Chapter 4-4: Masonry

Table of Contents

Chapter 4-4: Masonry 1
4-4.01 General 2
4-4.01A Work Included 2
4-4.01B Tips and Suggestions to Prepare for Inspection of Masonry Work 2
4-4.02 Materials Used in Masonry Construction 7
4-4.02A Prefaced Masonry Units & Concrete Masonry Units 7
4-4.02B Cement 9
4-4.02C Mortar 9
4-4.02D Coloring for Mortar 10
4-4.02E Lime 10
4-4.02F Admixtures 10
4-4.03 Masonry Wall Construction 10
4-4.03A Reinforcement 11
4-4.03B Grout 12
4-4.03C Joints 13
4-4.03D Lintel 13
4-4.03E Pilaster 14
4-4.03F Cleaning and Protecting 14
4-4.03G Waterproofing & Sealers 15
4-4.03H Special Inspection 15
4-4.03I Glass Masonry Units 16

4-4.01 General

4-4.01A Work Included

This division deals with the use of concrete masonry units (CMU), blocks, bricks, stone, and other veneers used in the construction of structures and shown on the plans. Hollow CMU are the most common type of product used. However, other products, such as split face, fluted, and slump masonry units, may also be used on State projects for aesthetic reasons and for non-structural uses. See Figure 4-4.9 for a sample of how veneers are attached to masonry.

Although not necessarily included in the scope of work for all projects, the following will always be included under Division 04, *Masonry*: prefaced masonry units, concrete masonry units, and glass masonry units. Other items, such as cement, mortar, reinforcing, and grouting material colors, will also be included in the project *Special Provisions.*

Review any applicable Standard Special Provisions (SSP) from Section 99[1], *Building Construction*, Division 04, *Masonry*, that have been included in the project *Special Provisions;* the information contained therein typically will not be repeated in the following sections of this chapter.

4-4.01B Tips and Suggestions to Prepare for Inspection of Masonry Work

1. Review the *Caltrans Employee Health and Safety Manual*[1] and the project's Code of Safe Practices for scaffolding and/or fall protection requirements. Figure 4-4.1 shows scaffolding erection in progress. Be aware of particularly loose materials, toe boards, rails, building ties, and verify that ladders are secured for scaffolding access.



Figure 4-4.1. Setting Scaffolding

[1] Caltrans internal use only

2. Review *Standard* Specifications Section 58-2, *Sound Walls – Masonry Block*, for related standard requirements for construction with CMU blocks.
3. Read the project *Special Provisions* to determine specific requirements for submittals, preconstruction testing, certificates of compliance, materials delivery and storage, different materials to be used, procedures for executing the work, requirements for cleaning and protection, quality control, inspection, and testing.
4. Review the project plans to determine the kind and types of CMU block required. A review of both the architectural and structural sections of the project plans will provide a complete picture of the work required. The Project Architect from the Division of Engineering Services (DES) Structures & Engineering Services (SES) will often use CMU blocks with different types of finishes to develop patterns, graphics, horizontal and/or vertical lines, and other configurations for aesthetic value. See Figure 4-4.2 for a sample of the different types of blocks that could be used on a single building.



Figure 4-4.2. Split Faced CMU, Smooth Faced CMU, Glass Masonry Units, Stone Veneer

5. A careful review of the project plans to determine if the CMU is going to be built on a footing, with the floor slabs to be poured inside the masonry walls, or if the masonry starts on top of the floor slab, is important. Review the plans to determine the type of windows and doors that are going to be used, and how they are going to be fitted and anchored into the walls.
6. A review of the mechanical and electrical sections of the project plans will be important to see how each will interface with the CMU. They will likely require mounting such items as conduit, water, gas, or air piping, ductwork, light switches, devices, and door operators on the CMU walls. Each may require unique hangers or other attachments. Additionally, louvers, exhaust fans, and similar equipment to be installed in the walls will require special framed openings.
7. Colors specified for both the CMU block and mortar can usually be found in the notes for exterior finishes on the “Finish Schedule”, which is part of the architectural section of the project plans.

8. The *Special Provisions* may require submitting samples of the CMU block and mortar, in the specified colors, for authorization by the Project Architect. Authorized samples are delivered to the site so the delivered materials can be checked against the authorized samples. Verify that all deliveries match the authorized samples. There may be differences in color of materials if there are multiple deliveries. Some manufacturers have problems maintaining uniform color from one lot to another when casting their block.
9. Check both the structural sections within the project plans and the *Special Provisions* (likely in 99-04230 *Concrete Masonry Units*) to determine requirements for special inspection (special inspector) as part of the field quality control for the masonry. Such requirements are usually referred to in the notes for structural properties on the “Foundation Plan” within the “Structural Plans” section of the project plans for each building. If required, the Contractor must provide a separate submittal with the special inspector’s qualifications for review and approval prior to construction.
10. Discuss the requirements for items such as pretesting and certificates of compliance to assure contract conformance, with the Contractor. Determine if a specific release from Materials Engineering and Testing Services (METS) is required.
11. Check the location of all bolts and hardware that are to be embedded in the masonry walls. The spacing and layout of the bolts may be critical for the design loads, which can influence the layout of bar reinforcing steel. The bolts should be placed as detailed on the plans, or the structural designer should be consulted prior to any changes. See Figure 4-4.5 for a sample of anchor bolts in masonry.
12. When a sloping ledger supports roof purlins, the bolts supporting the ledger must be placed so that they are at a minimum four bolt diameters from the upper and lower edges of the ledger. Placing the bolts at a greater distance from the edge of the ledger is preferred. When the bolts are installed along a level line, there usually is no problem if they are placed so that the uphill bolt falls near the bottom of the ledger.
13. Whenever a sill on top of a masonry wall is part of the wall support system, be sure that the bolts are either centered in the sill or have a minimum four bolt diameters edge distance.
14. Hardware connecting masonry wall to roof or floor system must be installed exactly as detailed unless the structural designer authorized a variation.
15. When existing masonry is to be matched, the samples will typically be submitted to the Resident Engineer for approval. Check with the Project Architect to see how this is to be handled.
16. When checking color and textures, it is best to stack several sample blocks adjacent to the existing structure; comparing a single unit with a large wall

surface can be misleading. Remember that you will seldom have an exact match; consider the effects of weathering.

17. CMU blocks are laid in running bond or stacked. The standard module for CMU block is 16 inches. This dictates the locations for, and size of, openings, lengths of walls between openings, overall length of walls, and other linear dimensions being set in multiples of full or half block lengths. A quick check to determine if the plan dimensions of the building are modular is worthwhile to find layout problems. Most of those dimensions can be found on the applicable “Floor Plan” within the “Architectural Plans” section of the project plans.
18. Review the Contractor's planned method for proportioning and mixing mortar and/or grout to assure compliance with the *Special Provisions*.
19. The vertical reinforcing bars that are cast into the foundation must be checked to verify they are properly placed to fall in the center of each cell of the CMU block. Minimum spacing is required for the grout between the reinforcing bars (rebar) and the inside faces of the CMU block, which includes the inside web. The size and spacing of rebar will be found on the wall elevations of the structural section of the project plans. Additionally, special reinforcing for areas such as jambs and headers of wall openings, corners, columns, and lintels will be found on the standard detail sheets of the structural sections of the project plans. When the Contractor lap splices the reinforcing bar, be sure to confirm that the lap is of the correct length, per *Standard Specifications* Section 52-6.03B, *Reinforcement – Splicing – Construction – Lap Splicing.*
20. When checking vertical reinforcing bar in columns and pilasters, watch for the specified size, placement, spacing, and clearances from the CMU block walls for the stirrups. See Figures 4-4.3 and 4-4.4 for a sample of vertical bars in pilasters. Reinforcing bar within those vertical members can become crowded, especially if there are horizontal reinforcing bars. Bond beam blocks will be used for the courses in which the standard horizontal reinforcing bar is to be placed. Those CMU blocks are cast without the upper portions of the end walls and center web. This allows the horizontal reinforcing bar(s) to be cradled within the course of the blocks and become properly embedded when the wall is grouted. The size and spacing of horizontal reinforcing bar will also be found on the wall elevations of the structural section of the project plans. Horizontal reinforcing bar for lintels and headers of wall openings will also be included on standard detail sheets of the structural section within the project plans.



Figure 4-4.3. Rebar in Pilaster and Wall



Figure 4-4.4. Rebar Congestion in Column

21. Watch the masons as the block is being laid to verify that excess mortar does not protrude into the cell cavity. Excess mortar will displace and reduce the amount of grout placed in the cell of the CMU block. Be sure the cells of the CMU block are clean before grouting. Using a hand mirror to reflect sunlight into the cell of the CMU block can assist with this inspection.
22. Review the project plans to determine how the anchors needed for securing other materials to the masonry are to be installed and the exact location where they are to be placed. This will include items such as the framing members for support of floors, lofts, roofs, and attached canopies. Most structural connections will require anchor bolts to be accurately placed in the masonry walls, prior to grouting, so they will be properly embedded in the grout (see Figure 4-4.5). For example, ledgers and other members are attached to the structure using the embedded anchor bolts. This is a common method for connecting floor and roof ledgers to the masonry in order to support the floor and roof deck framing

members. Anchoring ledgers for the rake of the roof requires careful layout, as the bolts for the ledger must follow the slope of the roof. Anchors for roof framing members will often consist of metal plates to which the roof frame members will be welded. These plates will have studs that have been welded to the underside and set in the top of the wall and/or columns or pilasters prior to grouting. This will provide the proper embedment in the grout. Accurate setting of these plates is critical, as they have to conform to the slope of the roof to allow proper fit-up for welding.



Figure 4-4.5. Anchor Bolts Ready for Grout

4-4.02 Materials Used in Masonry Construction

4-4.02A Prefaced Masonry Units & Concrete Masonry Units

A note about prefaced masonry: The requirements of the prefaced masonry *Special Provisions* are in addition to the applicable requirements for block work, reinforcing, grouting, and other details applicable to concrete masonry construction. Prefaced masonry units are blocks covered at the point of manufacture with resin, resin and inert filler, or cement and inert filler.

California State building jobs specify ASTM C90 grade N type II blocks. Manufacturer recommendations usually prohibit the double-stacking of pallets of blocks.

The supplier is required to furnish a certificate of compliance for masonry units. Check the *Special Provisions* for possible requirements for masonry preconstruction tests. No other testing is necessary unless there are obvious deficiencies or any reason to suspect non-compliance of the CMU block.

Concrete Masonry Units are the most common type of finish used on exterior walls; however, plaster walls, metal siding, wood siding, concrete walls (such as in concrete tilt-ups), and steel walls (such as in pre-engineered steel buildings) are also used.

It is usually required that the Contractor submit two samples of masonry units. For jobs with block texture or color requirements, one sample should be reviewed by the Project Architect for approval, and one held at the jobsite for comparison to the production blocks when delivered.

During wet weather, it is important that the CMU blocks are protected so that they remain reasonably dry until they are grouted.

Some typical block shapes and details are shown below in Figure 4-4.6. Not all shapes are available from suppliers. Blocks should only be cut with a power-driven masonry saw. In addition, special surface treatments, such as split-face, preclude construction of blocks in some shapes.

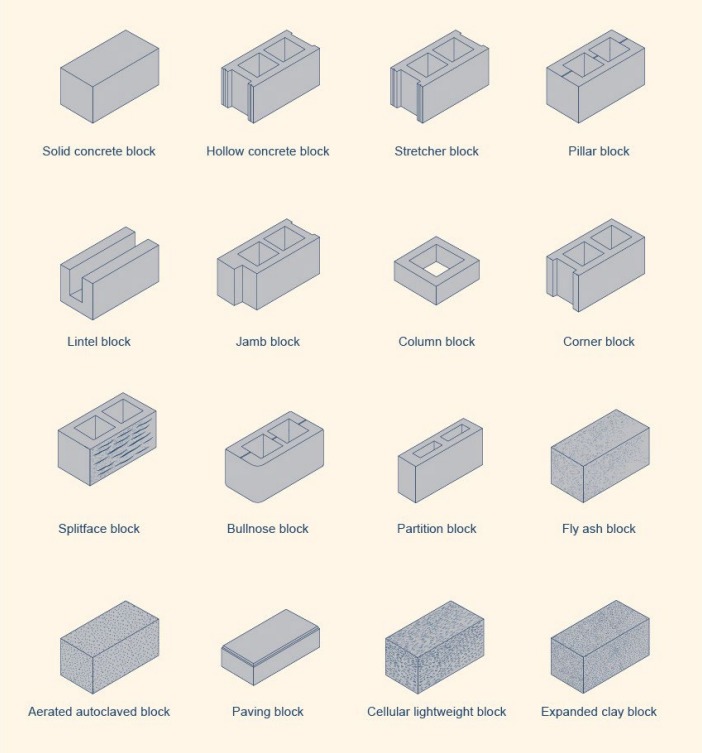


Figure 4-4.6. Types of Concrete Masonry Units

Some CMU blocks may not be available with specific faces split as drawn on the project plans; field modifications may be necessary to meet project plans for the CMU block finish as authorized by the Project Architect.

Split face block surfaces vary greatly from a straight plane. Attempting to match a split face wall with rigid construction, such as door frame, overhang soffits, or metal flashing, should be avoided whenever possible. Avoid using split face or fluted block on the first course where the concrete slab or original grade interacts with the building.

4-4.02B Cement

Most of the cements normally used in masonry work are included in the special provisions. However, this list may vary when project-specific problems are anticipated. Be sure to verify the requirements for cement with the project *Special Provisions*.

Cement for mortar will be delivered to the job in manufacturer's sacks. The information on the sacks should be compared with the special provisions and entered in the job records. Grout is usually handled like concrete, so it will be necessary to verify what type of cement is in the hopper. In both cases, a certificate of compliance may not be necessary. Minor deficiencies are usually not very important. Suspected deficiencies should be checked by sampling.

4-4.02C Mortar

The special provisions require mortar to be proportioned by volume. Mortar can be proportioned by converting volumes to weight. There are two methods of specifying mortar: proportion and minimum strength. The proportion method is the preferred method. If the proportion method is used, the minimum strength shall be verified at the time the proportions are determined. A pre-proportioned packaged blend of cement, lime, and sand may be selected for use. Mortar that has been mixed for more than one hour must not be retempered. See Figure 4-4.7 for a sample of prepackaged bags of mortar and grout.



Figure 4-4.7. Prepackaged Mortar and Grout

The applicable special provisions stipulate that the mortar joints shall be approximately 3/8 inch; this is appropriate for regular blocks.

Most project plans require that the joints be concave-tooled joints. A tooled joint is a mortar joint that has been compressed and shaped using a jointing tool after the mortar has begun to set slightly (see Figure 4-4.8). The surface of the joint is densified and compacted, reducing permeability. Tooled joints are typically formed into a concave,

"V", or weathered profile. Tooled joints provide better resistance to water penetration, especially wind-driven rain; they also improve the bond between mortar and CMU, enhancing durability. Tooled joints produce a uniform, finished appearance and can be applied to either the inside or outside face of the wall depending on the specific exposure condition.



Figure 4-4.8. Tooled Joints (Photo on right reproduced from Marshalltown.com)

4-4.02D Coloring for Mortar

A common practice is to purchase the same coloring agent that was used in the blocks to color the mortar. In general, it will be necessary to use the same manufacturer for the cement and the coloring agent. Coloring for mortar shall be chemically inert and fade-resistant, a mineral oxide or synthetic type.

4-4.02E Lime

The *Special Provisions* and the project plans specify that the hydrated lime meets Type S, ASTM Designation C207. Check the markings on the sacks to verify specification conformance. For additional information, refer to Section 4-4.03B, *Grout*.

4-4.02F Admixtures

Admixtures are not allowed in mortars; this includes the use of air-entraining cement.

4-4.03 Masonry Wall Construction

The *Special Provisions* contain the basic requirements necessary to produce satisfactory masonry construction. Debris, grout droppings, and mortar projections greater than 1/2 inch shall be removed from CMU cells prior to grouting. This is particularly important at the starter course where the grout column meets the footing. Figure 4-4.9 shows a sample of masonry wall construction.



Figure 4-4.9. Masonry Wall Construction. Note Tabs Set for Anchoring Veneer

4-4.03A Reinforcement

Reinforcing bars shall be secured and held in place prior to and during placing of the concrete grout.

While not stated in the special provisions, the California Building Code (CBC) tolerances are 1/2 inch for walls with a “d” dimension of 8 inches or less, and 1 inch for members with a “d” dimension between 8 and 24 inches (“d” = the distance from the compression face to the centroid of longitudinal tensile reinforcement). CBC tolerance for longitudinal location of vertical reinforcing bars is 2 inches (+/-); this means rebar can deviate up to two inches closer or farther from the design location.

CBC steel clearance requirements include the following:

1. Between parallel bars, except in columns: not less than one bar diameter nor less than 1 inch.
2. Between any bar and the surface of a masonry unit: 1/2 inch, except that CMU cross webs may support horizontal reinforcement.
3. Minimum cover (including masonry unit):
    a. 2 inches, when exposed to soil
    b. 1-1/2 inches, when exposed to weather
    c. 3/4 inch at other locations.

When placing dowels for the wall reinforcement, it is mandatory that they be placed accurately as shown on the plans. Placement of all reinforcement in masonry columns is critical and should be carefully inspected.

4-4.03B Grout

The special provisions follow the standard practice of giving proportions by volume. In practice, the grout is usually proportioned by weight at the batch plant and delivered in transit mix trucks. If a conversion of the batch weights to volume is desired, remember that hydrated lime is used and weighs about 40 pcf (lime ranges from 35 to 45 pcf).

Details of grout placing, the cleanouts required for grout pours over 5 feet in height, and height limitations for grout lifts are included in Section 99, Division 04, *Masonry*, of the special provisions.

The common term for grout pours of 4 feet or less is “low lift grouting.” “High lift grouting” describes any pours exceeding 4 feet high. In determining compliance with pour and lift requirements, the following definitions apply:

- Pour – The entire height of grout placed in one day and may be composed of a number of lifts.
- Lift – A layer of grout placed in a single continuous operation.

Remember that grout is not concrete. It is a fluid mixture that must be capable of flowing horizontally in a bond beam with only a slight hydrostatic head.

On most projects, grout is placed in the bottom course of blocks and other cells containing reinforcing bar. Current State requirements for placing grout are essentially the same as required by CBC and most other codes. The following comments are intended to put some of those requirements in perspective:

1. It is required to place and grout blocks in 4-foot lifts to avoid cutting cleanouts in the bottom course. The 4-foot limit is considered the maximum safe height - in most cases, without pausing -to allow hydrostatic pressure to dissipate. The true safe height is a function of mortar strength and is time-dependent. The specified limit may be conservative in many cases but does not guarantee that there will not be a blowout if the mortar hasn’t developed sufficient strength.

   The obvious consideration is how high you can go and still be able to clean out the cells. Cleaning the CMU cells is possible but difficult. Debris should be removed as the wall goes up. For schools and hospitals, where structural safety is critical and quality is mandatory, the height is limited to two feet. In any event, the primary concern is removing debris, not merely counting rows of blocks or adhering to a lift height limitation.

   When removing debris, the entire bottom course must be cleaned out. This is necessary to develop bond for maximum shear strength and to reduce the possibility of leaks at the floor line. For high lifts, cleanouts are required at all cells having vertical steel because that is where the debris accumulates and is difficult to remove.

2. When making horizontal construction joints, the grout must be stopped 1/2 inch below the top of the blocks. One reason for holding the grout down is to reduce the possibility of grout splashing and staining the face of the CMU blocks during the rodding or vibrating. This is particularly important when colored blocks are being used.
3. The special provisions require that the grout be vibrated or puddled at the time of placement. The vertical reinforcing steel makes vibrating difficult unless a stinger with a very small head is available. Rodding with a broomstick works well. Reinforcing bars used as rods should not be used for this purpose.

   The initial rodding will cause some of the excess water to rise to the surface and will help horizontal flow in bond beams. If excessive rodding is necessary for initial consolidation, something may be wrong with the grout mix.

   The second rodding, after the grout has reached a plastic state, is intended to improve bond by filling the voids that develop along the reinforcement and at the interface of grout and block. Large settlements due to consolidation are an indication that something was wrong during placement or the mix was not satisfactory.

On some projects, it is not feasible to use conventional pilaster blocks. In these cases, the pilasters are constructed from conventional blocks and are not interlocked in any way. To some extent, they resist hydrostatic pressure with mortar acting in tension. If the contractor pushes the pour height and rate to the maximum allowed, a blowout is a strong possibility. Suggest a slower pour rate to prevent form (face shell of the CMU) blowout.

4-4.03C Joints

Within the project plans, the sheet titled “Concrete Masonry Unit Standards” includes standard details for control joints. If no control joints are shown on the foundation sheets for larger buildings, the Structures Representative should contact the structural designer to confirm that no control joints are required. During the rebar installation phase of foundation construction, be sure to investigate the location of joints in masonry walls. Check the contract documents (including all applicable standards) for additional vertical rebar which may be required on either side of a masonry joint; this rebar is required to be anchored into the foundation.

4-4.03D Lintel

A lintel beam is a horizontal structural member constructed over an opening in a wall to carry the superimposed weight above. Mid-span splicing is <u>not</u> allowed for bottom horizontal reinforcing bars in lintels. Adequate shoring is required for lintel beam construction. See Figures 4-4.10 and 4-4.11 for examples of lintel beams.



Figure 4-4.10. Construction of Lintel Beam

4-4.03E Pilaster

A pilaster is a portion of a wall that projects on one or both sides of the wall and acts as a vertical beam, a column, or both. Check the location and layout of rebar and tie placements. See Figure 4-4.11 for an example of a pilaster beside an opening.

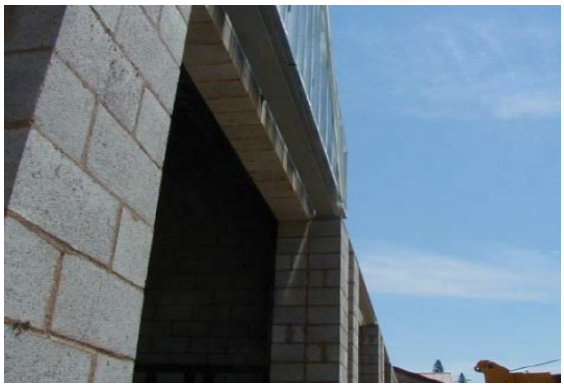


Figure 4-4.11. Pilasters and Lintel at Door Opening

4-4.03F Cleaning and Protecting

The special provisions stipulate that splashes, stains, and spots on the exposed face(s) of the CMU block must be removed. The intent is to obtain a uniform color and texture. Since grout stains are sometimes difficult to remove, care should be taken, particularly when working with colored blocks. A timely application of any required sealers or waterproofing provides some protection from stains during subsequent construction work.

The special provisions require that completed masonry be protected from freezing for five days after completion.

4-4.03G Waterproofing & Sealers

Unless otherwise required by the special provisions, waterproofing for masonry is a clear liquid intended to reduce deep penetration of water and to reduce water staining. While intended primarily for exterior surfaces of buildings, it may be used as a surface sealer on the interior of buildings or on accessory structures, such as walls, that are likely to be stained by intermittent spray from irrigation or cleaning operations.

There is a large variety of sealers, and some function better than others. However, there are other considerations such as cost, durability, ease of recoating, paintability, maintenance, natural appearance (no glaze or sheen), and resistance to darkening or yellowing with age. Another consideration is that they must meet the various environmental requirements. For the majority of State work, the project *Special Provisions* will specify one of the two basic systems described below.

The first system uses a product that is classified as a non-filming inorganic surface treatment. This type of material reacts with free lime to form calcium silicate or a similar insoluble compound.

The second type of material is a silicone product, which is classified as a repellent that causes water to bead and run off. Many paints will not adhere well to a silicone-treated surface, which makes graffiti removal easier. However, significant staining may remain and, during the cleaning process, the silicone product will be removed. However, there are no problems with touching up damaged areas.

Usually, these products are either about 5 percent silicone resin in a hydrocarbon solvent or 2 to 3 percent sodium methyl siliconate in water. Both have additives to help application and penetration. These products are less durable than many sealers and are not as effective on horizontal surfaces. The advantages, besides low cost, are that no film is formed and surfaces are simple to recoat. The surface must be dry when applying the hydrocarbon solvent type. The water solution type is very caustic. These products might be used for the prevention of water stains or where limited graffiti protection is desired.

4-4.03H Special Inspection

A Structural Masonry Special Inspector, similar to a Certified Welding Inspector for welding work, is responsible for inspection of the quality of workmanship and material used in the masonry construction per CBC requirements. Refer to CBC Chapter 17, *Special Inspections and Tests,* for special inspector responsibilities; this topic is also included in *Special Provisions* Section 99-04230, *Concrete Masonry Units*.

The special inspector cannot be an employee of the Contractor and needs to be International Conference of Building Officials (ICBO) certified. Some of the

responsibilities of a special inspector include inspection for proper workmanship and procedures as per the following:

1. Preparation and taking of required prism or test specimens (as required)
2. Concrete masonry unit placements (start only)
3. Reinforcing steel placement (continuous)
4. Mortar placement (continuous)
5. Grout spaces are free of obstructions prior to each grouting operation (continuous)
6. All grouting operations (continuous)
7. Anchor bolt placements (as needed).

4-4.03I Glass Masonry Units

Glass masonry units are frequently used to provide natural light in locations where a window might not be appropriate. Restrooms are often provided with natural light in this manner. Details for the installation of the glass block can be found in the authorized submittals.