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Structural Masonry Design Tips

Structural masonry is a cost effective engineering solution that offers many options and significant design flexibility. The TIPS below are crafted to help the designer make choices that optimize the structure. *Note: These tips should not be used in lieu of professional knowledge and expertise.*

TIP 1: Start out right and don't miss the MSJC Checklists.
One of the first steps to take when starting a structural masonry project is to use the right engineering design documents, which for most jurisdictions are - Building Code Requirements for Masonry Structures TMS402-08/ACI53-08/ASCE5-08 and Specification for Masonry Structures TMS 602-08/ACI530.1-08/ ASCE6-08[1] (MSJC). These editions are incorporated by reference into the 2009 International Building Code[2] (IBC). In addition to the structural provisions, the MSJC Specification has often overlooked checklists: Mandatory Requirements Checklist and Optional Requirements Checklist lists which help the designer produce well crafted project documents.

TIP 2: For ASD – consider using the 2011 MSJC provisions.
The 2011 MSJC Allowable Stress Design (ASD) provisions represent a substantial update over previous editions. There is a harmonization of ASD and Strength Design (SD) shear provisions, an extensive stress recalibration, the removal of the '1/3 stress increase' option and more. These provisions are included in the 2012 IBC. Consider using these most current provisions when designing with ASD.

TIP 3: Start with the correct and most current standard.
Start with the most current ASTM International[3] (ASTM) material standard appropriate for your project. As an example, units for loadbearing concrete masonry buildings should meet ASTM C90-09 *Standard Specification for Loadbearing Concrete Masonry Units*. Current ASTM standards are listed at: *www.astm.org.*

TIP 4: Unit compressive strength is independent of unit density.
From a structural standpoint, the minimum compressive strength requirements in ASTM C 90 are the same for all density classifications. In other words, 'lightweight', 'medium weight' and 'normal weight' units are all required to meet the same compressive strength requirement even though their densities are different.

TIP 5: Remember that ASTM C90 includes minimum requirements.
There is a minimum compressive strength listed in the ASTM C 90 Table 2, but there is no maximum compressive strength limit listed. This permits specification of higher strength units which in turn can lead to higher specified compressive strengths for the masonry wall.

TIP 6: Consider specifying above the ASTM minimum for unit compressive strength.
Often manufacturers routinely produce units which have higher compressive strengths than the ASTM minimum. So if standard production units have higher compressive strength than the ASTM C90 minimum, it makes good sense to use that strength in the design calculations. The project documents must specify that higher unit strength requirement and material test reports would verify compliance.

TIP 7: Mortar type matters.
Mortar type affects masonry wall compressive strength. The cost difference between Type S and Type N mortar is pennies per square foot but the first offers higher assembly compressive strengths.

TIP 8: Watch what is specified for field QA for mortar.
Consider first whether field testing of the mortar is really necessary. Many projects do not require mortar testing but if testing is needed or desired, the most applicable QA test for site mixed mortar is the Mortar Aggregate Ratio Test Method in ASTM C780 *Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry*. This test provides quick results and information on the mortar proportions — exactly what is needed to verify compliance.

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TIP 9: Get familiar with ASTM C1586.
ASTM C1586 *Standard Guide for Quality Assurance of Mortars* discusses proper use of ASTM C270 and ASTM C780 for mortars produced in the laboratory and those produced at the construction site. It helps designers evaluate project needs for specifying and testing masonry mortar.

TIP 10: Specify grout strength appropriately.
Grout and reinforcement enhance the structural capabilities of masonry assemblies, increasing the strength and allowing the construction of taller, thinner walls. The minimum grout compressive strength permitted by the MSJC, the IBC, and ASTM C476 is 2000 psi. For many structures, no change in the minimum strength requirement is needed. However, if higher assembly strength is desired, good practice is to specify grout strength that is approximately equal to the unit strength.

TIP 11: Understand grout pours and grout lifts.
A grout *lift* is the amount of grout placed in a single continuous operation. A grout *pour* is the entire height of masonry to be grouted before more courses of masonry are constructed. A grout pour can consist of one or more lifts placed in succession. Typically the decision to use pours without cleanouts (often called low lift grouting) or pours *with* cleanouts (often called high lift grouting) is left to the contractor although the engineer may have reason to specify one method over the other. *Grout pour height* is limited by the MSJC and is a function of the type of grout used (fine or coarse) and the grout space dimensions. *Grout lift heights* used to be limited to 5' maximum however the current MSJC documents permit lifts up to 12'-8" under certain conditions.

TIP 12: Give the mason contractor some latitude.
Take advantage of contractor expertise in both technical and constructability considerations. Unless there are engineering considerations that override specific means and methods, giving the mason contractor the latitude to select fine or coarse grout, determine the lift and pour heights, and the use of self-consolidating grout can result in cost and time savings.

TIP 13: Embrace new technology by considering self-consolidating grout.
One popular innovation in masonry construction is self-consolidating grout (SCG) - a highly fluid mixture of cement, water, fine and coarse aggregates, and plasticizing admixtures. Like conventional grout, it fills designated spaces in the masonry units and, after it hardens, transfers load to embedded reinforcement. While it can save time, specifiers and contractors need to understand how it performs and the differences in code and standards requirements, materials, testing, and installation.

TIP 14: Green your grout with fly ash.
Fly ash, a mineral by-product of coal combustion, often supplements portland cement in masonry grout. Fly ash may be called for specifically as part of the grout mix or included as part of a blended cement – ASTM C595 - which allows up to 40% fly ash by weight of portland cement as a cement replacement. Fly ash may enhance grout flow and pumpability. Grout mixes with substantial fly ash replacement may have slower early compressive strength gain than mixes without fly ash – a potential concern in situations such as setting planks or floor joists on newly built masonry or in cold weather.

TIP 15: Consider structural brick.
The engineering requirements for structural brick masonry are included in the MSJC and the IBC. Steel reinforcement is placed either within cells of the brick units or within a grout space formed between two wythes of brick units. ASTM C652 *Standard Specification for Hollow Brick* offers options for units that are cored up to 60 percent. When steel reinforcement is placed and grouted between 2 wythes of brick, any clay brick standard that is included within the MSJC and IBC can be used.

TIP 16: Consider AAC masonry.
Autoclaved Aerated Concrete (AAC) masonry is a lightweight cellular concrete formed by a chemical reaction between lime, portland cement, aluminum powder, aggregate and water which is then cut into blocks or panels laid in thin-bed mortar. Light weight and easily cut on site, AAC masonry can be used for the structural support system in most areas of the USA and provisions are included in the MSJC and the IBC.

TIP 17: Include reinforcing splice lengths in project documents.
Where issues of availability or constructability make it impractical to install a single continuous steel bar for the full length required, lap splices provide the needed reinforcement continuity. Designers must consult the applicable requirements and include lap lengths in the project documents. This is not a contractor responsibility.

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TIP 18: Reducing lap splice lengths.
Lap splice lengths are generally longer for larger diameter bars, assemblies with less cover, multiple bars in a cell, and lower-strength masonry units. Options that may reduce lap splice lengths include smaller diameter bars spaced more closely together, using higher strength units, and minimizing the splices needed by using higher grout pours.

TIP 19: Use the 2011 MSJC splice provisions.
There are two changes in the 2011 MSJC that may help reduce splice lengths. Since the 2011 MSJC is adopted into the 2012 IBC, using these provisions may be easily accepted by reviewing authorities and will offer reduced laps. The two changes are:

- The beneficial effect of larger cover for computing development length has been changed from 5 db to 9 db for both ASD and SD.
- A new transverse steel option which uses horizontal reinforcement within the splice to reduce the lap in the vertical steel reinforcement.

TIP 20: Consider other splicing options.
The MSJC and the IBC also permit reinforcement spliced with mechanical couplers or by welding. Mechanical couplers may be cost-effective compared to long lap lengths but welding steel reinforcement is difficult and rarely used.

TIP 21: Think joint reinforcement not bond beams when possible.
Both joint reinforcement and bond beams can be used in most regions of the country to meet horizontal reinforcement requirements, however, joint reinforcement is a much more cost-effective solution if it meets the structural criteria of the project. Bond beams can provide more steel area and can also be used in combination with joint reinforcement to meet structural and crack control considerations.

TIP 22: Cleanout options may lead to higher pour heights.
Cleanouts are required for 'high-lift' grout installation. Designers need not view cleanouts as an aesthetic reason to limit the use of higher pour heights. The full face shell does not have to be removed to meet the code mandated minimum opening of 3 inches and options exist to conceal the cleanout in the finished wall.

Bottom line: Structural masonry is environmentally sound, cost-effective and provides multiple options to the engineer, architect and owner. Masonry materials are produced locally and installed by local labor. Their inherent properties provide fire protection, blast resistance, thermal mass and acoustical control, thereby serving many functions efficiently. Masonry's durability is proven. For so many reasons, structural masonry is the right choice.

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1 The Masonry Standards Joint Committee (MSJC) is the group charged with developing and maintaining the MSJC Code and Specification and is under the sponsorship of The Masonry Society (TMS), the American Concrete Institute (ACI) and the Structural Engineering Institute of the American Society of Civil Engineers (SEI/ASCE).

2 The International Building Code (IBC) is published by the International Code Council (ICC) and is available for adoption and use by jurisdictions internationally. The scope of this code covers all buildings except detached one and two family dwellings and townhouses not more than 3 stories in height.

3 ASTM International, formerly known as the American Society for Testing and Materials (ASTM), is a globally recognized leader in the development and delivery of international voluntary consensus standards. Today, some 12,000 ASTM standards are used around the world to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence.