Most Common Misunderstandings in Masonry

By

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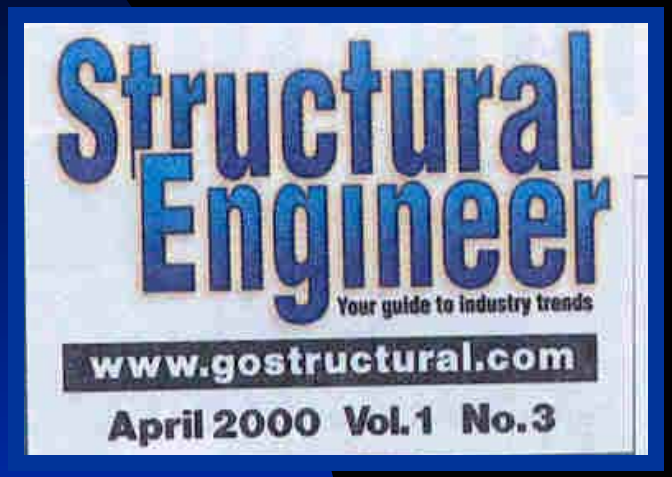
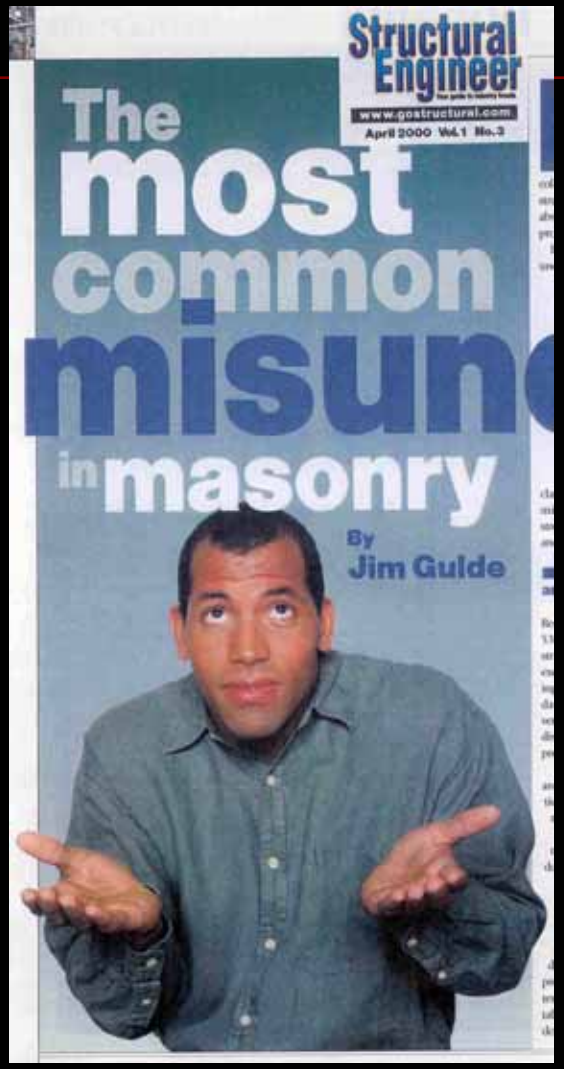
Most Common Misunderstandings in Masonry





Most Common Misunderstandings in Masonry

- Mortar
  - *Weakest is best*
- Grout
  - *Higher slump is a must !*
- Prisms
  - *Often misleading*

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Reference Documents:

MSJC

- **Building Code requirements for Masonry Structures (ACI-530, ASCE-5, TMS-402)**

ASTM's

- **Block- ASTM C-90**
- **Mortar- ASTM C-270, C-780**
- **Grout – ASTM C-476, ASTM C-1019,**
- **Prism – ASTM C-1314**

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Block- ASTM C-90

1900 psi

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MSJC - Table 2

ASTM C-90 Standard Block

High Strength Block

MSJC Specification - Table 2

Net area compressive strength of concrete masonry units, psi (MPa)		Net area compressive strength of masonry units, psi[1] (MPa)
Type M or S mortar	Type N mortar	
1,250 (8.6)	1,300 (9.0)	1,000 (6.9)
1,900 (13.1)	2,150 (14.8)	1,500 (10.3)
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4,800 (33.1)	5,250 (36.2)	3,000 (20.1)

[1] For units of less than 4 in. (102 mm) height, 85 percent of the values listed.

Block Strength

Prism (f'm)

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Lack of coursework in college:

Many college engineering courses don't offer masonry. Since 70 percent of all existing construction in the world includes masonry, this absence of education is a real detriment to the profession and to society. It is not surprising, therefore, that many misunderstandings exist. The main misunderstandings have to do with: codes, mortar strength and testing, grout strength and testing, and the prism test.

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Mortar

Proper proportioning of the mix is the most important factor in making mortar. Large batch to batch variations need to be avoided.

Five questions to evaluating mortar production:

Q. 1- Is it mixed for three to five minutes after all ingredients are introduced?

Q. 2- Is a measuring device evident on the jobsite for checking the volumetric control? (A cubic foot box can be used to calibrate the shovel, and a five gallon pail is equal to 2/3 cubic foot).

Q. 3- Is the sand kept damp and loose?

Q. 4- Is the cement covered and stored off the ground?

Q. 5- Is the water "cool"?

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1.Stronger is not always better.

There is a general perception that stronger is better, but in the case of mortar, *weaker* is better.

The most common mortar types are M, S, and N. The corresponding compressive strengths are: M = 2500 psi, S = 1800 psi, N = 750 psi. In almost all cases, the best mortar is the *weakest* mortar that will adequately do the job. The authority for this statement comes right out of the ASTM C-270. A close look at table X1.1 "Guide for the Selection of Masonry Mortar", clearly shows that the recommended mortar in all cases, except for footnote [c] is the weakest mortar. The stronger mortar is considered the alternate, not the recommended.

Why is this so? It is primarily a matter of bond.

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There are two important elements to bond:

Bond strength and Extent of bond.

The *bond strength* is the force required to separate the I units. The *extent of bond* is the amount of contact the mortar has with the masonry unit.

Interestingly enough, bond strength is adversely affected by compressive strength.

Complete and full contact between the unit and the mortar (good extent of bond) is important for water-tightness and tensile bond strength.

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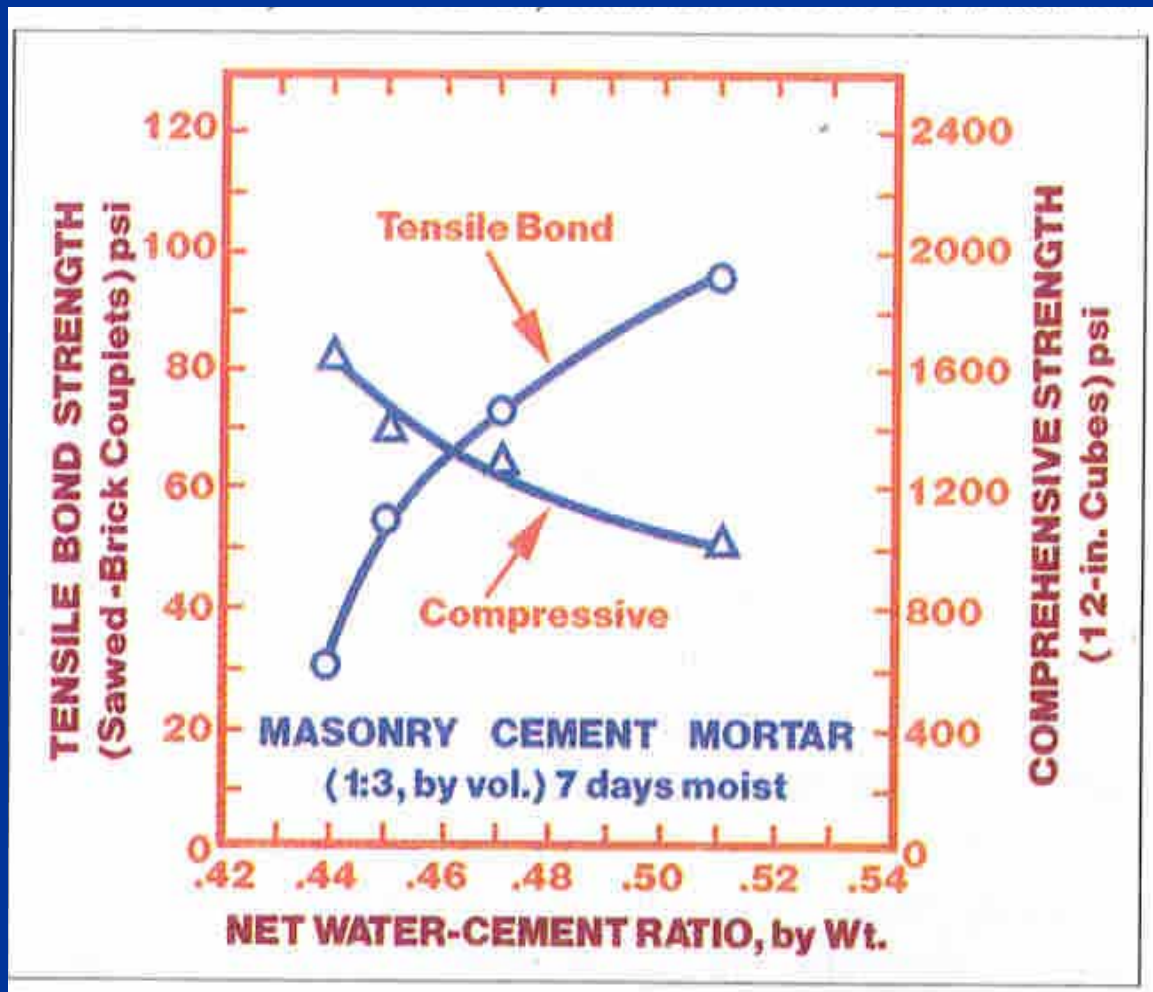
The graph illustrates the relationship between mortar compressive strength and bond strength. As the compressive strength decreases, the bond strength increases. This fact explains why weaker is better and why a lesser strength should be used, if sufficient.



This graph illustrates the relationship between tensile bond and compressive strength. It is taken from NCMA TEK.

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"Specified Strength vs Actual Strength"

Many specifiers don't realize that the field strength, [as determined by *ASTM C*-780**], is not expected to equal the laboratory strength, [**as determined by ASTM C-270**].**

The authors of the ASTM documents have done an excellent job of clarifying this. Both ASTM C-270 3.3 and *ASTM C*-780 1.4 clearly state that the two tests cannot be directly compared.

***ASTM C*-270 is a laboratory procedure used to specify mortar. Specifying ASTM C-270 assures a "good" specification for mortar.**

ASTM C-780 cannot achieve the strength specified by ASTM C-270. The introduction of ASTM C-780 states, "*No* attempt is made to claim or substantiate specific correlations between the measured properties and mortar performance in the masonry.

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“Data from these test methods [ASTM C-780] can be combined with other information to formulate judgments about the quality of masonry."

ASTM C-780, Section 1.4 states, "The test results obtained under this test method are not required to meet the minimum compressive values in accordance with the property specifications in Specification C-270”.

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Compare ASTM C-270, ASTM C-780, and wall in field

To further explain why the test results are not comparable, let's look at the differences between the lab and field tests.

The primary difference between ASTM C-270 and ASIM C-780 is the water content. All of the components of a particular mortar are the same in ASTM C-270 and ASTM C-780 *except the water content*. ASTM C-270 requires that the mortar have a "flow" of 110 +*[or]*- 5%. (ASTM C-270 : -6.41).

However, properly constituted field mortar used in ASTM C-780 may have a flow of over 130 percent as explained in PCA's "Trowel Tips –Field Testing Masonry Mortar."

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Conservative Values ? Yes.

1.Lower water/cement ratio in the field.

The strength test results from ASTM C-780 are actually lower than the actual field strength because the test uses non-absorbent molds, and the masonry units in the wall absorb some moisture in the mortar, thereby lowering the water/cement ratio. This makes the actual field mortar stronger than the test results indicate.

The field test using ASTM C-780 gives a lower compressive strength than the lab test since they both use non-absorbent molds and the lab mortar has a lower water/cement ratio than the test samples for ASTM C-780, which uses field mortar which has a higher water content.

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UBC

It might be noted here, that under the Uniform Building Code there is a method for mortar testing (2105.4) wherein the mortar is spread on the block at the thickness of the mortar joint for one minute and then placed into a mold.

The placing of the mortar on the block for one minute allows moisture to escape by being absorbed into the cmu and lowering the water/cement ratio. This is an attempt to more closely approximate the actual strength of the mortar in the field; however, this method has not found its way into ASTM.

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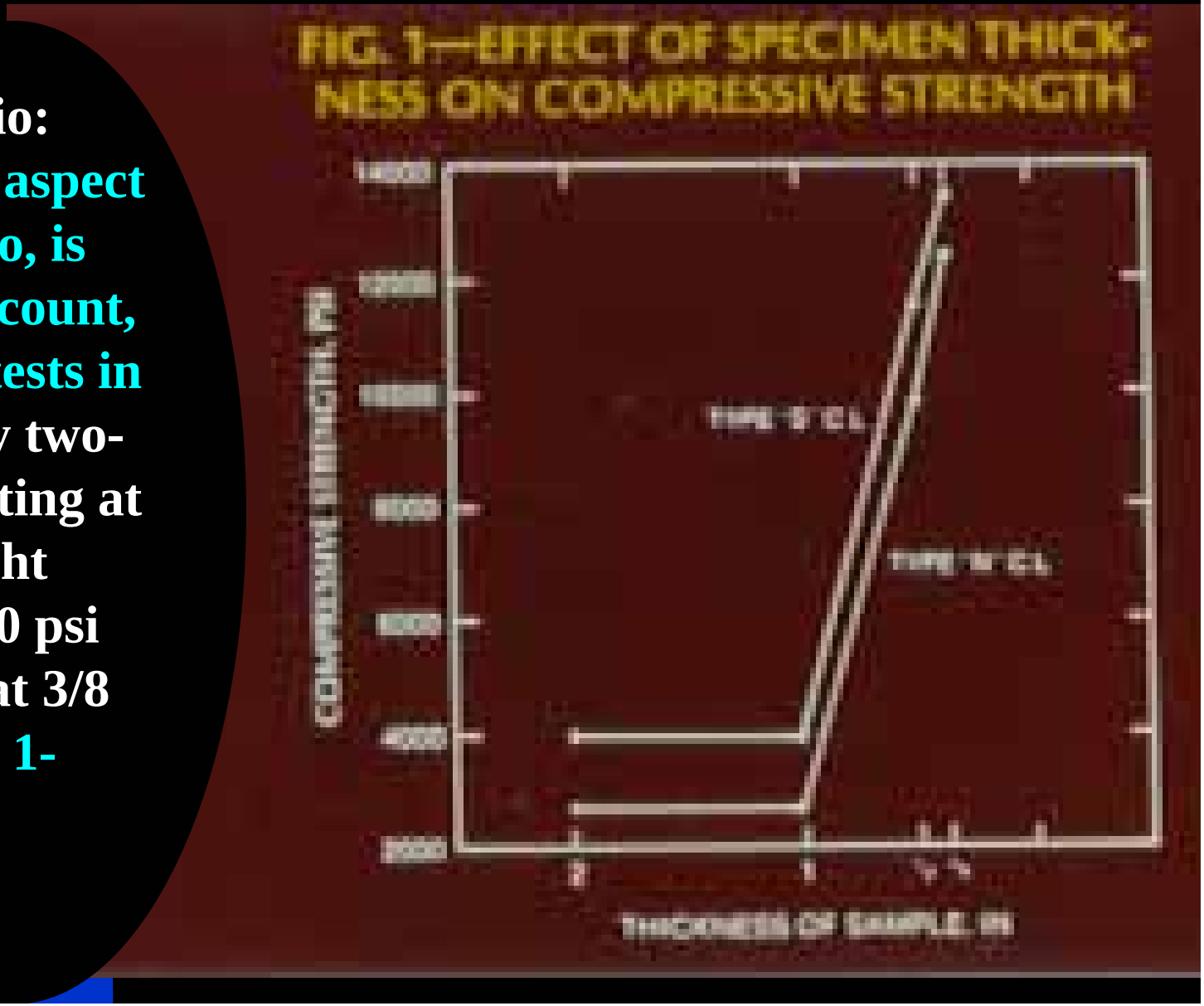
2. Aspect ratio:

When the aspect ratio, h/t ratio, is taken into account, mortar that tests in a two-inch by two-inch cube testing at 2,000 psi might well be 12,000 psi when tested at 3/8 inch thick by 1-1/4" wide.



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Why choose the compressive strength test?

A review of ASTM C-780 reveals that there are eight tests for mortar given in Appendices A1 through A8. The compressive strength test (A7), which is traditionally used to test mortar, will give results in 28 days. What can be done at that point? Waiting 28 days to take corrective action appears to be counter productive.

An excellent and timely way to monitor jobsite mortar is the mortar aggregate ratio test (A4). This test evaluates the ratio of cement to aggregate within hours so corrective action can be taken.

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Summary on mortar

The mortar tested in the field using ASTM C-780 will not have as high a strength as the laboratory design strength by ASTM C-270.

This fact is often misunderstood and can cause difficulties.

Sometimes engineers actually shut down jobsites because they misinterpret the field test results.

Here are the facts:

Mortar should be designed to meet the requirements of ASTM C-270.

Mortar is tested in the field by ASTM C-780.

The field mortar strength test do not have to equal the laboratory mortar strength as developed under ASTM C0270.

The key word in ASTM C-780 is "EVALUATION".

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Grout:

- **Strength – 2000 or f'm**
- **Slump – 8 to 11 inches**
- **Test Procedure for Strength – ASTM C-1019**

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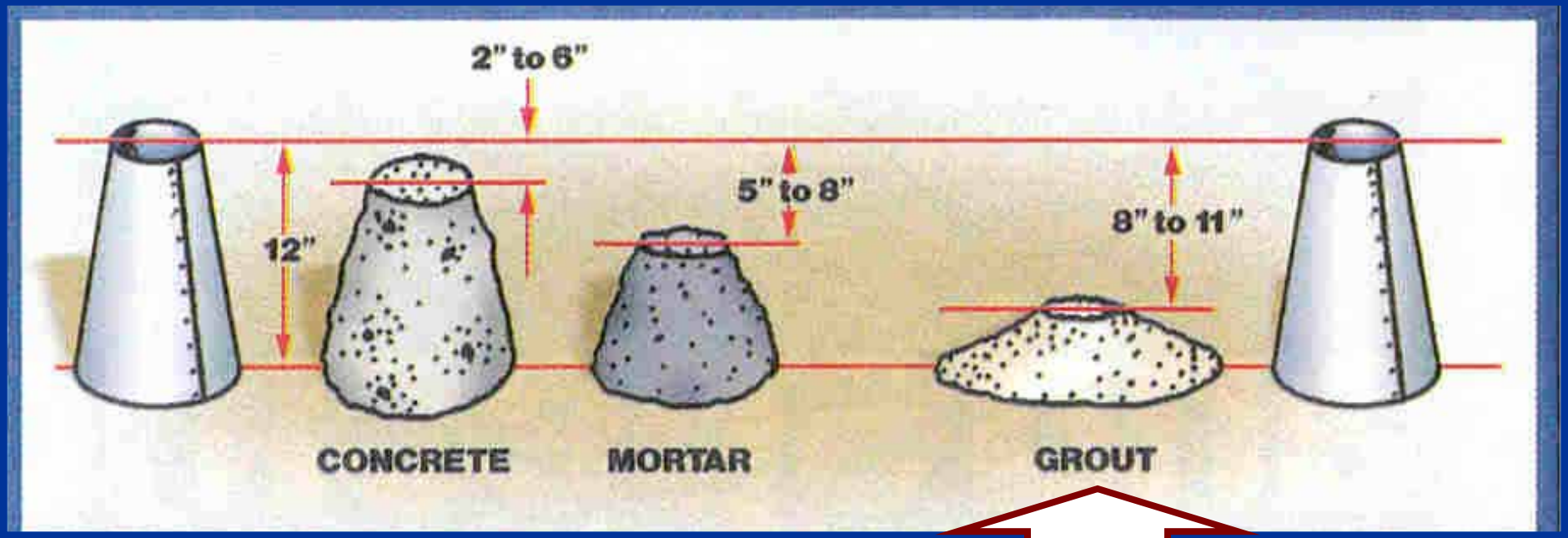
Let's consider Slump:



Grout is
8 to 11 inches

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Mix Design:

The MSJC specification refer to ASTM C-476 for grout provisions. This ASTM standard gives two ways to determine mix design.

Proportions can be taken directly from Table 1 in ASTM C-476 or the compressive strength of grout can be specified. If the strength is specified, the ASTM standard requires the grout compressive strength to equal *f'm* with a lower bound of 2,000 psi.

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Mix Design:

for perspective on Strength: **- Compare this to concrete.**

Concrete requirements generally range from 3,000 psi to 6,000 psi. The reflection here is that the required strength for grout is relatively low – *not high at all* - and should be equivalent to the *f'm*.

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Slump:

The MSJC specification requires , grout to have a slump between 8 and 11inches. It is important that grout be very fluid so that it flows down the cells easily. Investigations of damage from Hurricane Andrew provide ample evidence of the need for fluidity of the mix. For high lift grouting a six-inch slump will bridge Engineering course work usually includes over within two feet of the bond beam and the down cells will not be grouted solid. A slump of 8 to 11 inches is required by code for a good reason – *so that it will flow down the down cells.*

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Testing:

The MS
sample and
1019.

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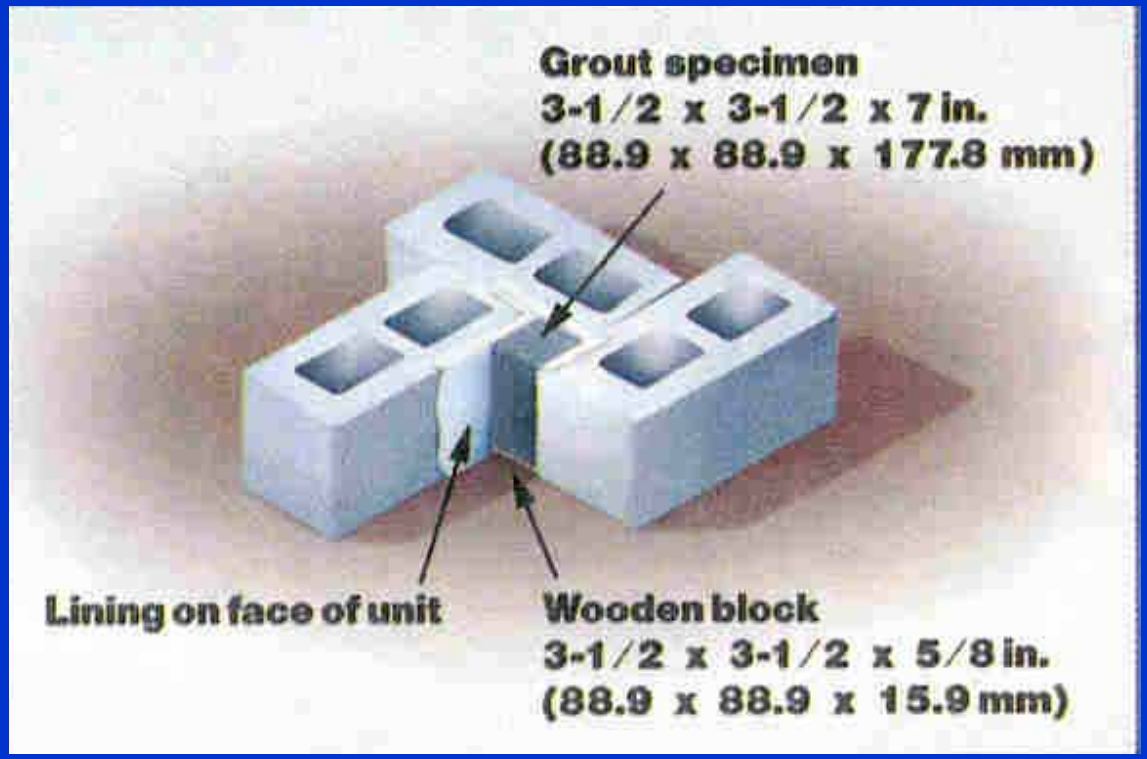
ASTM
sampling a
outlines a similar procedure.



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Summary on grout

Mix design in accordance with ASTM C-476.

Slump shall be 8 to 11 inches. This cannot be compromised.

Strength shall be equal to 2,000 psi or *fm*, whichever is higher.

Testing shall be done in an absorbent mold in accordance with ASTM C-I019.

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Prisms

Engineers and architects specify the field prism test (ASTM C-1314) to confirm the specified compressive strength of masonry (fm).

But is the prism test really necessary?

Let's look at the MSJC Specification, Table 2

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MSJC - Table 2

ASTM C-90 = 1,900 psi.
w/M or S mortar = *f'm* of 1,500 psi.

Block at 2150= w/M mortar= *f'm* of 1,500 psi.

MSJC Specification - Table 2

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[1] For units of less than 4 in. (102 mm) height, 85 percent of the values listed.

Block Strength

Prism (f'm)

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With limited funds for testing, it would be sufficient to test only the block and the mortar.

If the block results are okay, and the mortar aggregate ratio tests on the mortar are satisfactory, then we might consider eliminating the prism test.

----------*just test the block !* ----------

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There are two issues about prism testing that are important to understand.

1. **Cross webs are mortared in the prism test and**
2. **Transportation is a serious concern.**

The prism test can cause ulcers when it isn't done properly.

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Prism Test – *remember:*

1. **Cross webs are mortared Documents:**
1. **Cross webs are mortared in the prism test: Except for a few instances. the webs are not mortared in the field; however, the webs are mortared for the prism test. ASTM C-1314 [5.6] states clearly, "Build masonry prisms with full mortar bed (mortar all webs and face shells of hollow units).**
2. **Transportation: ASTM C-1314 6.1 states that each prism must be strapped or clamped to prevent damage during handling and transportation.**

The prisms must also be secure to prevent jarring, bouncing, or tipping overturning during transportation.

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This requirement must be covered in the pre-bid conference; otherwise, exactly who should take responsibility for the prisms may not be clear.
Who should strap, who should transport?
Is it the duty of the mason contractor, the general contractor, or the testing laboratory to strap the prism?
This task is extremely important since the mortar bed in the prisms can easily rupture and give false results.

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Summary of prism testing:

The prism test does have some problems. If the prism isn't *handled properly* and the assembly breaks in transportation, what value are the results? But if the prism test is required on a project, then:

Accept the fact that the cross webs are to be fully mortared in the prism test.

Handle the prism carefully with special attention to strapping and transportation.

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Summary:

For better masonry construction at reduced cost:

- **Engage a mason contractor in the design and engineering phase of the project.**
- **Conduct a pre-bid conference on masonry to review the highlights of the documents and explain specific responsibilities in detail.**
- **Eliminate or minimize the mortar compressive test; instead, use the mortar aggregate ratio test.**
- **Eliminate or minimize the prism test; instead, test the block and mortar.**

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Jim Gulde *is a former brick and block plant owner, a former director of marketing for a leading masonry supplier, and a past chairman of the board of NCMA. He teaches a workshop on the MSJC code sponsored by the Florida Concrete and Products Association.*

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