

CRACK REPAIR OF UNREINFORCED MASONRY WALLS WITH GROUT INJECTION

I. GENERAL

Background - The pressure injection method of crack repair was developed by the Hazardous Building Committee of the Structural Engineer's Association of Southern California and the City of Los Angeles. This method, when applicable, eliminates the need for removing and rebuilding the wall. However, the causes of the cracks should be carefully evaluated and addressed.

Earthquake damage to unreinforced brick buildings includes cracks through walls due to horizontal offsets in the plane of the wall. Such cracks generally do not represent immediate hazardous or unstable conditions, but rather weakening that in future earthquake shaking could lead to further cracking and hazardous instability and/or loss of bricks from the wall. An economical, structurally effective, and aesthetically satisfactory repair of such cracks can be accomplished by the injection of fine grout into the wall at the vicinity of the cracks. By filling the cracks and the surrounding voids inside the wall, the wall strength is restored and the adjacent mortar has not been disturbed. The injection system relies on the fact that the collar joints are poorly filled. This repair procedure stabilizes the wall by firmly rebonding loose components and it restores the lateral load resisting strength of the wall.

II. SCOPE

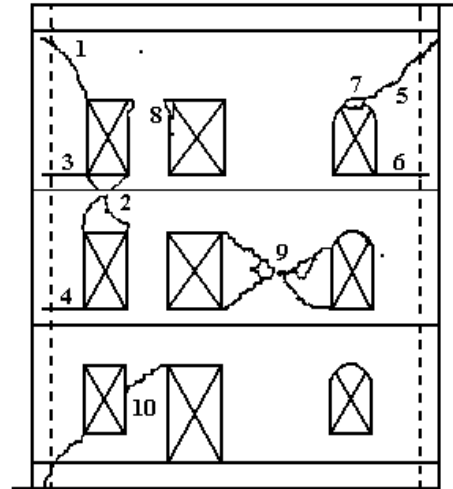
To provide rules and regulations governing the repair of unreinforced masonry walls by the injection of cementitious grout into cracks due to movement in the plane of the wall. Figure 1 delineates applicable cracks.

Figure 1. Typical Unreinforced Brick Building with Common Crack Patterns.

Cracks 1 and 5 may be repaired by the crack injection process. In addition to the repair of the crack itself, framing supported on the adjacent wall around the corner should be investigated for loss of or reduction of support, and appropriate repairs made. It is recommended that shear connection of the diaphragms to the wall also be made.

Crack 2 can be repaired by the injection process. Adjacent to a steel lintel at the top of the opening, injection from both sides of the wall is required since the lintel will prevent injection into the full wall thickness from one side.

Cracks 3, 4, and 6 will generally be closed by gravity and cannot receive injected grout. Grout may be used to fill the collar joints adjacent to the crack and bond adjacent loosened bricks.



Crack 7 cannot be repaired by injection. Arches generally were built with special effort to completely fill collar joints and head joints. Voids are small and not interconnected so that the injection process is not effective. An arch with loose bricks or with a part of the arch badly displaced downward shall be rebuilt.

Crack 8 do not have the typical pattern following bed and head joints: the loosened portion is separated from the wall along a diagonal line that has sheared through bricks. Restoration of support for the lintel requires that the corners of the pier be reconstructed after removal of the damaged bricks.

Crack 9, up to about 3/4 inch in width may be repaired by injection process under the following conditions:

- Related cracks similar to crack 8 shall be repaired as noted for crack 8.
- Where the cracks are in a pier that is part of the in-plane lateral load resisting system of the wall, the bed joints on which sliding has occurred shall be raked to a depth of 1 1/2 inch and repointed with type N mortar at both the interior and the exterior faces. The building shall be analyzed and the overstress that caused shear cracks in the pier shall be addressed.

Crack 10 that are related to foundation settlement or causes other than earthquakes may be repaired by the injection process after the causes have been addressed.

III. QUALITY CONTROL

1. A building permit shall be secured for all crack repair work. Drawings for the work shall be signed by a licensed Engineer. **EXCEPTION:** The Building Department may waive the requirement for the drawings

As a covered entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability and, upon request, will provide reasonable accommodation to ensure equal access to its programs, services and activities. For efficient handling of information internally and in the internet, conversion to this new format of code related and administrative information bulletins including MGD and RGA that were previously issued will also allow flexibility and timely distribution of information to the public.

to be signed by a licensed Engineer, depending on the nature and extent of cracks.

2. After obtaining a building permit, a pre-construction meeting shall be conducted at the job site by the contractor and the City Building Inspector. The purpose of this meeting is: (1) to review the approved plans and specifications, (2) to verify that the plans accurately represent the site conditions, and (3) to discuss the repair procedure, “core” testing, and inspection.
3. City Inspectors, the project Engineer and the Deputy Inspector shall be notified 24 hours prior to required inspections or meetings.
4. Inspections:
 - a. Required inspections by the City Building Inspector at the job site shall be as follows:
 - i. Pre-construction meeting at job site.
 - ii. Injection holes and verification ports drilled and cleaned but prior to injection of grout.
 - iii. After injection of grout to designate inspection hole locations. EXCEPTION: Requirement for inspection core hole may be waived by the Building official.
 - iv. When 2 ½ inch diameter inspection holes are ready for inspection.
 - v. After completion of clean-up work.
 - b. Inspection Holes:
 - i. When required, holes shall be drilled at locations selected by the City Building Inspector after the injection work is completed. Holes shall be 2 ½ inch diameter cores, centered on the crack, the depth equal to the depth of the injection holes. Fill the holes with dry packed mortar after inspection and approval by the City Building Inspector. Where exposed, tool the surface to match the adjacent brick work.
 - ii. Inspection shall confirm that the crack is fully grouted to the depth of the injection holes. Where confirmation cannot be made or evidence of incorrect procedure is found, additional inspection holes or further investigation may be required by the Inspector.

IV. DEPUTY INSPECTOR RESPONSIBILITIES

Continuous inspection shall be performed by a concrete or masonry Deputy Building Inspector with a controlled activities stamp. The Deputy Inspector shall be present during washout, batching, and all injection of the grout. However, Deputy Inspection is not required during the initial washout of the holes which occurs 24 hours prior to injection.

1. Verify proper building permit and that approved plans match the job conditions. All cracks to be repaired must be shown on plans.
2. Inspect contractor's equipment for the following:
 - a. Cleanliness of pumps
 - b. Maximum pressure of 30 p.s.i. at injection wand
 - c. Equipment compliance with the Information Bulletin specifications
3. Verify that materials for the grout mix are on site i.e.,
 - a. #60 and #90 grit silica
 - b. Plastic Portland cement
 - c. Type "F" fly ash
 - d. Potable water
 - e. Type "S" lime
4. Verify the thickness of walls with cracks to be grouted and the appropriate depths of injection and verification holes.
5. Inspect each crack to be grouted. Verify that the proper number and depths of 3/4 inch holes have been drilled.
6. Verify that the cracks to be grouted have been cleaned of loose mortar, repointed, and pre-moistened (flushed) at least 24 hours prior to grout injection; observe the second flushing of the areas of damage prior to injection and insure that water flows from each drilled hole.
7. Insure that the grout mix is volumetrically batched in approved containers. Specifications hereafter.
8. During placement of grout, verify that grout is placed in a bottom to top, far collar joint to near collar joint sequence, with all holes filled.
9. Conduct a flow test of each grout mix batched for each day of grouting. The procedure is as follows:
 - A grout sample shall be taken from the injection wand. Fill a 2-inch diameter by 4-inch high cylinder.
 - Pour the sample slowly from 12 inches high onto an impervious smooth level surface.

- Proper consistency is indicated by a 6-inch to an 8-inch diameter puddle on the impervious surface.
4. Confirm filling and tooling of holes in exposed walls.
 5. Insure that the cleaning of the wall surface does not damage the newly installed grout.
 6. Prepare an Inspection Form IN-07 for each day indicating the following:
 - a. Specific cracks that were grouted.
 - b. Ratios of materials and water used in the grout mix.
 - c. Observations of water flow.
 - d. Results of flow tests.
 - e. Name of contractor
 - f. Condition of equipment.

V. REQUIRED EQUIPMENT

1. Mortar pump with agitating hopper that is capable of producing 30 p.s.i. pressure.
2. Cement mixer.
3. Measuring containers.
4. 3/4 inch drill bits and rotary drill motor.
5. Power cord.
6. Water hose.
7. Long water hose nozzle that is adjustable to 1/4 inch.
8. O.S.H.A. approved scaffold and/or ladders.
9. A 5/8 inch injection tube capable of penetrating all collar joints into an unreinforced masonry wall with a method of retaining grout as pressure increases to 27-30 p.s.i. At 30 p.s.i. flow of grout to the tube must be automatically stopped to:
 - Prevent excessive pressure from blowing out the wall. Once the grout stops flowing. The pressure builds up rapidly.

- Prevent excessive pressure from locking up the equipment.
 - Help eliminate human error and give better control to the Deputy Inspector.
4. Pressure monitoring system at ground level for use by the Deputy Inspector.

VI. SPECIFICATIONS AND PRESSURE

1. Materials

a. Grout (Parts shall be measured by volume)

- 3 parts #60 silica sand.
- 1 part of #90 silica sand.
- 1 part plastic Portland cement.
- ½ part type S lime
- ½ part type F fly ash

Approximately 2 ½ parts of water are added. Water shall be sufficient to achieve a pourable but not watery consistency as determined by the flow test (Section IV, item 9). Water may be added to the mix to maintain the required consistency. Grout shall not be used more than 2 ½ hours after initially adding water to the dry ingredients.

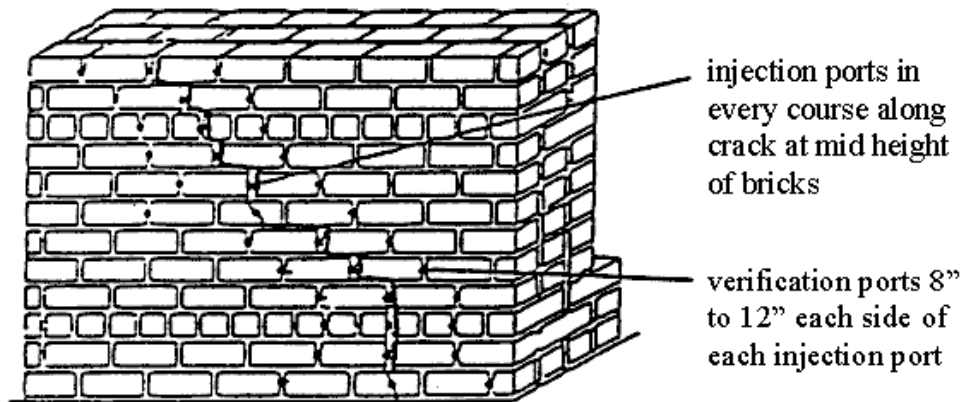
a. Mortar (Type N)

- 4 ½ to 6 parts masonry sand.
- 1 part type I or type II alkali cement.
- 1 part type S lime.

4. Preparation of the Walls

- a. Apply 1 coat of a masonry sealant to any portion of masonry wall to remain exposed on which grout may spill.
- b. Remove loose mortar from open joints. Mortar not bonded to at least one brick of an open joint, or easily debonded shall be removed.
- c. Clean the cracks by flushing with water.

- d. Fill the premoistened cracks and open joints with prehydrated mortar ½ inch deep. Tool the mortar joints to match the adjacent existing joints.
- e. Remove and reset, with mortar, bricks that are determined visually or by hand to be debonded from adjacent bricks. Clean loose mortar from the cavity and flush with water before resetting the brick.
- f. Drill ¾ inch minimum diameter injection holes into the crack at a head joint or cracked brick in each course of brick. Holes shall penetrate to the near face of the far wythe of brick. See Figure 2.



- g. Drill ¾ inch minimum diameter verification ports into the head joint approximately 8 to 12 inches on each side of the crack to the same depth as in f). See Figure 2.
- h. Thoroughly wash and saturate the wall by flushing with water approximately 24 hours before injection. Use water at City pressure through an injection wand that can be inserted the full depth of the holes. Flush each injection hole and verification port working from far collar joint to near collar joint in each hole and from top to bottom. Flush each hole until the water flows clear.
- i. Thoroughly saturate the wall by the same method immediately prior to grout injection. Repeat if more than two hours have elapsed between flushing and injection.

5. Grout Injection

Grout shall be delivered into the wall through an injection wand capable of sealing the injection hole approximately by 2 inches behind the nozzle. The grout pump shall be able to develop at least 30 p.s.i.

Inject grout into the wall at each injection hole, filling the collar joints starting at the far collar joint, proceeding to the near collar joint, working from the bottom to the top. Verification ports should be plugged as grout flows from them. When grout flows from the injection hole above, apply a temporary

As a covered entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability and, upon request, will provide reasonable accommodation to ensure equal access to its programs, services and activities. For efficient handling of information internally and in the internet, conversion to this new format of code related and administrative information bulletins including MGD and RGA that were previously issued will also allow flexibility and timely distribution of information to the public.

plug to the hole being injected and apply grout to the injection hole above. Continue until all injection holes have been injected. Inject grout into the verification ports from which no flow occurs. Wash grout spillage from the wall immediately.

Figure 2. Injection and Verification Port Pattern

6. Clean-up

- a. When the grout is firm, remove the temporary plugs and point holes with mortar. Tool the mortar to match the adjacent existing.
- b. Remove and dispose of all spilled mortar and grout.