



Evaluating the Strength of Concrete Masonry Structures



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Figure 1. Masonry test specimens positioned side-by-side on the turntable in the IBHS Research Center. The “common” poorly reinforced building suffered significant structural damage, while the “stronger” building, which was reinforced using current NCMA code requirements, emerged from the test without even cracks developing, despite experiencing wind loads that were roughly 50% higher than those that caused the failure of the “common” building.

About Reinforced Concrete Block Walls:

Many older masonry buildings have little or no reinforcing steel (re-bar) installed in the walls. Historically, the practice of building masonry structures in the United States has evolved from no continuous reinforcing to the addition of vertical steel reinforcing in the corners and in bond beams at the top of the walls, followed by the addition of vertical reinforcing installed on one side and then both sides of large openings (window and/or doors). Today, guidelines for reinforcing masonry built anywhere in the U.S. includes at a minimum vertical reinforcing in the corners, on both sides of large openings and spaced not more than 6 ft. to 8 ft. in sections of walls that are not interrupted by openings. This guidance also calls for the vertical re-bar to be tied into horizontal re-bar in bond beams at the top of the wall, into foundations and with proper overlap at corners.

Unfortunately, even today, in many parts of the country, masonry buildings are built the way they have “always been built” – without the reinforcing recommended by national consensus NCMA guidelines and without ensuring that reinforcing is properly connected. Using masonry industry reinforcing guidelines will enable walls to resist a high windstorm, as was illustrated through testing at the IBHS Research Center. Proper reinforcement can reduce structural damage that could lead to potentially catastrophic consequences. Figure 2 shows the remnants of a church

that collapsed when a tornado struck nearby. Note the metal rods with plates at the bottom that are hanging from the edge of the top-plate that was at the top of the wall (circled). This was the only connection between the roof and the top of the wall. There was no vertical reinforcing in the wall and no reinforced bond beam at the top of the wall.

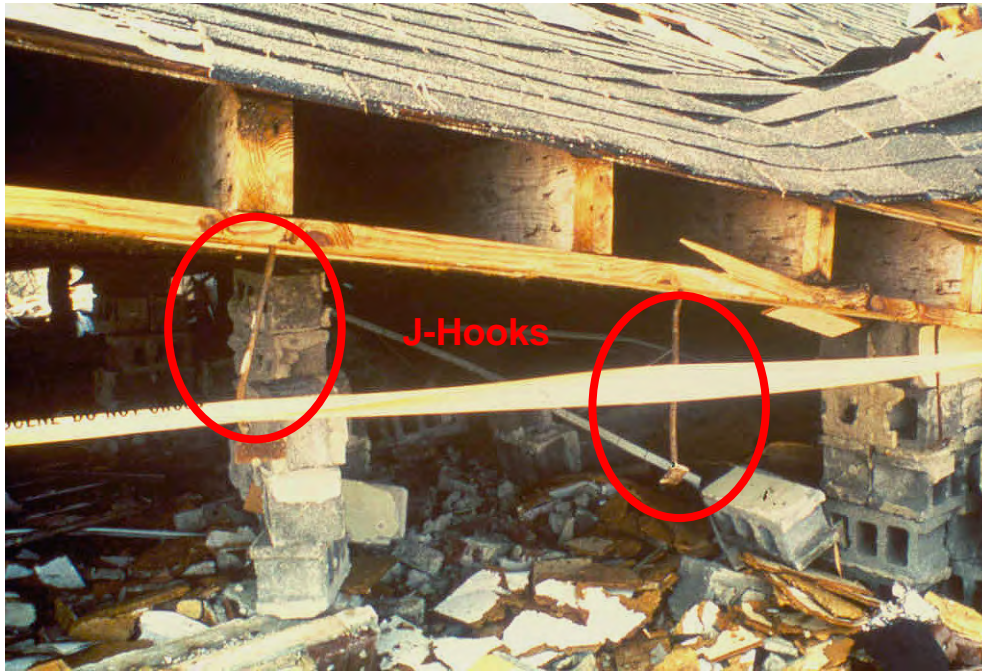


Figure 2. Collapsed masonry wall without vertical or horizontal reinforcing. The only reinforcing included in the masonry wall were the J-Hooks circled above.

Characteristics of building code compliant reinforcement:

- Vertical re-bar that runs from the footing in the ground to the bond beam at the top of the wall and ties into both.
- Vertical re-bar in the corners, on both sides of openings larger than 4 ft. and at regular intervals along wall segments without openings.
- Horizontal re-bar in a concrete masonry unit bond beam or poured reinforced bond beam at the top of the wall.
- Vertical re-bar size and spacing depend on design loads and wall dimensions.

Use the following checklist to identify key areas of inspection:

A metal detector, ideally one that has a depth penetration of at least 6 in., is needed when inspecting for the presence of or determining the lack of re-bar in a masonry wall. This device will detect re-bar that is located at the far side of the wall (or masonry cell). With a suitable scanner in hand, the inspector can traverse the surface to locate vertical re-bar within the walls and re-bar in a bond beam at the top of the wall. This qualitative assessment will provide sufficient information to draw a reasonable conclusion about the presence and quantity of re-bar, as shown in the table below.

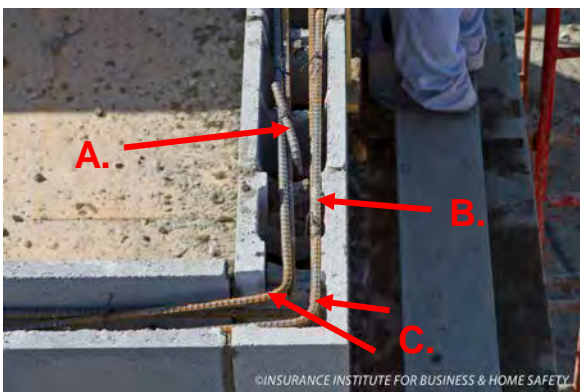


Figure 3. Bent pieces of reinforcing are laid in the bond beam corners at the top of the wall to tie the two sections of wall together.

- A. Vertical hook bar is inserted into a grouted cell beside the vertical steel. The long length of the steel provides adequate lap length so that the reinforcing acts like a single bar.
- B. Horizontal re-bar in upper bond beam located beneath and tied to corner bars.
- C. Corner bars provide continuity to tie the walls together at the corner.

Vertical Re-bar Located by Metal Detector					Assessment
Corners	Next to Windows	Next to Doors	Not more than 8 ft. between vertical reinforcing in walls	Reinforced Bond Beam at Top of Wall	
No	No	No	No	Yes or No	Very Poorly Reinforced
Yes	No	No	No	Yes or No	
Yes	Yes – one side	No	No	Yes**	Better; but still poorly reinforced
Yes	No	Yes – one side	No	Yes**	
Yes	Yes – both sides	Yes – both sides	No	Yes**	Good; but does not meet current standards
Yes	Yes	Yes	Yes*	Yes**	Very Good; Reinforcing likely meets current standards

* Re-bar size and spacing in uninterrupted walls depend on design loads and wall dimensions.

**While it's unlikely there will not be a reinforced bond beam, if the beam is missing the wall should be considered poorly reinforced.

Strengthening or Replacing Poorly Reinforced Walls:

Listed below are two methods that have been used to strengthen poorly reinforced masonry buildings. However, IBHS recognizes due to the costs associated with either of these retrofit methods, it is not likely that strengthening is a cost effective solution. If a building owner wants to strengthen a poorly reinforced masonry structure, they should engage a licensed structural engineer to assess the building and design the retrofits:

- A. The faces of the blocks are cut, where reinforcing is to be added, all the way from the bond beam at the top of the wall to the footing at the base. Short sections or re-bar are epoxy grouted into the footing and the bond beam to extend into the cavity behind where the face block has been removed. A long section of re-bar is then installed in the cavity, so that it overlaps by about 27 in., with the re-bar sticking up from the footing and down from the bond beam. The cavity is then filled with grout until it is flush with the exterior face of the surrounding block.
- B. Metal straps are applied to the outside and inside surfaces of the block wall opposite each other and they are connected by bolts through the wall that tie the straps to the masonry and the straps are attached to the bond beam and footing.

Strengthening Buildings in Hurricane-Prone Regions:

Installing opening protection and strengthening the roof against hurricanes damage are effective ways to protecting masonry buildings against more common weaker wind conditions. During IBHS Research Center testing of poorly reinforced masonry, the test building survived gust wind speeds of approximately 130 mph when the windows were not broken. However, the building was heavily damaged at a gust wind speed of 105 mph when a window was broken and the wind loads on the building were significantly increased by pressure building up inside.