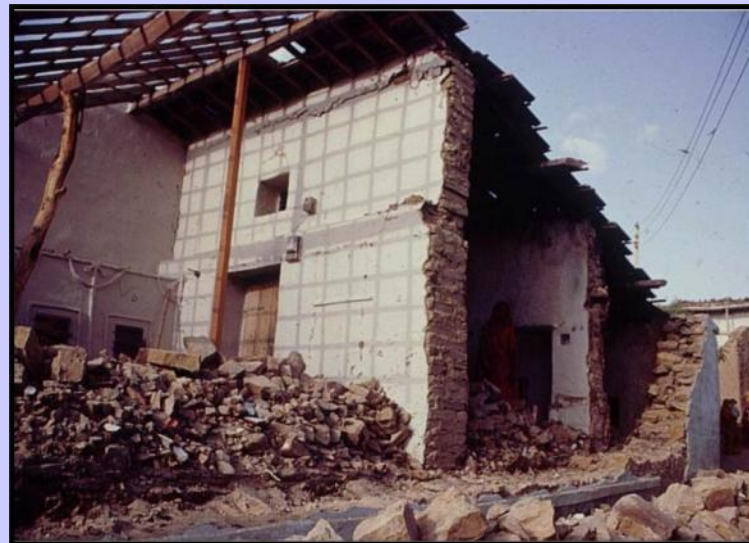
Wide Cracks at window and door opening corners – **Prop up lintles, dismantle damaged portion and rebuild**



Cracks along corners – **Grout the crack followed by splicing at two to three levels on both faces**



Collapsed Gable Wall – **Rebuild collapsed wall ensuring proper connection with wall still standing**



Options for restoration

Collapsed Wall – Prop up roof and rebuild walls ensuring proper connection with portions of wall still standing



Gable wall cracks at its base – Grout the crack and install splices at three to four points on both faces of wall

Restoration of Original Strength

- Damaged beams of RCC, Wood (G2-G4) – If the member has failed then it may be replaced. But in case of local failure it is possible to splice the member using basic engineering understanding and common sense to restore original strength
- Damaged structural elements of floor & roof (G2-G4)
 - In case of small crack in RCC floor epoxy grouting may be used. If the bars have yielded then damaged bars may be cut and new bars may be welded. In case of wooden elements replacement or splicing be used.

Options for restoration



Collapsed Slab due to
Collapsed Wall –

- Remove all the concrete from fallen slab and half meter beyond;
- Straighten out bars;
- Rebuild walls;
- Install shuttering and formwork;
- Attach adequately long dowel over the bent portion of the bars;
- Cast the slab

Examples of restoration of damaged buildings



Examples of restoration of damaged buildings



Examples of restoration of damaged buildings



Things to Remember

- Assess need for **repair** of damage, followed by **reconstruction** of dilapidated or severely damaged elements and **restoration** of original strength.
- Understand the situation, use common engineering sense, and **evolve solutions**
- Look at each **part of building** and then the structure as a **whole**
- Always look at the structure from **saving it from demolition** and objectively decide the course of action
- Be ready for **real life situations** rather than hypothetically simple text book situations
- Demand adherence to **right procedures** to ensure improvement in performance
- Exercise caution not to damage or weaken the structure – use **skill** and **trick** rather than brute strength

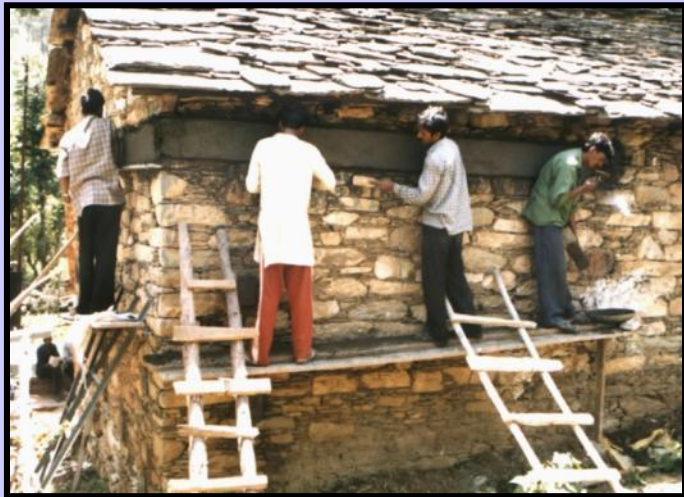
Finally...

You are in an area that has high Seismic Risk and moderate Cyclone risk

Restoration alone is not enough. The future earthquake or cyclone can cause severe damage or collapse. Retrofit the structure to bring long-term safety against future disasters



Thank
You



National Centre for Peoples'-Action In Disaster Preparedness
103,"Antariksh", Panjarapole Cross Roads,
Dr.V.S.Marg, Ahmedabad - 380 015. Guj. India.
Tel : 30920065, Fax : (79) 2630 8843.
Email : mitigation@ncpdpindia.org