team™ TECHNOLOGY BRIEF

AUGUST 2009

RESOURCE INFORMATION FROM THE INTERNATIONAL MASONRY INSTITUTE

Section 2.11.2

MASONRY GROUT

SCOPE

This Technology Brief presents general information on masonry grout, discussing such topics as grout materials, mixes, and admixtures. Knowledge of applicable standards, codes and field practices is required to thoroughly understand masonry grout. The information contained in this guide is intended to further educate the user on grout and grout materials.

INTRODUCTION

Grout is a cementitious material, primarily composed of portland cement, fine aggregate, possibly coarse aggregate and, in some cases, lime. These ingredients are combined with a sufficient amount of water to produce a fluid, flowable mixture.

Grout is neither concrete nor mortar. There are distinct differences in water content and material composition between these materials. Concrete differs from grout in that it contains a much coarser aggregate and a significantly lower water-cement ratio. Concrete is poured with a minimum amount of water into non-absorptive forms. Conversely, grout is poured with a significantly higher water-cement ratio into what are essentially absorptive forms - masonry unit cells or cores. The initially high water-cement ratio of grout is rapidly reduced because the masonry absorbs much of the water.

Mortar, on the other hand, differs from grout in that it often contains hydrated lime, additives, finer aggregates and only enough water to make it workable.

SPECIFYING GROUT

Grout should conform to ASTM C 476, "Standard Specification for Grout for Masonry." The Standard allows grout to be mixed according to the proportions listed (see ASTM C 476 Table 1) or by compressive strength. Research has indicated that grout mixed to the Table 1 proportions may obtain higher compressive strengths than the minimum specified in the property sections of ASTM C 476. Specifying grout by compressive strength may achieve better structural compatibility with the specified masonry units.

TABLE 1 Conventional Grout Proportions by Volume

Type	Parts by Volume of Portland Cement or Blended Cement	Parts by Volume of Hydrated Lime or Lime Putty	Aggregate, Measured in a Damp, Loose Condition	
			Fine	Coarse
Fine grout	1	0–1⁄10	2¼ –3 times the sum of the volumes of the cementitious materials	. . .
Coarse grout	1	0–1⁄10	2¼ –3 times the sum of the volumes of the cementitious materials	1–2 times the sum of the volumes of the cementitious materials

Source Adapted from American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA

TYPES OF GROUT

Grout is classified into two types according to ASTM C 476 - fine grout and coarse grout. Fine grout uses only fine aggregates (natural or manufactured sand) with a maximum aggregate size of 3/8 inches. Coarse grout adds coarse aggregate to the mix (crushed stone or pea gravel) in addition to the fine aggregate. The maximum size aggregate is 1/2 inch. All aggregates, fine or coarse, must conform to ASTM C 404 “Standard Specification for Aggregates for Masonry Grout.” In the ASTM C 476-09 edition of the standard, requirements were also included for Self-consolidating Grout (SCG) in addition to conventional grout. Self-consolidating grout is covered in more detail in a separate Technical Brief.

Pour height and minimum clear grout space dimensions, as well as economics, dictate the choice of fine or coarse grout. There is no significant difference in the compressive strengths that can be attained with either fine or coarse grout. Generally speaking, smaller clear grout space dimensions - spaces not exceeding 2 to 3 inches - or where the minimum clearance between the masonry unit and the reinforcing bar or between reinforcement is only 1/4 inch, call for fine grout. When the grout spaces are larger and the clearance between the reinforcement and the unit is more than 1/2 inch, coarse grout is generally used. Pour height also affects the choice of fine or coarse grout.

WATER CONTENT

High water content is required in grout to provide fluidity and pumpability. Fluidity allows grout to completely fill openings and to encapsulate steel reinforcement. Fluidity of grout is measured by a slump cone test. Grout must contain enough water to produce an 8 inch to 11 inch slump per codes and ASTM C 476. The proper grout slump for the application will depend on several factors such as how much water will be absorbed by the adjacent masonry, weather, lift and pour height. The more water the masonry units absorb from the grout, the more water the grout must contain to remain fluid. When determining the ideal grout slump, consider all of the following factors:

Initial Rate of Absorption (IRA) of Masonry Units - Masonry units with high IRA will absorb more water than units with low IRA. Integral water repellants added to concrete masonry units lower the absorption so grout with slumps on the lower end of the permissible slump range should be considered.

Weather conditions - Masonry walls constructed in hot and arid conditions will absorb water more rapidly than masonry constructed under cold or humid conditions.

Size of grout space - Small, narrow grout spaces have larger surface-to-volume ratios than wider grout spaces and will absorb water at greater rate.

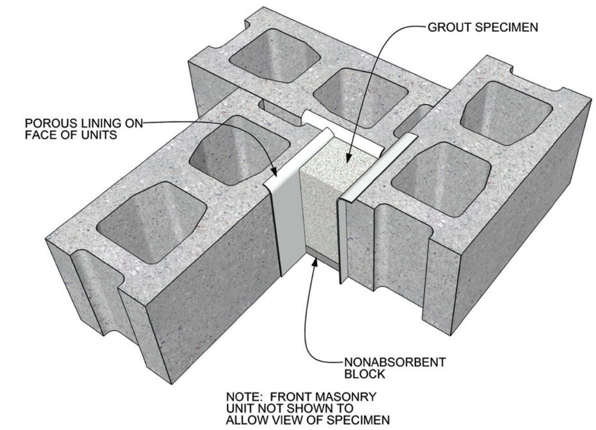
Lift and pour height – The longer the fall of the grout, typically the more fluid the mix needs to be. This must be balanced with the grout clear space and also construction site considerations.

Therefore, grout slump should be adjusted accordingly. In damper climates or when the masonry contains low-absorption units or wider grout spaces or lower lifts, use a grout with an 8 or 9 inch slump. In dryer climates or when the masonry contains high-absorption units or narrower grout spaces, and higher lifts or pours use grout with a 10 or 11 inch slump.

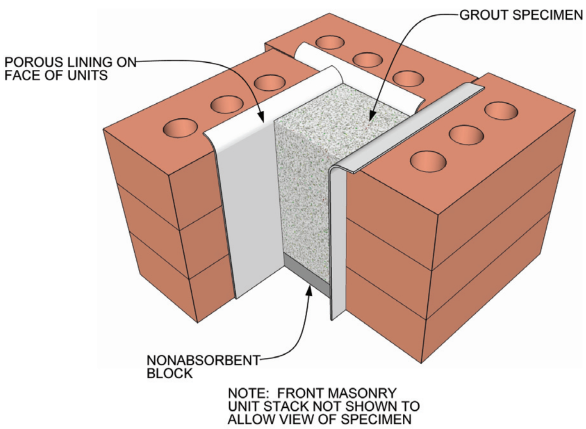
GROUT MIXES

If grout is specified by compressive strength, the contractor should contact an accredited masonry testing laboratory, and in some cases the grout producer, to acquire an appropriate grout mix. The mix design will list mix proportions that meet the specifier’s requirements. Though grout is specified by proportion, test laboratories and ready-mix suppliers batch grout materials by weight. If required, volume proportions can be converted to equivalent weight proportions. Once the grout mix has been determined and approved by the specifier, the contractor has the option of either mixing the grout on site or ordering the mix from an experienced supplier. Onsite mixing procedures for grout are described in ASTM C 476 and in building codes.

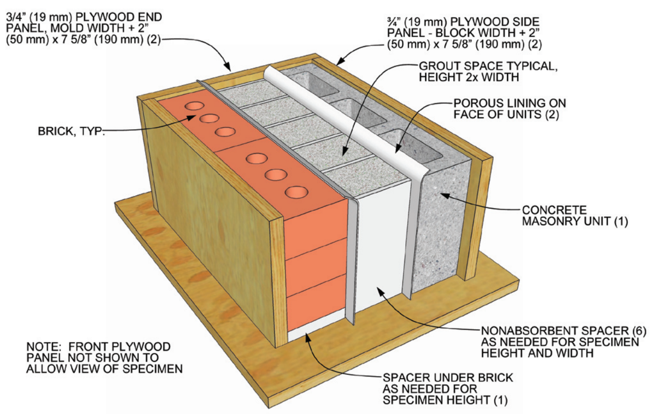
Self-consolidating grout, a highly fluid and stable grout that typically includes admixtures to increase fluidity, but remains homogeneous when placed and does not require puddling or vibration for consolidation is permitted by the IBC 2009 Building code and the 2008 Building Code Requirements for Masonry Structures TMS 402-09/ACI 530-08/ASCE 5-08 – often called the MSJC. Jobsite proportioning of self-consolidating grout is not permitted. Given the increased flowability of SCG, the slump cone test is replaced by a slump flow test and visual stability index using ASTM C 1161. Self-consolidating grout must also meet specified compressive strength per ASTM C 1019.



MOLD FOR UNITS OVER 6” IN HEIGHT



MOLD FOR UNITS 6” OR LESS IN HEIGHT



MOLD FOR COMBINATIONS OF UNITS

FIGURE 1 GROUT MOLD CONFIGURATIONS

GROUT TESTING

To ensure consistency of grout strength, field samples should be tested periodically in accordance with ASTM Standard C 1019. This standard requires testing of field samples constructed from a mold consisting of the masonry units proposed for construction. (See Figure 1). Typically called a “pinwheel”, molding the grout sample with masonry units simulates the water absorption from the grout that will take place in an actual wall.

Plastic, cardboard or metal molds should not be used for conformance testing because the molds are not absorptive nor approved for this use in the ASTM standard. These alternative methods of forming the grout specimens are only permitted to be used with the approval of the specifier and such approval must be based on comparative testing to the masonry unit “pinwheel” molds described above. The most common use of the alternative method is for field consistency testing of the grout.

ASTM C 1019 is specific in the methods for constructing, curing and testing masonry grout samples. It is critical that the procedures in the Standard be followed to attain accurate results. Whoever produces the samples, either the mason contractor or the testing lab, must make sure they are formed and site-cured according to the Standard and placed in an area where they can remain undisturbed and not exposed to excessive heat or cold.

Several other factors can impact the test results:

- not retrieving the test sample from the jobsite within the specified time
- not properly curing or capping the specimens
- having testing machines with platens not rigid enough to spread the load evenly to the entire sample
- Improper specimen construction such as non-parrallel sides, bottom or top surfaces that are skewed or faults within the specimen itself.

While this list is not comprehensive, it does include many of the most common testing errors that result in erroneous test values. It is imperative that the testing laboratory understands the ASTM C 1019 procedures and follows them.

GROUT ADMIXTURES

Grout admixtures should not be used unless specified in the contract documents. Some common grout admixtures are:

Superplasticizers - Substituting superplasticizers for a portion of water in a grout mix can provide additional fluidity while maintaining a low water-cement ratio, ensuring high compressive strengths. Superplasticizers can be used when grouting masonry assemblies with very low absorption rates.

Anti-Shrinking Agents - These admixtures counter grout's tendency to shrink as water is absorbed from it. Anti-shrinking agents act as an expanding agent and are typically combined with other commonly used plasticizers.

Accelerators - Adding accelerators to grout will hasten grout set time during cold weather, minimizing the amount of time the wall must be protected from freezing. Accelerators containing calcium chloride should not be used in grout that will be in contact with reinforcing steel or any other embedded steel items.

Retarders - Adding retarders to grout will delay grout set time during hot weather construction. Retarders help extend grout fluidity keeping it workable long enough to be placed properly and consolidated sufficiently.

Fly Ash - Fly ash is a pozzolanic material produced from coal and man ufacturing by-products. A cementitious material that can be more economical than portland cement, fly ash can be added to a grout mixture as a partial substitute for portland cement or lime. Also, fly ash helps grout maintain a given slump and improves grout pumpability. Note that the strength gain of the grout may be slower with fly ash than with portland cement and this must be factored into construction sequencing. However, it is important to be familiar with the specific fly ash product being used as in a few cases, compressive strength gain may actually be accelerated.

MASONRY SUSTAINABLE DESIGN

Fly ash is a mineral by-product of coal combustion that is often used to supplement the portland cement in masonry grout. As such it can contribute toward LEED Materials and Resources points for use of recycled materials. It may be called for specifically as part of the grout mix or included in a blended cement. ASTM C 476 permits the use of cement meeting ASTM C 595, Standard Specification for Blended Hydraulic Cements, which allows 15 to 40 percent fly ash by weight of portland cement as a cement replacement. This means fly ash can be substituted for portland cement up to these limits per ASTM C 476.

Besides adding strength, the fine spherical particles of fly ash enhance the important grout properties of flow and pumpability. Grout containing fly ash generally reaches at least a similar compressive strength as grout with just portland cement. However, most fly ash grout develops compressive strength slower. Therefore, this should be investigated in situations where the early strength of a grouted wall is critical, such as when setting planks or floor joists on newly-built masonry or when building in cold weather conditions.

Currently two types of fly ash, Class C and Class F, are used in masonry grout. The designations result from the coal source. Class C fly ashes are typically found west of the Mississippi and Class F east of the Mississippi. Class C has some cementitous properties when used alone but Class F needs portland cement or calcium hydroxide resulting from hydrating cement to kick off its reaction. Usually this means that Class C fly ash hydrates faster and may have more early strength. This underscores why it is important to know the products available in the project area.