

Special Inspections & Masonry

Part 2: Implementing the Program

By Christopher N. Latreille, P.E.

Part 1 discussed general Special Inspection requirements as they pertain to reinforced concrete masonry construction. The roles of the Registered Design Professional (RDP), Testing Agent (TA), Contractor, and Special Inspector (SI) were discussed with emphasis on preliminary planning and coordination which can be achieved, in part, by utilizing a masonry pre-installation conference. (For Part 1, see the May, 2007 issue.)



CMU Wall Under Construction.

Code requirements for masonry may appear straight-forward, but once construction begins, inspectors can be confronted with numerous challenges. Perhaps the greatest challenge is inexperience. Senior staff in most engineering firms will oversee, but not necessarily perform, day-to-day inspections because the cost would be prohibitive. This task falls primarily to younger staff which may have ample experience designing masonry structures, but probably have less experience inspecting. In addition, Special Inspections are still relatively new.

Part 2 focuses primarily on the role of the TA and SI and is written predominantly from the point of view of the Structural Engineer performing Special Inspections.

General Requirements

Inspections and testing must be performed in either a continuous or periodic manner. Chapter 17 of the International Building Code (IBC) defines continuous inspection (paraphrased) as "full-time observation in the area where the work is being performed." Periodic inspection is defined (paraphrased) as "part-time or intermittent observation in the area where the work has been or is being performed and at the completion of the work."

There are two levels of masonry inspection; Level 1 is required for non-essential facilities (IBC Table 1704.5.1) and Level 2 is required for essential facilities (IBC Table 1704.5.3). The list of tasks is generally the same, but Level 2 requires more tasks be continuously inspected. This article is based on the more common Level 1 inspection.

Mortar Proportions

Mortar proportions must be verified on-site by the TA periodically. How this is accomplished depends whether the Contractor is mixing cement, lime, masonry cement, aggregate, and admixtures on-site, or if they are using pre-blended mortar. If the components are site-mixed, the TA must observe the blending process as the components are being batched.

For instance, let's say the project calls for a Type N, cement-lime mortar which meets the Proportion Specification in accordance with Table 1 of ASTM C 270 *Standard Specification for Mortar for Unit Masonry*. In this case, the TA observes the Contractor add one part Portland cement, one part hydrated lime, and three parts aggregate into the mixing apparatus. The Contractor must use a batch control method to provide consistent volumes of each component. This can be accomplished by using pre-measured bags or bins. The TA also verifies that each mortar material on-site matches the specified and accepted materials.

For pre-blended mortars, the process is easier. Since the components are premixed at a plant, the TA need

only verify that the specified and approved mix matches that which is being used on site. This should be as simple as reading the product name on the side of the bag.

With either site-mixed or pre-blended mortars, the TA should make sure that the Contractor is protecting the mortar materials from moisture prior to batching, as this can affect consistency.

Though the code only requires the TA to verify proportions for most projects, there are other requirements specified in ASTM C 270 that the TA and SI should be aware of as follows:

- Mortar must be mixed for 3 to 5 minutes with enough water to achieve a workable consistency. This may vary from mason to mason.
- Mortar is usually mixed using mechanized equipment. Hand mixing may be allowed for some projects with written approval from the RDP.
- Mortars may be tempered with water as often as needed up to 2½ hours unless otherwise specified by the RDP.

If Contract Specifications require testing for mortar properties, the SI should coordinate the sampling and testing with the TA.

Grout Proportions

Verification of grout proportions is also performed periodically by the TA. The verification process is essentially the same as that for mortar. There is one difference in that sometimes grout is batched and mixed off-site and transported wet in a mixing truck. In this case, the TA can record the information indicated on the batch ticket which should indicate proportions.

Additional requirements in ASTM C 476 *Standard Specification for Grout for Masonry*, that the TA and SI should be aware of are:



Heavily Reinforced Wall.

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Pencil Vibrator for Grout Consolidation.

- Grout is selected as coarse or fine depending on the lift height and size of the CMU cells and reinforcement. Fine grout will be specified in heavily reinforced walls or when small CMU sizes are used to facilitate placement and hinder segregation. Table 7 of the ACI 530.1/ASCE 6/TMS 602 (MSJC) specification provides criteria.
- Grout needs to be mechanically mixed for a minimum of 5 minutes with enough water to achieve a slump between 8 and 11 inches.
- Grout should be placed within 1½ hours after mixing.
- Grout must have a minimum strength of 2000 psi.

Using the proportions specification of ASTM C 476 will basically guarantee the 2000 psi minimum is met. If the properties specification is used, laboratory testing by the Contractor prior to construction should verify the mix meets the 2000 psi minimum. It is important to remember verification of mortar and grout strength during construction is not necessary for most projects; the Contract Specifications should indicate what is required.

Construction of Mortar Joints

Construction of mortar joints is generally performed by the SI periodically. Even though this is a periodic task, the SI should visit the site at the beginning of masonry work as the first courses of CMU are laid in order to detect any initial tolerance problems.

Chapter 3 of MSJC specifies the following tolerances for mortar joints in structural masonry (veneer tolerances should be specified in the Contract Documents):

- Head joints should be ⅜ inches thick, but can be as little as ⅛ inches and as much as ¾ inches.
- Bed joints should be ⅜ inches thick, but can be as little as ¼ inches and as much as ½ inches. Bed joints laid directly on top of foundations can be up to ¾ inches thick.

- Face shells should be bedded with mortar for their full thickness with webs bedded adjacent to grouted CMU cells.

- Head joints should be mortared for the full thickness of the face shell.

The MSJC does not allow any tolerance for mortar filling of head and bed joints; 100% is required. RDPs will often specify full bedding of all webs, to prevent

webs at grouted cells from being accidentally missed and extra grout from being placed in the wall. Extra grout may not be a problem for the structural capacity of the wall itself, but will make the wall heavier than intended which may affect supporting structures and/or add unexpected mass to the structure.

The most common bond pattern for reinforced CMU is running bond. The SI should verify CMU is being laid in a manner which vertically aligns the CMU cells. Mortar joints are supposed to be tooled with a concave jointer to consolidate the mortar after it is thumbprint hard. If Contract Specifications allow flush joints at unexposed areas, portions of partially set mortar might be torn out creating voids. These voids need to be filled. Therefore, the SI must inspect the joints at both exposed and concealed locations.

Reinforcement Placement

Inspection of reinforcement including joint reinforcement is typically done by the SI periodically. This should be emphasized at the beginning of construction.

Aside from verifying proper reinforcement size, grade, and lap length are being used, Chapter 3 of MSJC specifies the following requirements for placing reinforcement:

- Reinforcement must be restrained to prevent movement from construction loads or placement of mortar or grout. Wire-tying or prefabricated positioners are methods of restraining reinforcement. Wet-setting reinforcement is not permitted.
- Bending reinforcement after it is embedded in grout or mortar is not permitted without permission from the RDP.
- For most walls, reinforcing bars must be placed within ½ inches

of the location required within the thickness (out-of-plane) of the wall. For 12-inch or larger CMU or for pilasters, this tolerance may be increased to 1 or 1¼ inches. The SI should consult the Contract Specifications or, if necessary, verify these tolerances with the RDP before performing inspections.

- Vertical bars must be within 2 inches of the required location along the length of the wall (in-plane) from the location required.
- Clear distance between reinforcing bars and any face of the CMU cell must be a minimum of ¼ inches for fine grout and ½ inches for coarse grout.
- Bars may be moved more than one bar diameter or out of the specified position tolerance to avoid interference with the consent of RDP.
- Joint reinforcement must be placed so that the longitudinal wires have ⅝ inches of mortar cover where exposed to weather or earth and ½ inches of cover in unexposed locations. Joint reinforcement must be lapped a minimum of 6 inches. Heavy gauge joint reinforcement laps should be specified by the RDP.
- Reinforcing bars must be lapped a minimum of 12 inches. However, the specified lap length is often much greater. The SI must be thoroughly familiar with lap length requirements since they vary with rebar size and location.

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Mortar Extending into CMU Cell.



Preblended Grout Mix & Mixing Apparatus.

Heavily reinforced masonry walls or pilasters create inspection challenges. For example, CMU cells reinforced with two bars with intersections at bond beams or other reinforced masonry structures will appear to be very congested. Lapping reinforcement compounds congestion. The Contract Documents do not always indicate which bars control for positioning. Verify these requirements with the RDP prior to performing inspections.

Bed joints less than $\frac{3}{8}$ inches thick make it difficult to fit heavy joint reinforcement or anchors in some walls. The thickness of the joint reinforcement or anchor must not exceed one half the thickness of a bed joint. If possible, thinner joints (less than $\frac{3}{8}$ inches thick) should be located at courses which don't have joint reinforcement. Joint reinforcement may be installed prior to or after installation of mortar.

The SI is responsible for inspecting connections of masonry to other construction to verify compliance with the Contract Drawings. A certified welding inspector provided by the TA is responsible for inspecting any welding of masonry reinforcement continuously, though welding of reinforcement is not specified for most projects. Lapping reinforcement or using mechanical connectors are generally preferred in lieu of welding.

Before Grouting

Prior to placement of grout, the SI must perform periodic inspection to verify that the CMU cells are free of obstructions. Sometimes excess mortar extends into the cells and partially or completely obstructs them. Mortar from bed joints that extends more than $\frac{1}{2}$ inch into the CMU cells must be removed prior to grout placement. The SI should point this out to the Contractor during inspection of mortar joint construction so that the excess can be more easily and completely removed. There is always the possibility that the SI will find other forms of debris in the CMU cells (coffee cups, cigarette butts, the Contract Drawings, etc.). These must also be removed prior to grout placement.

Grout Lifts and Pours

Table 7 of the MSJC specifies lift and pour heights. A lift is the height to which grout is placed in one continuous operation, and cannot exceed 5 feet. Once initial water loss to the CMU is achieved, additional

grout can be placed on top of the previous lift (within about an hour). The total height of grout placed without allowing the grout to fully set is called a pour height. Maximum pour heights are governed by the size of the CMU cells and the grout type (course or fine). The SI should verify these requirements with both the RDP and Contractor prior to inspecting grouting operations.

As mentioned in Part 1, the Contractor should have already disclosed which grouting method (high lift or low lift) will be used during the pre-installation conference. For low lift, the Contractor builds the wall in sections not exceeding 5 feet in height. Grout is placed and allowed to set for each 5-foot section, prior to the construction of the next 5 feet. For high lift grouting, the Contractor builds the wall in tall, sometimes full-height sections prior to grouting. Regardless of which method of grouting (high or low lift) is used, lift heights may not exceed 5 feet.

High-lift grouting is often preferred, because the Contractor can build tall sections of wall and then lower single bars into the CMU cells requiring reinforcement. For low lift, the bars need to be lapped, welded, or mechanically connected at each lift. Using high lift may reduce the number of grout operations and reinforcement splices required, thereby lowering the tonnage of reinforcement. High-lift grouting will probably also reduce the number of times the SI needs to be on-site to perform inspections.

Cleanouts are required at the bases of walls and pilasters at each grouted cell when high lift grouting is used. The cleanouts allow for removal of debris (mostly mortar droppings) which will collect at the bases of the CMU cells, and also provide a direct method of verifying that grout is getting to the base of the wall. Freshly grouted CMU is generally obvious from the exterior, since the water from the grout will bleed through the face shells and be visible. Rebar positioners are required for high-lift grouting to maintain the reinforcement in the proper position for the full height of the wall.



Freshly Grouted Wall with Cleanouts.

Grout Placement

The SI inspects grout placement continuously, and is present until grouting stops and consolidation is complete. The Contractor should schedule the SI for inspection of masonry prior to grouting, leaving enough time to correct any non-conforming work. The following are general grouting procedures.

- Grout is placed into the cells using buckets or is pumped.
- Once placed, each lift is consolidated using mechanical vibrators (roughly $\frac{3}{4}$ inches in diameter) so that they can fit in tight spaces. Grout vibrators are commonly called pencil vibrators. Rodding (inserting a piece of reinforcement down each grouted core and withdrawing repeatedly) is not an acceptable means of consolidation for lifts exceeding 12 inches.
- Consolidation must be performed in each grouted cell immediately after placement, and then again after initial water loss and settlement have occurred which usually takes about ten minutes. Once vibration starts, it will become very clear why consolidation is required. After initial placement, grout which is vibrated will often settle a few inches as it penetrates and fills all the voids in the cell.

Industry standards now allow the RDP to evaluate demonstration panels in order to verify the acceptability of alternate grouting methods. This should be discussed during the masonry pre-installation conference.

With the conclusion of Part 2, we now have covered the most common inspection requirements for reinforced concrete masonry which are required as a minimum by the IBC. A potential future Part 3 will cover additional inspection topics including, sampling and testing of masonry materials, Level 2 inspection, and exterior cavity wall systems.■

Christopher Latreille, P.E., is a professional engineer with Ryan-Biggs Associates, P.C. He serves as Special Inspector for many of the firm's projects and is involved in structural design of educational, medical, and industrial buildings. Chris can be reached via email at clatreille@ryanbiggs.com.

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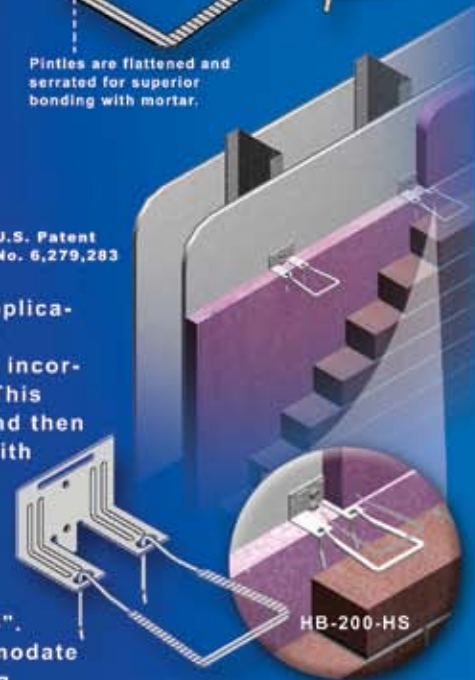
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