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PRACTICAL CONCERNS FOR JACKING AND SHORING MASONRY STRUCTURES

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ABSTRACT

Building movement or structural distress may sometimes cause settlement and cracking of a masonry building. The Owner and Engineer are then left to a) stabilize it in its deflected condition, b) lift the structure back into position and then stabilize it, or c) demolish the structure. This paper will discuss the issues associated with jacking (lifting) and shoring to stabilize a masonry structure. General concepts will be discussed along with case studies including that of a four-story brick building constructed c.1876. Portions of the load bearing brick building were constructed with timber framing at the ground floor to create interior commercial space and to support exterior openings. By the 1970s, timber deterioration had caused portions of the brick walls to deflect 75-100 mm (3-4 inches). Several owners from the 1970s to current were dissuaded from restoring the building due to the deteriorated condition and potential costs to repair. A recent restoration included jacking portions of the masonry walls and stabilizing the supporting framing.

KEYWORDS: *bracing, jacking, masonry, shoring, temporary stabilization*

INTRODUCTION

One of the most difficult decisions to be made is whether to restore, repair or rebuild an existing building that is in distress. If settlement is part of the distress, the decision is even more complicated. The decision to jack or shore is often driven by economic reasons, but it can also be complicated because the technical aspects of repair are not always familiar.

Why is there such a technical challenge? Because lifting and shoring portions of an existing building can be a very difficult process to plan and implement. The older the building, usually the more difficult the process. Lifting and shoring only a portion of a building must be done so as not to damage the portions of the building that remain. Although it's beyond the scope of this paper, the effects of vibrations should be considered for safely shoring or jacking a structure.

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Moving a building is an extreme example of lifting and shoring. While the loads and logistics are magnitudes larger than repairing a portion of a building, there are some advantages. Primarily the building remains intact. In Figure 1, the foundation of this masonry building is a thickened slab that provides a base for the temporary support and lifting. The lifting method replicates the foundation support of the existing building so that it might be moved intact.

Figure 1: Moving a Masonry Building (Courtesy Of Buckingham Structural Moving Equipment, Bernville, PA)

For buildings without a continuous slab foundation, the exterior and interior walls are often supported by foundation walls and interior piers. While the foundation provides complete support, it is not uniform. Therefore to lift and move the structure, the lifting framework must replicate the various support points of the original foundation. A specialized moving plan must be developed that considers the support of the lowest floor system and all masonry walls independently (Figure 2).

Figure 2: Lifting a Masonry Building (Courtesy of Buckingham Structural Moving Equipment, Bernville, PA)

Jacking and shoring a masonry building as part of a repair or restoration program is not as invasive as a complete move. However, that does not necessarily make it easier. Due to the complexity, the work is often performed by a specialty contractor. However with knowledge, a

mason contractor could perform this work. But, it is essential that the consulting engineer and the contractor both agree on the methodology and collaborate on the planning.

Jacking includes vertically lifting and stabilizing a specific part of the building thereby leaving the remaining structure intact. The reasons for the jacking are often settlement or shifting of some part of the foundation or localized distress of the structural system that supports the masonry. The need for jacking is often determined based upon large cracks in the mortar joints and/or units where gaps have formed (Figure 3).

Figure 3: Masonry Cracks

SHORING MASONRY STRUCTURES

Shoring includes temporary support while modifications or additional strengthening is added to a masonry wall. It is usually employed when new openings are placed in an existing wall or an existing opening is enlarged. The key components to implementing a shoring scheme are a) evaluate the structure, b) determine the loadings, c) design the shoring, d) prepare the structure, e) install the shoring, f) complete the structure, and g) remove the shoring. As with any project, the evaluation and planning are essential to success. The engineer needs to understand the structure and the load path before and after the shoring installation. This step will lead to a proper shoring design solution. The shoring design must limit deflections to prevent further cracking.

Case Study 1

Figure 4 partially shows an interior opening for an industrial elevator in a six-story masonry building (c.1902). The wall is four brick leafs thick (41cm); the opening is 2m wide. A large T-section with a thick bottom flange supports 2m of brick wall above. The owner desired an enlarged opening that would match the size of the openings on the upper floors (see red line outline of proposed opening on Figure 4). 33 cm of the masonry above the opening needed to be shored so that a new support could be installed.

Some of the key concerns were:

- Provide adequate support capacity for the loads. This is usually based upon a straightforward structural analysis.
- Proper placement of the temporary supports that do not limit the proposed modifications. The supports had to be installed in phases so that support is maintained yet can be removed without interfering with the strengthening or modifications. This aspect of the shoring usually provides the technical challenge.

Figure 4: Existing Opening to be Enlarged Vertically

Several options were considered for shoring. One option included cutting holes in the wall above the proposed opening, installing needle beams through the wall, and then supporting them with shoring posts. Afterward, the lower masonry could be removed and a new lintel beam installed. Finally, the shoring system could be removed and the masonry holes filled in.

Another considered solution was to install steel angles on both sides of the wall with the horizontal legs routed into the mortar joint. These angles would span full length and support the wall area above temporarily. Figure 5a graphically shows the existing opening and a portion of the wall above. A dashed line shows the wall area intended to be removed. In Figure 5b, steel angles were designed to satisfy load capacity and deflection criteria and added to both sides of the wall by routing the mortar joints just above the desired opening. The angles have 178mm vertical legs, 102mm horizontal legs and are 10mm thick. 13mm bolts were added to keep the angles tight to the wall. The angles were extended beyond the jambs to provide adequate bearing. Figure 5c is the view after the masonry was removed and the jambs rebuilt at the cut brick. Finally, a 7mm plate was welded to act as a closer to the underside after a mortar parging was added (Figure 5d).

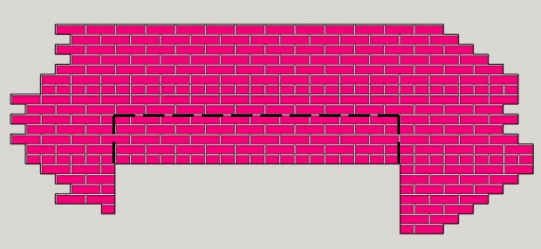

Figure 5a: Existing opening

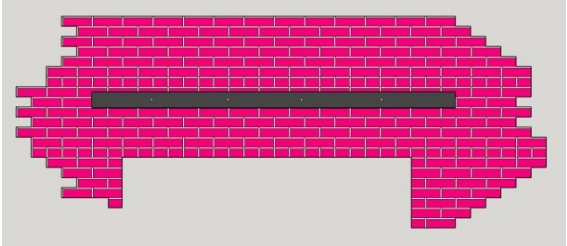

Figure 5b: Steel angles both sides of wall

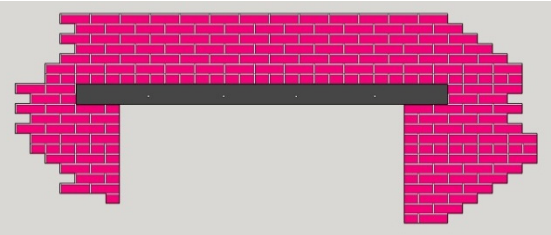

Figure 5c: Wall area removed

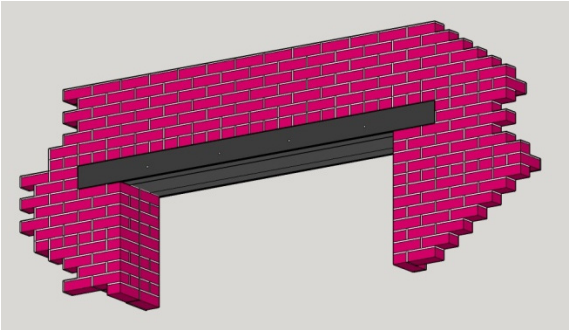

Figure 5d: Bottom cover plate added

This shoring solution was selected because it had two advantages; the angles did not require temporary posts and they served as the permanent support. There was one disadvantage; dependent upon the opening width, the local building code may require that the steel framing be fireproof protected.

Case Study 2

Evaluation

Figure 6 shows an 1848 tavern building where the brick exterior was noticeably cracked, deflected and bowed around the entry door [1]. The building has a wood frame and brick was used as both the exterior leaf and nogging between the wood framing. The exterior leaf and nogging were connected by brick headers.

The evaluation of the building structure indicated the vertical deflection problems were created by the foundation support of the exterior leaf. The deflection created bowing of the exterior leaf that affected the brick nogging also. The determination was that the exterior leaf of the lower floor needed to be removed, rebuilt and re-anchored.

Figure 7 shows timber shoring installed and the exterior leaf being removed. The brick nogging and wood frame are exposed. Figure 8 shows the brick laid out on the ground; the broken and cut headers are visible. The exterior leaf was reinstalled in its original position as an anchored veneer.

Figure 6: 1848 Tavern with Deflection, Bowing and Cracking around Door

Figure 7: Shoring Installed

Figure 8: Exterior Leaf and Headers

Timber framing was used for the shoring; steel could have been used but the loads did not require it. A ledger was bolted into the wood framing to support the exterior leaf above with the assistance of the shoring. The solution was simple to implement; the loads were calculated by the weight of the exterior leaf.

Case Study 3

Figure 9 shows a building with a steel frame (c.1972). The exterior cavity wall has cold-formed metal stud backup and anchored brick veneer for the upper floors and glass window wall below.

Just above the glass window wall, the exterior veneer has stone trim (Figure 10). After nearly 30 years, bulges were found in the brick veneer and there was noticeable window movement [2].

Project records indicated a design error was discovered during construction and the solution implemented was to make the veneer full height bearing despite there being shelf angles. The

brick veneer was mortared tight at the shelf angles at each floor and the window mullions were strengthened to support the full veneer.

Figure 9: Four-story Steel-framed Office Building

Figure 10: Stone Trim at Bottom of Brick Veneer

Investigations and analyses performed to evaluate the veneer bulges determined that horizontal eccentricities from the brick veneer placed an outward load on the stone panels that were not accommodated in the initial stone panel anchorage design. This required removal of the stone panels and several courses of brick up to the first shelf angle to correct the anchorage problems. Temporary shoring was installed and then the panels and brick were reconstructed.

Figure 11 shows pipe shoring installed where the panels were removed between the shelf angle above and the lower framing. Notice the added steel angles at the top of the pipes. The shoring spacing allowed the panels to be removed incrementally. Figure 12 shows the original condition on the right and the rebuild on the left.

Figure 13 shows one area nearly completed. New lighter-colored brick that matched the stone trim was selected because the original brick was not available. Vertical steel angles were added as the backup support to strengthen the stone anchoring. The temporary shoring was removed as the stone panels were reinstalled with new, more substantial anchors.

Figure 11: Shoring after Panel Removal

Figure 12: Shoring during Rebuild

Figure 13: Nearly Complete

JACKING MASONRY STRUCTURES

Evaluation

A successful jacking operation is preceded by proper evaluation of the structure and its problems. Without an understanding of the problems, it is impossible to assess whether there is a distinct need for jacking. The evaluation usually begins with a survey of the structure. The engineer needs to know:

- What is the building construction?
- What is the masonry wall construction?
- Where is the area of the wall that is deflected and cracked? Is it localized or global?
- Why has there been settlement of the wall? Is it foundation movement or structural distress?
- What are the magnitudes of the loads on the cracked wall?

Preparation

Preparation includes correcting the underlying problem that caused the settlement and cracking. If the cause was foundation settlement, this may require a reconstructed foundation, underpinning, or soil stabilization. If the cause was structural distress, it may be due to overload or deterioration of the support. A structural fix needs to be planned and made part of the scheme for jacking. Some issues to consider are:

- Most cracks create an irregular surface in the broken mortar joints and masonry. Prior to jacking the crack closed, it is advisable to clean out the loose mortar and masonry chips within the cracks so that there is no restriction to the joint binding or closing tightly.
- For multi-leaf walls with cracks, more involved investigation is needed to determine whether the cracks are straight through the wall or are staggered from one leaf to the next. The concern is that the staggered cracks will cause the leafs to separate during

jacking. If leaf separation should occur, there could be a localized failure of the wall. To avoid separation, adhesive anchors could be installed on either side of the crack to solidify the masonry.

- If there is any concern for bowing out-of-plane, consider adding temporary lateral bracing. The structure should not be left in an unstable condition during the jacking.
- A structural analysis is needed to determine the loads to the area to be jacked. It is common to provide twice the jack capacity of any load estimate.
- Uncontrolled movement is not advisable; consider installing gauges, either manual or electronic, to measure movement.

Jacking

The process of jacking is the most dramatic stage. It can do additional damage if you go too far or too fast. Some suggestions include:

- Preferably the jacking should proceed in a slow, continuous operation of lifting and resupport. Jacking is often done in 1 to 3 mm increments. It is advisable to stop after each increment until the crack has stabilized.
- During the jacking, check for any bowing and monitor the cracks so that leafs are not separating.
- One common technique is to slightly tap the wall with a sledge hammer to loosen any initial binding of the crack.
- For safety reasons, the jacking should be halted if the structure binds up or bowing develops. The monitoring should check for new cracking or if doors bind adjacent to jacking.

Follow-up

Once the jacking is completed, a) the cracks and adjacent area can be repointed, b) the cracks can be strengthened with stitches, and c) any loose areas of the leafs can be anchored with adhesive anchors, if necessary.

Case Study 4

Figure 14 shows an interior bearing wall of a four-story historic building (c. 1876) where the support structure for the two-leaf brick bearing wall is timber. Previous building modifications were inadequate to support the upper three floors and each floor had settlement and cracking similar to what is shown.

New piers and structure were added to the first level (Figure 15). The foundations were strengthened beneath the piers which were oversized for architectural purposes. The steel beam shown was used for jacking the walls above approximately 50mm and kept as permanent support.

Figure 14: Cracked Wall

Figure 15: Jacking Beam/Permanent Support

Once the jacking was completed, the upper wall repairs were implemented (Figure 16). A steel channel was added at the jambs to help support the header above and retain the cracked wall laterally.

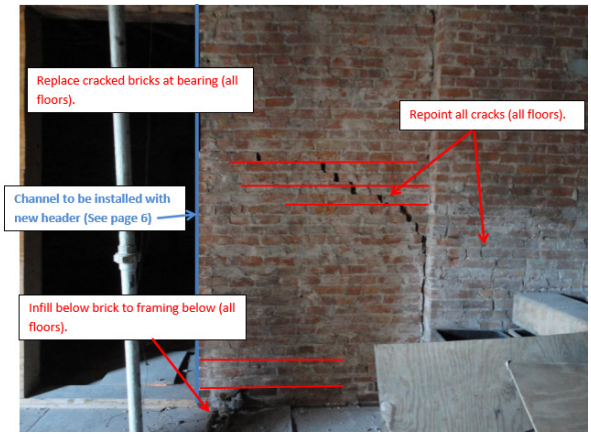

Figure 16: Follow-up Strengthening

Case Study 5

Figure 17 is part of the same historic building. It is an exterior non-bearing wall. The dashed lines indicate where a portion of the wall settled as much at 75mm due to deterioration of the lower supports. Previous attempts to add concrete masonry infill and framing were unsuccessful in stopping the cracking and settlement. Prior to jacking, temporary X-bracing was also added to the windows so they remained square during jacking.

Figure 18 shows the lower part of the wall. There are no photographs of the jacking in progress but the arrows show pads created for the jacking posts (the right one was also used for some temporary shoring).

Figure 17: Cracked Wall

Figure 18: Jacking Locations

All the cracks were cleaned out before jacking which took about an hour. Once the jacking was completed, the follow-up included pointing cracks, adding crack stitches, and vertically strengthening the masonry pier with reinforcement cut into the wall from the interior and then grouted.

CONCLUSIONS

Jacking and shoring requires much pre-planning to be successful. There is no one method that works every time. Each case requires an assessment of the conditions. Designers should collaborate with the construction team whenever possible.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Biggs, D.T. (2005), "Brick Nogging: Investigation and Repair", *Proceedings of 10th Canadian Masonry Symposium*

[2] Biggs, D.T. (2003), "Repairing a Brick Veneer on Metal Studs", *Proceedings of the Ninth North American Masonry Conference*, pp. 710-721