Engineering Notes For Design With Concrete Block Masonry

MASONRY CHRONICLES

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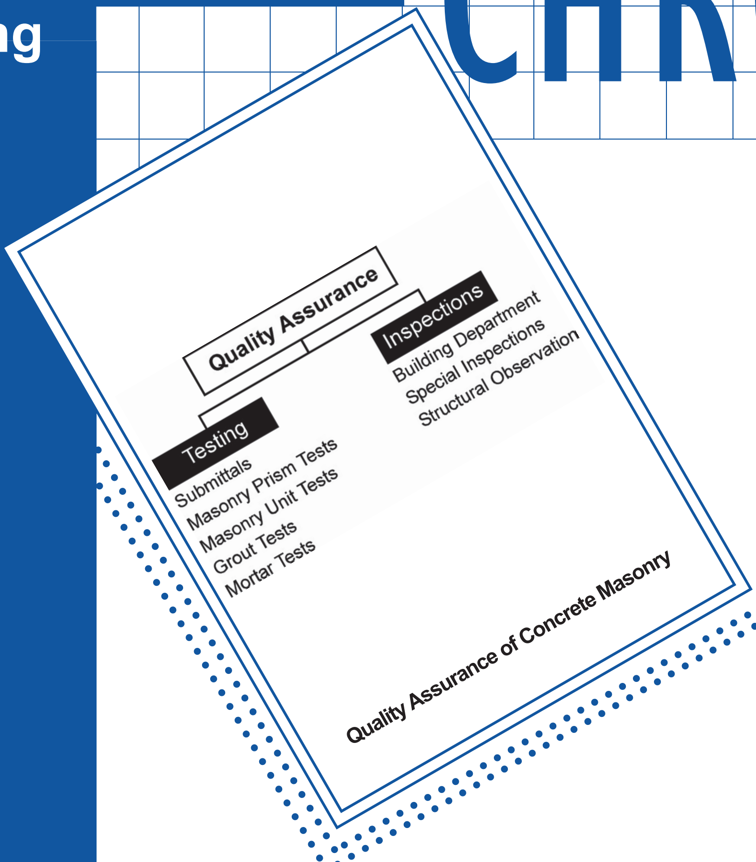

Quality Assurance of Concrete Masonry: 1997 UBC vs. 2006 IBC

Introduction

Quality assurance is defined as the administrative and procedural requirements established by the contract documents to assure that masonry is constructed in accordance with the contract documents. This includes verifications that the material properties conform with the plans and specifications, as well as inspections, to ensure that the handling, preparation, and placement of different masonry components is in conformance with the construction documents. This edition of "Masonry Chronicles" will discuss quality assurance procedures for concrete masonry by providing a comparison of the requirements of the 1997 UBC and the 2006 IBC.

Overview of Quality Assurance Procedures

The actions required to achieve quality assurance include testing to ensure that the materials are in accordance with the construction documents and inspections to ensure that workmanship is also acceptable. Quality assurance processes are typically performed by the owner or owner's representative. The owner hires the structural engineer (or architect) of record to develop a quality assurance plan in accordance with the applicable codes and standards. The design professional must include the quality assurance plan as part of the contract documents. The owner also hires a qualifed testing agency and an inspection agency to perform the testing and inspections required by the quality assurance plan. The testing agency samples and tests the masonry materials as specified, and reports the results to the engineer, the inspection agency, and the contractor. The inspection agency inspects and evaluates the construction at intervals specified by the quality assurance plan and provides the inspection reports to the engineer and contractor. Neither the testing agency or inspection agency is authorized to approve or reject any portion of the work. However, they are required to bring any deficiencies or on-conforming items to the attention of the engineer or design professional, building official, and contractor.

In addition to the standard inspections requirements outlined in the codes there are also special inspections, which must be performed on certain critical building components by persons with specialized training and expertise called special inspectors. Special inspections may be continuous special inspections, which consist of full time observation by the special inspector at all times while the work is being performed, or periodic special inspections, which consist of intermittent observations at selected stages of construction and at the completion of the work.

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Several jurisdictions also require that structural observations are performed by a licensed professional to verify that the construction is in general conformance with the approved plans and specifications. Structural observation is typically performed by the engineer of record or his representative and is carried out in addition to other inspections by the inspection agency, special inspectors, and building officials. Since most inspectors are not structural engineers, the structural observer is typically the only participant in the quality control program that understands the intent of the design. Therefore, the presence of a knowledgeable observer during key stages of construction of the gravity and lateral load resisting systems improves the likelihood of conformance with the contract documents, and reduces the possibility of gross errors and omissions. Nevertheless, it should be noted that the role of the structural observer is as the IBC states, "a visual observation of the structural system by a registered professional for general conformance to the approved construction documents." The structural observer is not responsible for certifying or ensuring conformance to all of the specific requirements of the construction documents, nor does structural observation waive the inspection or testing requirements that are required as part of the quality control program.

1997 UBC Quality Assurance Procedures

According to the 1997 Uniform Building Code [1] (UBC), quality assurance for masonry construction shall include assurance that:

- Masonry units, reinforcement, cement, lime, aggregate and all other materials meet the requirements of applicable standards.
- Mortar and grout are properly mixed using specific proportions of ingredients.
- Construction details, procedures and workmanship are in accordance with the plans and specifications.
- Placement, splices, and reinforcement sizes are in accordance with the code and plans and specifications.

Testing required for concrete masonry essentially involves tests to verify that the masonry compressive strength, f'_m, complies with the construction documents (Section 2105.3). The following methods allowed by the code for verification of f'_m:

- Masonry prism testing
- Masonry prism test record
- Unit strength method

In addition, mortar and grout shall be tested when required. If the allowable masonry stresses are used for design are reduced by half (Section 2107.1.2), field testing during construction is not required. A letter of certificate from the supplier of the materials to the job site shall be provided prior to the delivery of materials.

The 1997 UBC allows for different levels of inspection, depending on the type of concrete masonry units and the allowable stresses used in the design. The items required to be inspected by a special inspector for structural masonry are given in Section 1701.5.7. Different levels of inspection can be identified as follows:

- If half of the allowable masonry stresses are used for design, non-continuous inspection is permitted according to the exception of Section 1701.5.7.2. While the wording used in the exception is "noncontinuous inspection," it is widely interpreted to mean that no special inspection is required under these circumstances. The 1997 UBC requirements for this "minimum" level of quality assurance are listed in Table 1.
- The next level of special inspection is applicable to fully grouted open-end hollow-unit masonry (Section 1701.7.2) and partially grouted hollow unit masonry, where f'_m is no more than 1500 psi (exception of Section 1701.7.1). For this level, inspections are required at critical stages during construction. Table 2 summarizes the 1997 UBC inspection requirements for this "standard" level of quality assurance. This is the most commonly-used method of construction used in California, since most concrete masonry in regions of moderate to high seismicity is fully grouted with open-end units and/or has a masonry compressive strength of no greater than 1500 psi.
- The highest level of inspection is applicable to masonry that does not fall into the above two categories. At this "high" level, inspections are required at the beginning of and continuously during the construction of the masonry. The 1997 UBC requirements for this level are listed in Table 3. The 2001 California Building Code (CBC) stipulates that essential facilities such as hospitals and schools must be constructed with this highest level of quality assurance.

TABLE 1 1997 UBC "Minimum" Level Quality Assurance

Minimum Tests and Submittals	Special Inspection
Letter of certificate from the supplier of the materials	No special inspection required

TABLE 2 1997 UBC "Standard" Level Quality Assurance

Minimum Tests and Submittals	Special Inspection
Letter of certificate from the supplier of the materials Verification of f'_m of the masonry units prior to construction and every 5,000 square feet during construction Grout tested for each grout pour, or 5,000 square feet depending on the test method	1. During preparation and testing of any required prism or test specimens 2. At the start of laying units 3. After the placement of reinforcing steel 4. Grout Space Prior to each grouting operation 5. During all grouting operations

TABLE 3 1997 UBC "High" Level Quality Assurance

Minimum Tests and Submittals	Special Inspection
Letter of certificate from the supplier of the materials Verification of f'_m of the masonry units prior to construction and every 5,000 square feet during construction Grout tested for each grout pour or 5,000 square feet depending on the test method	1. During preparation and testing of any required prism or test specimens 2. During placing of all masonry units 3. During placement of reinforcement 4. During inspection of grout space 5. Immediately prior to closing of cleanouts 6. During all grouting operations

2006 IBC Quality Assurance Procedures

The sections for quality assurance for masonry construction in 2006 International Building Code (IBC) [2] are adopted from the 2005 Masonry Standards Joint Committee (MSJC) code [3]. However, while the requirements of the two codes are generally comparable, some differences exist in the way the quality assurance requirements are laid out. The MSJC code provides three levels of quality assurance, which are designated as quality assurance levels A, B and C in order of increasingly rigorous quality assurance requirements.

Level A Quality Assurance only requires acceptable certificates for the materials and minimum inspection to verify compliance with the construction documents. The 2006 IBC also does not require special inspection under certain conditions (Exception of Section 1704.5) for:

1. Empirically designed masonry, glass masonry, or masonry veneer

2. Certain types of masonry foundation walls

3. Masonry fireplaces, masonry heaters, or masonry chimneys when installed and constructed with certain provisions

The quality assurance requirements at this "minimum" level are shown in Table 4.

The next level of quality assurance in the IBC, which is called Level 1 Quality Assurance, contains all the inspection requirements for Level B Quality Assurance in the MSJC code, with some additional items that need to be verified. Level 1 Quality Assurance involves testing at the start of the project and inspections at critical stages during construction. Table 5 provides details on the requirements of level 1 special inspection.

Level 2 Quality Assurance of the IBC contains all the inspection requirements of Level C Quality Assurance of the MSJC, with some additional items that need to be verified. Level 2 Quality Assurance requires testing throughout the project and inspections at the beginning of and continuously during the construction of the masonry. Table 6 provides details on the requirements of Level 2 Quality Assurance.

In both codes (IBC and MSJC), the special inspection program used for a project depends on the method used for design and the type of building being constructed. Masonry buildings designed with methods that take the most advantage of masonry properties require higher level of quality assurance, as do buildings that are designated as essential facilities. Table 7 summarizes the requirements for various buildings for MSJC and IBC. As can be seen from the table, essential buildings designed using allowable stress or strength design procedures require the highest level of quality assurance (Level 2 or C), while most non-essential buildings require less rigorous (Level 1 or B) procedures. Both codes permit buildings designed with empirical design procedures to be constructed using minimum quality control procedures. However, it should be noted that empirical design of masonry is not permitted in most parts of the western United States and other areas of moderate to high seismic activity.

TABLE 4 2006 IBC "Minimum" Level Quality Assurance

Minimum Tests and Submittals	Special Inspection
Certificate of compliance for materials used in masonry construction	Verify Compliance with the approved submittals

TABLE 5 2006 IBC Level 1 Quality Assurance

Minimum Tests and Submittals	Special Inspection
Certificate of compliance for materials used in masonry construction. Verification of f'_m and f'_{AAC} prior to construction, except where specifically exempted by this code.	1. As Masonry Construction Begins, the following shall be verified to ensure compliance: a. Proportions of site-prepared mortar. b. Construction of mortar joints. c. Location of reinforcement, connectors, prestressing tendons, and anchorages. d. Prestressing technique. e. Grade and size prestressing tendons and anchorage. 2. The inspection program shall verify: a. Size and location of structural elements. b. Type, size, grade, and type of reinforcement. c. Specified size, grade, and type of reinforcement. d. Welding of reinforcing bars. e. Protection of masonry during cold weather (temperature below 40^{o}F) or hot weather (temperature above 90^{o}F). 3. Prior to grouting, the following shall be verified to ensure compliance: a. Grout space is clean. b. Placement of reinforcement and connectors, and prestressing tendons and anchorages. c. Proportions of site-prepared grout and prestressing grout for bonded tendons. d. Construction of mortar joints. 4. Grout placement shall be verified to ensure compliance with code and construction document provisions. a. Grouting of prestressing bonded tendons. 5. Preparation of any required grout specimens, mortar specimens, and/or prisms shall be observed. 6. Compliance with required inspection provisions of the construction documents and the approved submittals shall be verified.

TABLE 6 2006 IBC Level 2 Quality Assurance

Minimum Tests and Submittals	Special Inspection
Certificate of compliance for materials used in masonry construction. Verification of f'_m and f'_{AAC} prior to construction, and every 5,000 square feet during construction. Verification of proportions of materials in mortar and grout as delivered to the site.	1. As Masonry Construction Begins, the following shall be verified to ensure compliance: a. Proportions of site-prepared mortar, grout, and prestressing grout for bonded tendons. b. Placement of masonry units and construction of mortar joints. c. Placement of reinforcement, connectors, and prestressing tendons and anchorages. d. Grout space prior to grouting. e. Placement of grout. f. Placement of prestressing grout. 2. The inspection program shall verify: a. Size and location of structural elements. b. Type, size and location of anchors, including other details of anchorage of masonry to structural members, frames or other construction. c. Specified size, grade, and type of reinforcement. d. Welding of reinforcing bars. e. Protection of masonry during cold weather (temperature below 40^{o}F) or hot weather (temperature above 90^{o}F). f. Application and measurement of prestressing force. 3. Preparation of any required grout specimens, mortar specimens, and/or prisms shall be observed. 4. Compliance with required inspection provisions of the construction documents and the approved submittals shall be verified.

TABLE 7 Quality Assurance Requirements of 2006 IBC and 2005 MSJC

	Empirical Design, Veneer, Glass Unit Masonry	Working Stress or Strength Design, Prestressed Masonry	Empirical Design, Veneer, Glass Unit Masonry	Working Stress or Strength Design, Prestressed Masonry
	MSJC		IBC	
Occupancy Category I, II, and II (Non-Essential Facilities)	Level A	Level B	Minimum	Level 1
Occupancy Category IV (Essential Facilities)	Level B	Level C	Level 1	Level 2

Summary

While the 1997 UBC and the 2006 IBC present the requirements for quality assurance in different formats, the two codes have very similar provisions. The main difference between the UBC and the IBC is the absence of the half-stress provisions in the IBC. This means that the option of reducing the quality assurance requirements by not taking full advantage of the masonry properties will no longer exist when the IBC is adopted. The IBC will require some form of special inspection for all structures in the western United States and other areas of moderate to high seismic activity. In other areas, engineers may still be able to use the “minimum” quality assurance requirements by using empirical design.

Another less significant difference is the fact that the UBC requires a “high” level of quality assurance for masonry other than fully grouted open-end or partially grouted hollow unit masonry, where f'_m is no more than 1500 psi, while a “standard” level (Level 1 Quality Assurance) is acceptable under the IBC for non-essential facilities. However, since the most masonry in the western United States is constructed with fully grouted open-end units, and/or f'_m of no more than1500 psi, the need for highest level of quality assurance is often unwarranted, as is the case with the IBC.

The absence of occupancy category as a factor in determining the level of quality assurance in the UBC, also appeared to be a difference. However, the provisions of the 2001 CBC for schools and hospitals require the same level of quality assurance as essential facilities designed using the 2006 IBC.

References

[1] International Conference of Building Officials (ICBO), 1997 Uniform Building Code, International Conference of Building Officials, Whittier, California, 1997.

[2] International Code Council (ICC), 2006 International Building Code, International Code Council, Inc., Country Club Hills, IL, 2006.

[3] Masonry standards Joint Committee (MSJC), Building Code Requirements for Masonry structures, The Masonry Society, Boulder, CO 2005.

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