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Masonry Handbook

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The essential symbol of Italcementi innovation and quality, the spiral logo is shown in the key color specific to each product's performance.

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Describes the performance of products in that category. In this case, products for standard use. The prefix "i" stands for Innovation and Italcementi.

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Identifies the specific formulation of that particular product.

To see which Family of Performance each product belongs to, visit us at www.essroc.com/inova

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FFF-8X-6.13

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Product Name	Description	Type I, IA, II, I/II, III	Availability (See Map)
Saylor's	Portland Cement	94 lbs 43 kg	

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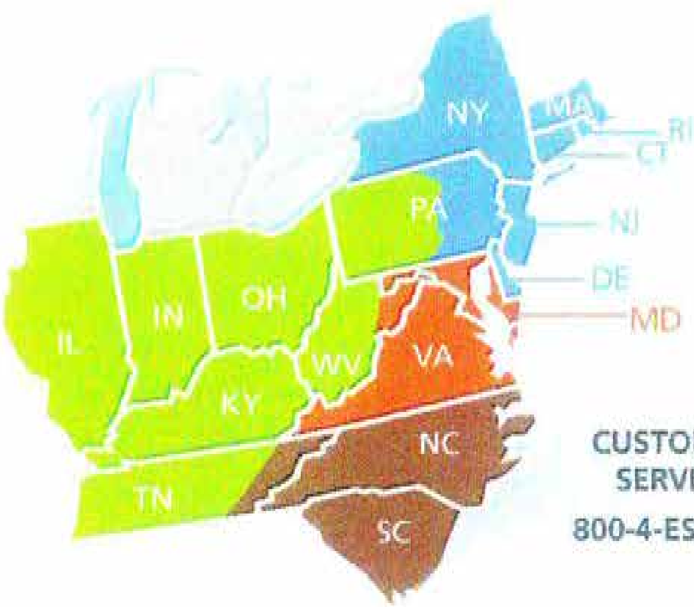
Product Name	Description	Type N	Type S	Type M	Availability (See Map)
BRIXMENT	Masonry Cement	70 lbs 32 kg	75 lbs 34 kg	80 lbs 36 kg	
VELVET	Masonry Cement	70 lbs 32 kg	75 lbs 34 kg	80 lbs 36 kg	
BRICK-LOK	Masonry Cement	70 lbs 32 kg	75 lbs 34 kg	80 lbs 36 kg	
Saylor's P.L.U.S.	Portland & Lime Mix	70 lbs 32 kg	75 lbs 34 kg		

i.tech

Product Name	Description	Type N	Type S	Availability (See Map)
Saylor's	Mortar Cement with Easy-Spred	60 lbs 27 kg	65 lbs 29 kg	
BRIXMENT	Mortar Cement	70 lbs 32 kg	75 lbs 34 kg	
STONE-HOLD	Cement for Stonework		75 lbs 34 kg	

i.design

Product Name	Description	Type N	Type S	Availability (See Map)
flamingo-BRIXMENT	Masonry Cement	70 lbs 32 kg	75 lbs 34 kg	
flamingo-BRIXMENT	Portland & Lime Mix	70 lbs 32 kg	75 lbs 34 kg	
flamingo-BRIXMENT	Mortar Cement with Easy-Spred	60 lbs 27 kg	65 lbs 29 kg	



CUSTOMER SERVICE

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For more information, MSDS's, and product data sheets, visit **www.essroc.com**.

For more information on the Families of Performance, visit **www.essroc.com/inova**.

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i.pro BRIXMENT
Masonry Cement

PRODUCT DESCRIPTION:
i.pro BRIXMENT Masonry Cement is a prepackaged masonry cement meeting or exceeding the requirements of CSA A3002, Masonry and Mortar Cement. Essroc carefully selects and blends the raw materials and follows stringent quality control procedures in the manufacturing of i.pro BRIXMENT. This attention to detail results in a superior performing masonry cement for use in mortar during construction and for long lasting, water-resistant walls.

BENEFITS:
- Excellent workability
- Superior board life
- Consistent color
- Long-term durability

APPLICATIONS:
i.pro BRIXMENT Masonry Cement can be used for mortar in the construction of all types of masonry walls. The most common masonry units utilized are concrete block, clay and concrete brick and natural and manufactured stone. i.pro BRIXMENT can also be used for stucco and parging applications.

TYPES AND USES:
i.pro BRIXMENT is manufactured in two types: Type N and Type S. CSA A179 Annex A.1 states that Type N is suitable for general use in exposed masonry above grade. Type S is recommended when high lateral strength is desired and can also be used for below grade applications. CSA A179 Table A.1 provides recommendations for mortars.

Location	Building Segment	Recommended Mortar	Alternative Mortar
Exterior above grade	Loadbearing walls requiring high compressive strength	Type S	Type N
	Loadbearing walls requiring low compressive strength	Type N	Type S
	Nonloadbearing walls	Type N	Type S
	Parapet walls	Type N	Type S
Exterior at or below grade	Foundation walls, retaining walls, manholes, sewers, pavements, walks and patios	Type S	Type M
Interior	Loadbearing walls	Type N	Type N
	Nonloadbearing partitions	Type N	Type N

From CSA A179 Table A.1

PACKAGING:

i.pro BRIXMENT Type N is packaged in 30 kg multi-walled bags and Type S is packaged in 33.3 kg multi-walled bags. Packages should be kept free from moisture.

AVAILABILITY & PRICING:

Contact your Essroc Sales Representative for availability and pricing in your area.

APPLICABLE STANDARDS:

i.pro BRIXMENT conforms to the requirements of CSA A3002, Masonry and Mortar Cement.

MIXING:

Assure that the mixing equipment is clean and in good working order. Provide a one cubic foot box or other suitable container for volumetric measuring of aggregate. Aggregate shall conform to the requirements of CSA A179. Water shall be potable. i.pro BRIXMENT should be mixed with 2 ¼ to 3 cubic feet of sand according to Table 4 of CSA A179. Start the mixer, place ½ of the required amount of water, ½ the required amount of sand and all the i.pro BRIXMENT into the mixer. Mix briefly. Add the remaining sand and water to the mixer and mix for a minimum of 3 and a maximum of 5 minutes after the last mix water has been added. This assures homogeneity and workability of the mortar. Although minor retempering is allowed, mortar should be used or discarded after 90 minutes.

WORKMANSHIP:

Set masonry units in mortar beds as quickly as possible after the mortar bed is placed. Avoid furrowing bed joints. Provide enough mortar to guarantee full head and bed joints. Don't attempt to move or adjust masonry units once the mortar has begun to stiffen. This can interfere with the bond between the mortar and the masonry unit. If one or more masonry units needs to be adjusted, remove the units and reset them in fresh mortar.

TOOLING JOINTS:

Mortar joints should be tooled when the surface is 'thumb-print' hard. Proper tooling increases the contact area between the masonry unit and mortar and provides for a weather-resistant joint. Improper or inconsistent timing when tooling joints lead to variation in the colored of the mortar joint and could adversely affect weather resistance.

PRECAUTIONS:

Minimize direct contact with wet cement. Exposure of sufficient duration to wet portland cement can cause serious, potentially irreversible tissue (skin or eye) destruction in the form of chemical (caustic) burns. Consult the relevant MSDS before working with i.pro BRIXMENT.

WARRANTY:

Essroc warrants that its products are free from manufacturing defects and conform to applicable CSA standards. Essroc makes no warranty or guarantee, express or implied, including warranties of fitness for a particular purpose or merchantability, respecting its products. User assumes all risks and liability in connection with the suitability of the products for the intended use.

FOR MORE INFORMATION:

For more information on Essroc's products call 800-4-ESSROC or visit us online at www.essroc.com.

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www.essroc.com

July 2013

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i.tech STONE-HOLD
Cement for Stone Work

i.tech
STONE-HOLD

PRODUCT DESCRIPTION:
i.tech STONE-HOLD cement, when used in the recommended formulations, is an excellent choice for today's stone construction applications. It provides optimal bond strength while maintaining excellent workability. This proprietary formulation also improves resistance to cracking during freeze/thaw cycles.

BENEFITS:
- Excellent durability.
- Superior strength and adhesion.
- Consistent workability.
- Compatible with natural and manufactured stone for exterior or interior applications.

APPLICATIONS:
i.tech STONE-HOLD cement is specially formulated for mortar and grouting with natural and manufactured stone.

AVAILABILITY & PRICING:
Contact your Essroc Sales Representative for availability and pricing in your area.

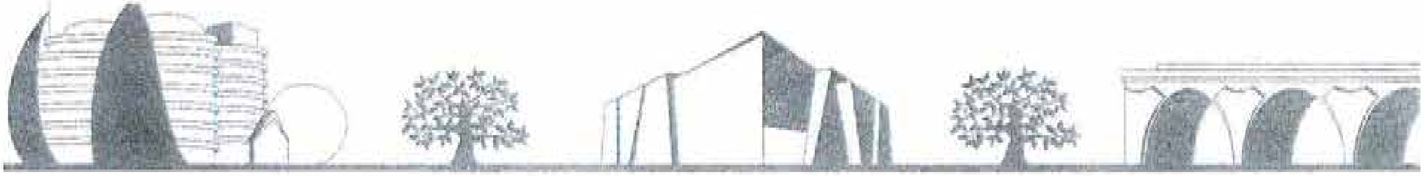
TYPES AND USES:
Based on application experience, for every 100 square feet of stone surface, you will need an estimated three bags of i.tech STONE-HOLD cement. Using the following recommended formulations will reduce shrinkage cracks, and improve overall performance.

Mortar for Wall and Stone Surface

Parts by Volume
i.tech STONE-HOLD **1 Part**
Masonry Sand **2¼ Parts**

Grout Proportions for Stone Work

Parts by Volume
i.tech STONE-HOLD or i.design flamingo-BRIXMENT **1 Part**
Masonry Sand **3 Parts**



PACKAGING:

i.tech STONE-HOLD is packaged in 75 lbs. (34 kg) multi-walled bags. Packages should be kept free from moisture.

APPLICABLE STANDARDS:

i.tech STONE-HOLD conforms to the requirements of ASTM C 1329, Standard Specification for Mortar Cement and ASTM C 91, Standard Specification for Masonry Cement. i.tech STONE-HOLD cement for stone work should be used in accordance with local building codes. Consult all instructions and requirements provided by the stone manufacturer prior to installation.

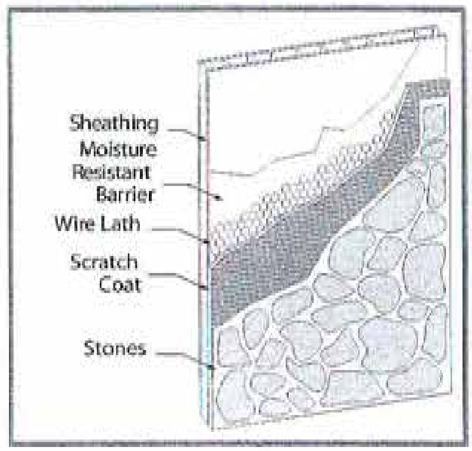
MIXING:

Assure that the mixing equipment is clean and in good working order. Provide a one cubic foot box or other suitable container for volumetric measuring of aggregate. Aggregate shall conform to the requirements of ASTM C 144. Water shall be potable. i.tech STONE-HOLD should be mixed with 2 ¼ to 3 cubic feet of sand according to Table 1 Proportion Specification of ASTM C 270. Start the mixer, place ¾ of the required amount of water, ½ the required amount of sand and all the i.tech STONE-HOLD into the mixer. Mix briefly. Add the remaining sand and water to the mixer and mix for a minimum of 3 and a maximum of 5 minutes after the last mix water has been added. This assures homogeneity and workability of the mortar. Although minor retempering is allowed, mortar should be used or discarded after 90 minutes.

STONE INSTALLATION:

IMPORTANT: First consult the stone manufacturer's instructions.

Properly prepare surfaces. Apply ½ inch of mortar over concrete masonry unit (CMU) wall, sheathing or rigid insulation (see diagram right). Apply ¾ inch of mortar to the back of each stone unit. Cover back completely. Press coated unit firmly on wall. Some mortar should be squeezed out around the stones' edges. Ensure complete coverage between vertical surface and back surface of the stone.



FINISHING JOINTS:

Use a grout bag to fill in joints. Avoid smearing on stone. Accidental smears should be removed only when dry. Use a dry brush. Finish joints when surface is 'thumb-print' hard with a metal or brush tool.

PRECAUTIONS:

Minimize direct contact with wet cement. Exposure of sufficient duration to wet portland cement can cause serious, potentially irreversible tissue (skin or eye) destruction in the form of chemical (caustic) burns. Consult the relevant MSDS before working with i.tech STONE-HOLD.

WARRANTY:

Essroc warrants that its products are free from manufacturing defects and conform to applicable ASTM standards. Essroc makes no warranty or guarantee, express or implied, including warranties of fitness for a particular purpose or merchantability, respecting its products. User assumes all risks and liability in connection with the suitability of the products for the intended use.

FOR MORE INFORMATION:

For more information on Essroc's products call 800-4-ESSROC or visit us online at www.essroc.com.

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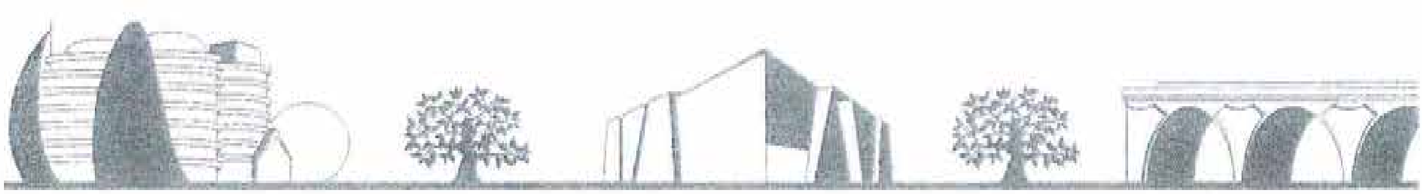
July 2013



ESTIMATING

ESTIMATING QUANTITIES

BLOCK 2-1/4 BAGS BRIXMENT PER 100 BLOCK (40 BLOCK PER BAG)
800 LB. OF SAND PER 100 BLOCK
1.125 BLOCK PER SQ. FT. OF WALL AREA
75% OF LENGTH OF WALL GIVES NUMBER OF BLOCK PER COURSE
TAKE HEIGHT OF WALL (IN FEET) TIMES 1.5 FOR NUMBER OF COURSES

BRICK APPROX. 7 BAGS OF BRIXMENT PER 1000 BRICK (143 BRICK PER BAG)
APPROX. 1 TON SAND PER 1000 BRICK
FIGURE BRICK 7 PER SQ. FT. OF WALL AREA (ALLOWS FOR WASTE)
1-1/2 BRICK PER RUNNING FOOT OF WALL
4.625 COURSES OF BRICK PER FOOT OF WALL HEIGHT
5 BRICK PER SQ. FT. FOR PAVING, HEARTHS (LAID FLAT-SOLID BRICK)

CEMENT PLASTER
1/4" THICK (100 SQ. FT.) 220 LBS. SAND, .8 BAG BRIXMENT
3/8" THICK (100 SQ. FT.) 330 LBS. SAND, 1.2 BAG BRIXMENT
1/2" THICK (100 SQ. FT.) 440 LBS. SAND, 1.6 BAG BRIXMENT

CONCRETE
3 1/2-2 1/2-MIX-2000 LBS. GRAVEL, 1250 LBS. SAND, 6 BAGS CEMENT

FIRE CLAY
2 PARTS FIRE CLAY, 3 PARTS CEMENT

FILLING BLOCK
CORES WITH CONCRETE;
12" BLOCK-1.64 CU. YD. PER 100 BLOCK (APPROX.)
8" BLOCK-.93 CU. YD. PER 100 BLOCK (APPROX.)

MORTAR
MIX 1 PART BRIXMENT TO 2 1/4 TO 3 PARTS SAND

CONCRETE
APPROX. 100 LBS. GRAVEL PER RUNNING FOOT OF GRAVEL

SAND-GRAVEL APPROX. 3000 LB. PER CU. YD. (# YDS. TIMES 1.5 FOR TONS)
APPROX. 110 LB. PER CU. FT. (27 CU. FT. IN CU. YD.)

Grout Fill Estimate for Block

Rule of Thumb

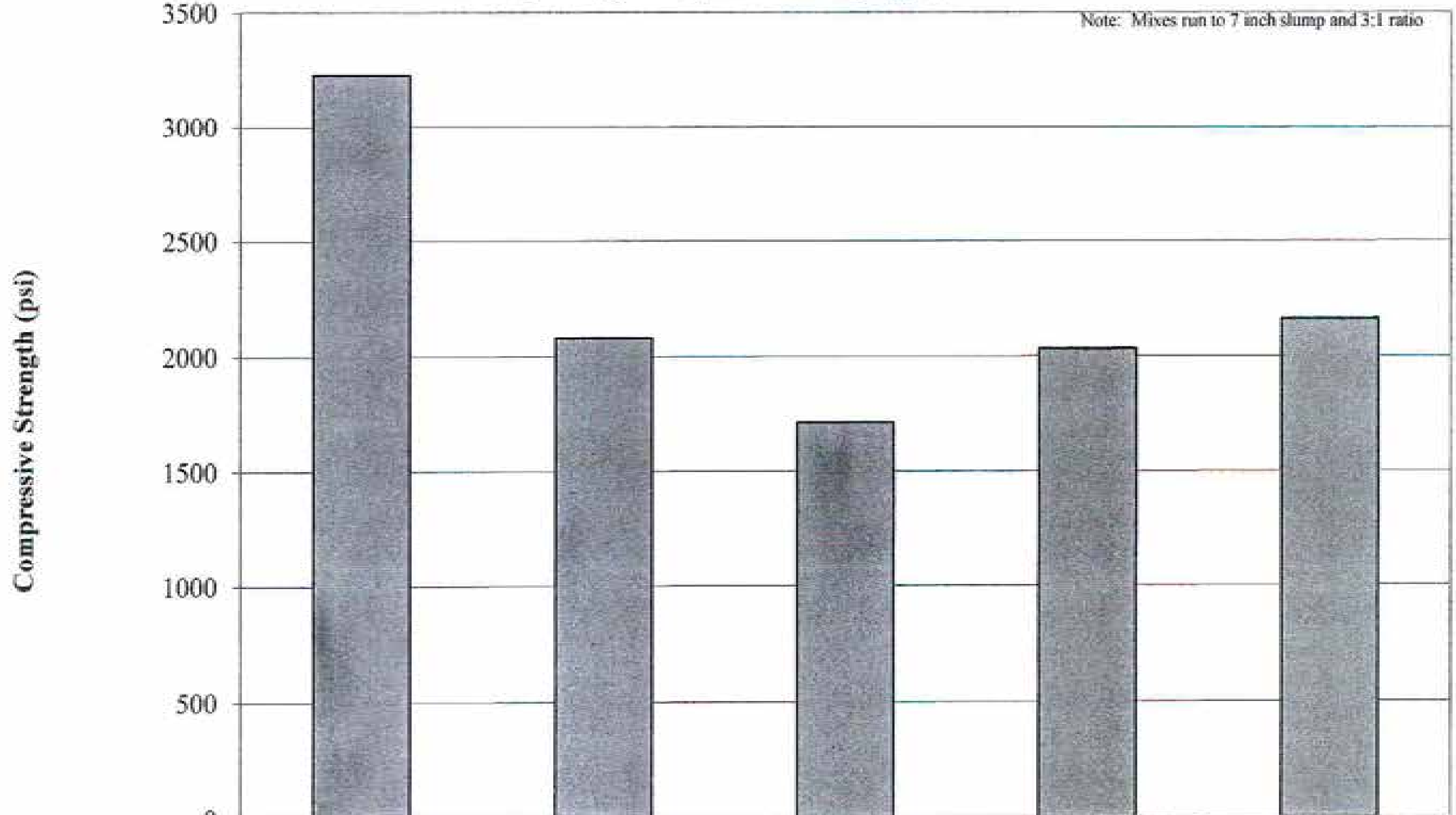
Block per Bag of Mortar

6" Block = 17

8" Block = 12

10" Block = 9

12" Block = 7



	Type I	Brixment Type M	Brixment Type S	Saylor's Plus Type S	Saylor's Plus Type N
28 Day Average (psi)	3226	2082	1714	2032	2162

TECHNICAL DATA

Do's & Don'ts of Proper Masonry Workmanship

1. **Do** use clean, potable water...**Don't** use water from a dirty, rusty drum.
2. **Do** use the same sand from start to finish of brick job...**Don't** change sand source in middle of job.
3. **Do** use cool water & damp sand in summer conditions...**Don't** use dry sand & hot water.
4. **Do** mix the mortar in a mortar mixer for 3 – 5 minutes from the time all ingredients has been added to mixer...**Don't** let the sand cake on the side of the mixer.
5. **Do** use the mortar within 2 ½ hours of mixing...**Don't** mix a batch of mortar and then take a lunch break!
6. **Do** have full head joints and full bed joints to create a good bond & water resistant wall...**Don't** forget the 3/8" mortar joint should be consistent through the entire job.
7. **Do** keep the 1" cavity clear from mortar...**Don't** allow mortar drippings to clog and bridge air cavity.
8. **Do** use wall ties, proper flashing, and weep holes...**Don't** forget to pay attention to the total wall system.
9. **Do** use a concave jointer to tool the mortar joint for proper bond & weather resistant...**Don't** just brush the joints.
10. **Do** saturate the wall well before cleaning...**Don't** forget to rinse the wall well after cleaning.
11. **Do** remember "less is better" when cleaning a brick wall...**Don't** over use cleaning solutions.
12. **Do** call Tom Slosser 330-550-8617 at ESSROC Cement Corporation if you have any questions or concerns...**Don't** hesitate to call!

"Take it to the Wall"™

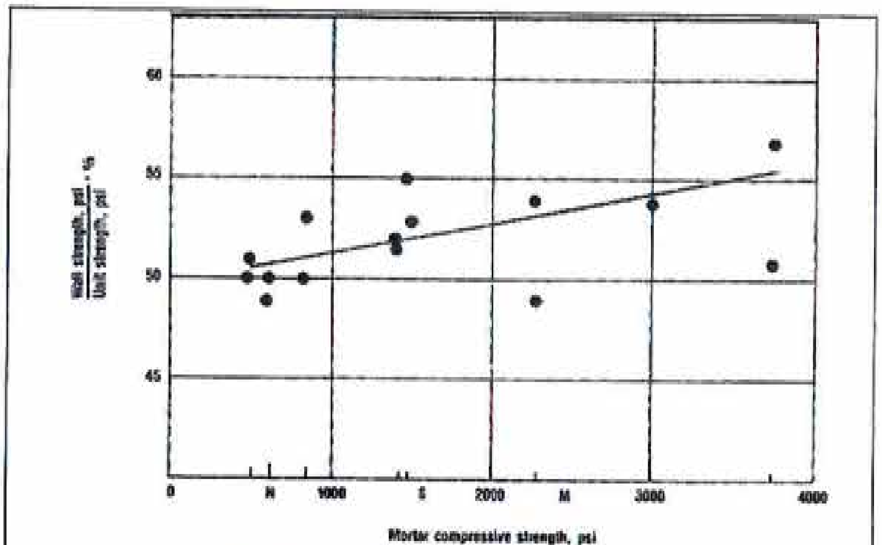
Stronger isn't always better

Specify the weakest adequate mortar

By Bruce A. Suprenant

We tend to think that stronger is better. This doesn't apply when selecting mortar, though. Specifying a high-compressive-strength mortar doesn't guarantee a high-strength wall. It does increase mortar cost (due to higher cement content), increase labor cost (due to decreased mortar workability), and can cause more cracking.

Many architects specify Type M mortar, with a minimum average compressive strength at 28 days of 2500 psi (for laboratory-prepared mortar specified by properties). But ASTM C 270 recommends weaker mortars—Types S (1800 psi), N (750 psi), and O (350 psi)—as the architect's first choice (Ref. 1).



Source: Adapted from "Compressive Strength of Concrete Masonry," NCMA Tek 15, National Concrete Masonry Association, P.O. Box 781, Herndon, VA 22070.

Figure 1. Compressive strength tests on hollow block prisms show how little the mortar compressive strength affects wall strength. For example, a 200% increase in mortar strength (from 1000 psi to 2000 psi) provides less than a 5% increase in wall strength.

Higher cost

The compressive strength of a wall can be an important load-carrying characteristic of masonry, but how much of that total wall strength can be attributed to mortar? Tests on hollow block masonry prisms show that as the mortar strength and cement content increase, the block masonry increases in compressive strength, but only slightly (Figure 1). The cost of the mortar, however, increases much more. In Colorado, for example, going up a mortar type increases the cost of a bag of masonry cement or preblended portland

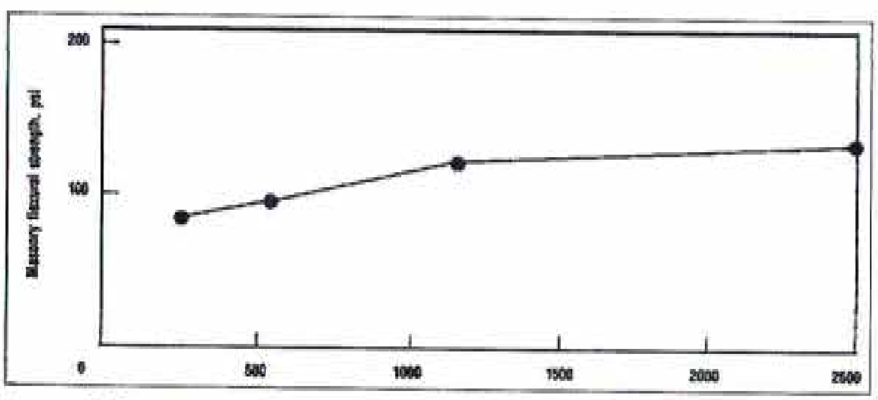


Figure 2. For unreinforced masonry, flexural strength usually is more critical than compressive strength. Tests on brick walls show that mortar compressive strength (or mortar type) has little effect on flexural strength.

SELECTING MASONRY MORTAR

Location	Building Segment	Mortar Type: Recommended	Mortar Type: Alternative
Exterior, above grade	load-bearing wall	N	S or M
	nonload-bearing wall	O[1]	N or S
	parapet wall	N	S
Exterior, at or below grade	foundation wall, retaining wall, manholes, sewers, pavements, walks, and patios	S[2]	M or N[2]
Interior	load-bearing wall	N	S or M
	nonload-bearing partitions	O	N

[1] Type O mortar is recommended where masonry is unlikely to be frozen when saturated, or unlikely to be subjected to high winds or other significant lateral loads. Types N or S mortar should be used in other cases.

[2] Exterior horizontal masonry surfaces are extremely vulnerable to weathering. Select mortar for such masonry with due caution.

Source: Adapted from Ref. 1.

cement-lime mortar by an average of 10%.

More cracking

Mortar type also can affect the amount of cracking within a wall because mortar restrains the masonry units as they shrink or expand. A hardened mortar with low stiffness (low modulus of elasticity) can accommodate larger deformations and more shrinkage without cracking. Test results show that walls with Type O mortar accommodate about twice as much shrinkage without cracking as walls with Type M mortar (Ref. 2).

Choosing a mortar

For unreinforced masonry, the wall's compressive strength usually isn't important. Typically, lateral loading requires the flexural or bending strength to control the wall's design. The masonry's modulus of rupture provides an indication of the wall's flexural strength and, like wall compressive strength, is not very dependent on mortar compressive strength (Figure 2). In fact, test results indicate that to obtain high resistance to lateral loading, the mortar type is not as important as the plasticity of the mortar (Ref. 2). A workable, cohesive, plastic mortar ensures a good bond between masonry units and is the most important requirement for flexural strength.

How should you choose a mortar, then? For unreinforced walls, bond strength is more important than compressive strength. Choose a mortar that develops a workable, cohesive plastic mix suited for the masonry units on the job. Masonry units with high suction may require a different mortar than units with low suction. The table, from the appendix of ASTM C 270, gives some guidelines on mortar selection.

Remember, avoid the idea that stronger is better. Instead specify the lowest strength mortar that meets structural requirements. Follow the guidelines in the table for mortar selection but resist the temptation to be conservative—don't specify a higher strength mortar than is necessary.

References

1. Appendix to ASTM C 270, "Standard Specification for Mortar for Unit Masonry," ASTM, 1916 Race St., Philadelphia, PA 19103.

2. "Compressive, Transverse, and Racking Strength Test of 4-inch Brick Walls," Research Report Number 9 of the Structural Clay Products Research Foundation, 1965, Geneva, IL.

Editor's note

For more information about choosing a mortar, see "How to specify mortar," pages 22-26, The Magazine of Masonry Construction, April 1988.

Bruce Suprenant is a consulting engineer, an Adjunct Associate Professor at the University of Colorado at Boulder, and a contributing writer to this magazine.

Mortar for Brickwork

Type N mortar is the best mortar for almost all brick in non-load bearing applications. Type S would be used only where extra strength is required for load bearing or structural applications.

The combination of Type S mortar and brick can have a very negative effect on the performance of the masonry. While increasing the load carrying capacity of the masonry, the joints are likely to allow more water penetration than with Type N mortar. In order for Type S to develop more compressive strength, the Portland cement content is increased at the expense water retention capability. Without increased water retention the mortar will produce undesirable qualities. The strong absorption of brick can dry out the mortar so fast that it will not bond properly to the brick, the masons will not be able to lay the brick properly, the mortar will not cure properly, and proper tooling will be challenging, leading to a higher probability of water penetration. It is also more likely that the appearance of the wall will be affected by uneven coloration of the mortar.

The high cement content of Type S also leads to shrinkage of the mortar while curing. This contributes to water penetration.

There is seldom any reason to use Type S mortar in brick veneer applications. Although Type S develops higher compressive strengths than Type N, brick veneer can support itself hundreds of feet high with Type N mortar. When high flexural strength of brick veneer is desired, such as with metal stud backup in high-rise construction, it is still better to use Type N than Type S because of the potential curing and shrinkage problems associated with Type S.

Type N mortar actually bonds better to brick than Type S. It can be detrimental to use Type S mortar with brick, as pointed out above.

Efflorescence

Efflorescence is a crystaline deposit on surfaces of masonry, stucco or concrete. It is whitish in appearance, and is sometimes referred to as "whiskers". Efflorescence has been a problem for many years, and is a topic of much controversy. The formation of these salt deposits are not mysteries. They are, for the most part, water-soluble salts that come from many possible sources to mar and detract from an otherwise beautiful and serviceable structure. First of all, there must be water present to dissolve and transport the salts. Groundwater is often a source of efflorescence. For water to carry or move the salts to the surface there must be channels through which to move and migrate. The more dense the material, whether it be brick, stone, stucco or concrete, the more difficult for the water to transport salts to the surface. Conversely, the more porous the material, the greater the ease with which salts are transported and deposited. Salt-bearing water, on reaching the surface of a structure, air evaporates to deposit the salt. When humidity is low, the water may evaporate before reaching the surface of the structure, leaving the salt deposit beneath the surface, and unseen. When the humidity is high, water evaporation is slower allowing more opportunity for whisker growth. Growths which project 1/4 to 1/2 inch below the surface have been reported in some areas of the country.

Since humidity has a definite effect on whether or not the salts appear, it can be assumed that efflorescence is a seasonal problem. The intensity of efflorescence increases after rainy winter seasons, decreases in spring, and by summer has practically disappeared. This cycle may repeat for months or years, but generally the intensity of the efflorescence decreases in all but very extreme cases, and by about the third year it should be practically eliminated.

The mechanics by which efflorescing salts are carried to the surface of structures by moisture and capillary action through porous materials, is understood. The amount and character of the material deposited varies considerable, depending on the nature and source of the soluble materials.

Composition of Efflorescence

The problem of efflorescence, or the deposit of water-soluble salts on the surfaces of masonry, stucco or concrete, is an old one, and one that has been studied and reported on as early as 1877. These reports are all in common agreement that efflorescence originates from more than one source, and may be made up of more than one or two compounds.

In addition, other salts such as chlorides and nitrates, and salts of vanadium, chromium and molybdenum are mentioned without giving specific composition. These last, particularly vanadium, are said to produce green efflorescence on white or buff burned clay units, while other salts produce white or gray deposits. Efflorescence derived from complex vanadium compounds contained in the clay used in brick manufacture is not uncommon in the southwestern part of the United States.

Sources of Efflorescence

There are many sources for water-soluble salts with some salts more soluble than others. The movement of groundwater into building foundations and by capillary action, or wicking, upwards into masonry, stucco or concrete, is very often the cause of efflorescence. In the case where soil conditions exhibit water soluble sulfates, precautions should be taken to preclude the passage of this sulfate-bearing water to the structure. Low absorption is the best assurance against efflorescence. Properly graded aggregates, low water-cement ratio, good compaction and proper curing practices will produce concrete of maximum density and low water absorption.

Sand and gravel, in their natural state, may or may not have been associated with salt bearing water or soil. If they have, and these salts are not removed by washing, this can be a possible source for efflorescence. Most rock, sand and gravel plants, however, are conscientious in washing material so that any contribution made to efflorescence from this source is negligible.

When mixing-water used for mortar, stucco or concrete is obtained from a natural source which has been in contact with a sulfate-bearing soil, the resulting structure may exhibit efflorescence. The adherence, again, to a good concreting practice of low water-cement ratio, will help reduce the appearance of salts from this source.

Another potential source of soluble salts is clay products, such as building brick and face brick. Generally, in the present day manufacture of these products, the highly soluble salts are washed from the clay, and a barium salt such as barium carbonate is added to the product, to react with the calcium sulfate which may be present. In this reaction, the product is two fairly insoluble compounds-barium sulfate and calcium carbonate. When produced in this manner, clay products exhibit little tendency to efflorescence.

Building brick must be stored in a dry place off the ground to prevent absorption of moisture or dampness from possible salt bearing soil. A standard test may be made to show the capacity of brick to contribute to efflorescence through soluble salt content. A brick is placed on end in a pan of distilled water for seven days, in which time water is drawn upward and through the brick and then evaporated from the surface. Soluble salts are taken into solution by the water and deposited on the surface.

It has also been noted that the occurrence of efflorescence bears a relationship to the type of mortar used. With a particular type of brick and a certain mortar no efflorescence may occur, whereas, the same brick with different mortar may produce a wall heavily coated with salt deposits. The appearances of sodium and potassium salts (as sulfates) usually suggest Portland cement mortar as the origin. The use of low alkali cement in mortar and grout will minimize efflorescence, at least from this source.

Since, for the most part, concrete masonry is somewhat porous, evaporation of the salt bearing water usually takes place before reaching the surface when exposed to a drying atmosphere. The hydroxides are converted by reaction with the carbon dioxide of the air to alkali and calcium carbonates. Efflorescence in the form of alkali chlorides and sulfates is formed when the structure is surrounded, exposed, or in contact with salt-bearing water or soil and appears as columnar or whisker-like crystals.

Some of the sources of water-soluble salts have been covered. These may be deposited on stucco, masonry or concrete walls as efflorescence. Practically any building materials in direct contact with the earth are potential sources for water-soluble salts. This fact has been recognized by the various producers of building materials, and steps have been taken to reduce their presence to a great degree.

Removal of Efflorescence

Several methods are suggested. One is to use water under pressure or one of a number of products available from stone dealers; another is muriatic acid with subsequent flushing with water. Acid applied to brick masonry, without previous wetting, may cause "burning" or discoloration of the brick and may also eat into the mortar. The Handbook on Reinforced Grouted Brick Masonry Construction suggests the use of light sandblasting for removal of stubborn efflorescence (after many months). Allowing the surface to dry thoroughly and then using a stiff brush, prior to washing with water, has helped prevent re-penetration of the surface by the salt.

Various methods have been used in attempts to remove efflorescence from masonry structures. It has been found that when efflorescence is caused by soluble alkali salts, the salts will dissolve in water applied to the structure and migrate back into it. These salts would then reappear on the surface as the structure redried. It was learned accordingly, that the best way to remove these soluble salts was to brush the surface thoroughly with a stiff brush. Water, however, has been satisfactory for removing efflorescence from the face of concrete structures, since concrete is fairly well saturated with water. In fact, efflorescence in the form of alkali salts will be washed from the surface of concrete structures, if exposed to rain, over some period of time. If the coating is largely calcium carbonate or calcium sulfate, it adheres rather strongly and is difficult to remove by brushing. The practice developed in this case for masonry surfaces, has been to saturate the structure as thoroughly as possible with water, and then wash with diluted muriatic acid, followed immediately with an alkaline wash, then washed with water. The acid recommended is five (5) parts hydrochloric to one hundred (100) parts water, or twenty (20) parts vinegar to one hundred (100) parts water. The alkaline wash recommended is diluted household ammonia.

Much care must be taken in applying acid to Portland cement products. The acid will attack, not only the calcium carbonate and calcium sulfate efflorescence, but also other calcium compounds to produce calcium salts such as calcium chloride. It is, therefore, very important to neutralize the acid before it can attack other compounds.

Discoloration

My observation is that joint discoloration problems occur mostly in cold weather. In cold weather, all masonry materials can freeze including masonry brick. The degree of saturation of the brick at the time of freezing can have a big influence on whether your mortar joints will be light or dark in color.

Let's assume a few different scenarios using the same IRA frozen bricks when laying up masonry walls.

1) Lets assume the bricks are completely saturated and then become totally frozen:
In this situation the frozen saturated bricks will not contribute any water to the fresh mortar joint because water in the bricks will be in the ice state. The excess water in the mortar will not be absorbed into the bricks either since the pores in the bricks will be filled with ice. The mortar joints will likely be light in color.

2) Lets assume the bricks are dry and then become totally frozen:
In this situation the frozen bricks will not contribute any water to the fresh mortar joint since they are dry. The excess water in the mortar could be absorbed into the bricks since the pores in the bricks will be available. The mortar joints will likely be dark in color.

3) Lets assume the bricks are partially saturated and then become totally frozen:
In this situation the frozen bricks will have pores that are filled with ice, to some that are partially filled with ice, to others that are empty. The bricks will likely not contribute any water to the fresh mortar but could absorb some water from the mortar in portions of the bricks. The mortar joint color could vary drastically here, next to just one brick.

4) Lets assume the bricks are partially saturated and are partially frozen:
In this situation the partially frozen bricks may or may not contribute a little water to the mortar joint since the unfrozen water in the bricks can move to the mortar joints if the mortar is dry, but the frozen ice cannot. The excess water in the mortar could be absorbed into the unfrozen empty pores in the brick, but not into the pores filled with ice. The mortar joint color could vary drastically here, next to just one brick.

There are many more scenarios to consider other than just those described here for frozen brick in cold weather masonry construction, but it is all saying the same thing that mortar joint color can vary in cold weather.

Ice in frozen brick will likely not contribute any water to a fresh mortar joint unless the ice in the brick thaws during the initial laying of the brick before tooling, but this is not very likely. Also, even in warm conditions, there is very little transfer of water from the brick to the mortar unless the mortar is drying out.
The best way to limit the amount of mortar joint discoloration in cold weather, is to keep all the materials to be used in the cold weather masonry wall construction protected from rain, snow and freezing temperatures; in other words, use good recommended cold weather masonry construction practices.
In cold weather, it all boils down to controlling the degree of saturation of the same IRA bricks, protecting them from the elements, and keeping them from freezing at the time of laying the bricks.

Masonry Technical Notes

T – 4: COLOR OF MORTAR JOINTS

The eye-appeal of a masonry wall depends on the color of the mortar joints and that of the masonry units (brick or block). It is the contrast that is important. The exact color of the mortar in the joint may not be as significant as the relation between the color of the mortar and the color of the adjoining brick or block. The same joint may appear light or dark, pleasing or unpleasing, depending upon the contrast afforded by the masonry unit and the joint.

Mortar joints of varying color in the same wall are undesirable. Some buildings may be intentionally constructed with varying shades of color in the brick, but a uniformity of mortar joint is needed to bring out these brick colors.

One of the prime causes of color variation in the same wall is variations in the absorption of the brick. This is possible with any mortar where a mixture of absorptive and non-absorptive units are used on the same job. The brick that rapidly absorb water from the mortar will cause the joint to be relatively dry at the time of tooling and a darker surface will result. Brick having a lower rate of absorption will cause the mortar to be softer and wetter at the time of tooling and water will be drawn near the surface by the force of tooling with the result that extra curing occurs and a lighter-colored surface develops (increased curing increases the hydration rate of the portland cement component and the products of this increased hydration are relatively light in color).

During mild or warm seasons, dry absorptive brick should be wetted ("pick and dip") before use. The wetting of brick provides for a more uniform suction and will help toward more uniformity of joint color. This wetting of brick should not be done in very cold and freezing weather.

In winter, a drop in temperature may often be followed by dry, cold winds. Mortar laid under such conditions with dry, cold brick may dry out and fail to develop a normal color because of too slow hydration of the cement. However, the color of the mortar can be expected to lighten as continued curing occurs in more favorable weather.

Masonry Technical Notes

T – 4: COLOR OF MORTAR JOINTS (continued)

Good tooling ensures weather-tight joints and a nice appearance. The proper time for tooling must be given consideration. Tooling should be done when the mortar has stiffened to the extent that a thumb-print is barely visible. Tooling beyond this time is quite likely to give darker joints.

As a mortar hardens, it shrinks a little and loses intimate contact with the edges of the units. Contact can be restored by use of a jointing tool and any small cracks sealed.

SUMMARY

Differently colored joints (lighter/darker) originate principally from job-site variables that influence (change) the rate of hydration (curing) of the cement:

- Amount of water in the mix
- Rate and amount of suction by units
    - Ambient temperature
    - Time of tooling
    - Tooling technique

Moisture is essential to hydration. The products of hydration are of a lighter color than that of the original cement. The tell-tale sign of changes from one day's work to that of the next is called the "scaffold effect".

CHOOSING THE CORRECT STRENGTH MORTAR

There seems to be some confusion as to what type of masonry cement to use for masonry construction. This document can also be used for strength selection for all masonry. I haven't been able to put my hands on any one document that in a simple manner answers this question. I don't feel there is one simple "cut and dried" answer. Here is my attempt to answer some questions and to try to clear up some confusion. I am sourcing many different documents.

There are 3 basic types of masonry cement that we can choose from, types N, S and M. I will specifically address why I feel Type N masonry cement should be used on load bearing and non-load bearing walls. My first belief is that Type N has a higher degree of workability than Type S or M and workability is an essential property of any mortar used in masonry construction. Mortar is considered workable when it can be placed and spread easily and also has "stickiness" or adheres to vertical surfaces on masonry units. This is an important factor to ensure watertightness. The value of good workability is that it is a key factor in good workmanship. A mason could not be expected to do a good job if he has inferior materials to work with.

The next point that I would like to make is based on mortar strengths from ASTM C270 which is the laboratory specification of mortar for unit masonry. In the property specification requirements for mortar, Type N must meet 750 psi; Type S must meet 1800 psi and Type M must meet 2500 psi. When we speak of a 2500-pound mortar we are referring to a standard two-inch cube that is prepared under the provisions of ASTM C270. The cube is able to carry a compressive load of 10,000 pounds before failing and therefore mathematically has a compressive strength of 2500 pounds based on a four square inch area. The compressive strength of a standard 3/8" mortar joint will be considerably greater than that of the standard 2" cube, because of the specimen shape/compressive strength relationship of greater resistance to crushing for shorter specimens. In other words, it's easier to break a 2" by 2" cube than it is a 3/8" by 2" cube.

The following interesting comments relative to the strength of mortar were published about 60 years ago in Circular No. 30 of the National Bureau of Standards:

"This question of the strength of a mortar is apt to be given undue weight. Since masonry is assumed to weigh 150 pounds per cubic foot, then the compressive load (in pounds per square inch) at the bottom of a wall will be 144 divided by 150 (.96) times its height in feet. A mortar with a compressive strength of 100 pounds per square inch, should, according to this reasoning, be able to carry a wall 96 feet high, or about nine stories. (Here is the math 100 x [144/150]. The compressive strength of the mortar is usually measured by crushing 2-

inch cubes. For a homogeneous material, the unit compressive strength varies with the shape of the specimen, being dependent upon the ratio between the least horizontal dimension and the height. In a cube, this ratio is one. A mortar joint in a wall may possibly be 4 inches wide by 30 feet long by 1/2 inch thick. In this joint, the ratio is 4 divided by 1/2 = 8. If a mortar has a strength of 100 pounds per square inch when tested in the form of a cube, it should theoretically have a strength of 800 pounds per square inch when laid up in a wall." Based on this equation, Type M mortar will give you a compressive strength of 20,000 psi.

Most brick have a compressive strength greater than 6000 psi. Mortar can range from 750 to 3000. However, in most masonry construction the compressive stresses do not exceed 200 psi. Most masonry has far more compressive strength than it needs. It can be argued that the compressive strengths are greater in the lab than in the field. But, compressive strength requirements are not a realistic reflection of the actual need of mortars to withstand compressive loads in structures. Many times specifies "go overboard" with compressive strength requirements. Most architects, engineers and other specifies are overly impressed with higher strength mortar being the means of obtaining a high factor of safety in masonry design. Over 50 years ago Howard Staley, a professor of building engineering and construction at M.I.T., called such excessive factors of safety "factors of ignorance" because high strength mortars tend to sacrifice other desirable properties. Most experts will agree that the most common cause of cracking in masonry is inadequate provision for movement. Strong mortars restrain movement of building units rather than accommodating or absorbing it. Such restraint can result in the cracking of units. A mortar should deform significantly before failure, thus minimizing the risk of brittle failure or cracking. Excessively strong mortars may also cause problems if it becomes necessary to rake and repoint the joints at a later date. Some units tend to break away and come loose as a strong mortar is raked out. Strength has a bearing on durability, but the highest strength does not always imply maximum durability. This is particularly true for brick masonry construction where high strength mortars used with some units have volume changes and other properties which cause walls to leak. Type M masonry cement can many times have a higher shrinkage factor than Type N, which results in hairline cracks along the point of bond thus allowing a path for water.

ASTM C270 TABLE X1.1, which is the guide for the selection for masonry mortars states that "exterior above grade, load bearing walls, non-load bearing walls, and parapet walls are recommended to be constructed with Type N mortar. Type S is recommended below grade, with Type M as an alternative. I prefer Type S. ASTM C270 also states in Section 3.1.1, "unless otherwise stated either a cement/lime mortar or a masonry cement mortar may be used. Mortar of a known higher strength shall not be indiscriminately substituted where a mortar type of anticipated lower strength is specified."

Commentary on Specifications for Masonry Structures which (ACI 530.1-95/ASCE 6-95/TMS 602-95) in section SC8 states that "a good rule of thumb is to specify the weakest mortar that will perform adequately, not the strongest". In the case of above grade load bearing and non-load bearing walls my recommendation is to use Type N Masonry cement. Combined with good Design and Proper Workmanship the results will always be favorable.

Thomas J. Slosser
Territory Manager - Package Sales - Essroc
Certified Consultant for Concrete Masonry

TROUBLESHOOTING CRACKS IN MASONRY

There is a lot of unseen movement in all masonry construction. Absent to the eye, structures expand and contract with changes in temperature, moisture content, and stress. The most common cause of cracking in exterior masonry is inadequate provision for movement.

As concrete block cures and water evaporates, it shrinks. Clay brick absorbs moisture and permanently expands. Both brick and block walls also expand and contract in response to thermal changes and stress. Expansion and Contraction cannot be stopped, therefore this movement and resulting forces must be accommodated.

Cracking of masonry structures is probably the most frequent cause of masonry performance failure and has been an engineering concern for at least the last 150 years. Cracks can be eliminated or made so small as to be unnoticeable

Troubleshooting masonry cracks is not always easy. The problem can generally be attributed to several causes and at times there is no apparent cause. Cracks in masonry should not be taken lightly. Cracks as small as a human hair can allow water into a wall. Cracks can be repaired with no further problems or may widen and additional cracking may occur. For repairs to be effective you must determine the cause of the cracks before attempting any repairs.

A crack is defined as "a break, split, fracture, fissure (a very small crack), separation, cleavage, or elongated narrow opening visible to the normal human eye and extending from the surface and into a masonry unit, mortar joint, interface between a masonry unit and adjacent mortar joint, or into the joint between masonry and an adjacent construction element."

The theory of fracture mechanics has been applied to masonry by researchers. In order for a crack to be visible, the surfaces of the crack must separate, indicating the previous existence of tensile stress. Since masonry is relatively weak in tension, tensile force is more likely to cause in cracking rather than compression or shear force. Shear can cause cracks too, but masonry is stronger in shear than tension.

CEMENT SHRINKAGE

Mortar, grout, concrete masonry units, shrink upon drying. When shrinkage is restrained, cracks usually result. Shrinkage of materials made with Portland cement is caused by water loss and by carbonation. Water loss shrinkage is somewhat reversible. Carbonation shrinkage is not. As CMU's dry the recession of water in capillaries creates surface tension that places the material in compression and reduces volume. Because sand and gravel are stiffer than lightweight aggregates, CMU made with such aggregates have greater shrinkage. Carbonation is primarily a reaction between calcium hydroxide, (which aids in the hardening of cement), released by hydration of cement, and carbon dioxide from the air to produce calcium carbonate and water. Carbon dioxide may also react with other cement paste components. Lime also carbonates and therefore shrinks. Mortar shrinkage increases with water-cement ratio, which increases with lime content. As mortar sand fines increases, water demand to add workability increases and shrinkage increases. Result; mortar joint cracking increases with sand fineness. The most common cause of mortar shrinkage that we see in the field is due to a high cement ratio in the mortar or too "rich of a mix."

SHRINKAGE OF CONCRETE MASONRY UNITS

The block that we today has a shrinkage requirement is .065%. (This means the block cannot shrink more than .065% of the total length of the block.) There are generally two ways to cure block, low pressure and high pressure (which is commonly known as autoclave). Most block manufactures use low pressure curing. We might recognize this as a moist room for curing. Shrinkage of low pressure cured CMU is about 85% greater than for high pressure cured units.

CONCRETE WALL SHRINKAGE

Total prevention of cracks in concrete masonry is said to be technically and economically unfeasible. Shrinkage of mortar and of concrete masonry units in concrete masonry walls results in wall shrinkage that is greater than CMU shrinkage, perhaps 30% greater. Total concrete masonry wall shrinkage may range from 0.01% to 0.1%. Wall shrinkage is restrained at the wall base by bond and friction, but may not be restrained at the top of the wall. For walls of excessive length to height ratio, this phenomenon results in a vertical crack near

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SEALANT JOINTS

Sealant joints are sometimes called "movement joints." The two most common types of joints used for crack control are "Expansion and Control". Expansion joints close to accommodate expansion of brick or stone masonry; control joints open to accommodate shrinkage of concrete masonry. To avoid the terms "expansion joint, and control joint" should not be used interchangeably.

CRACK CONTROL IN CMU WALLS

Methods for controlling cracks in concrete masonry walls include: (1) Limitation on length to height ratio of walls; (2) Limitations on horizontal distance between vertical control joints; (3) Installation of bed joint reinforcement or bond beams; (4) Location of control joints at points of stress concentration; (5) Control of moisture of content in CMU at time of construction; (6) Installation of slip joints.

In addition, control joints are required at critical points of high stress concentration, or in other words, at changes in wall height or thickness, above joints in floors or foundations and below joints in slab roofs bearing on the wall, at one or both sides of wall openings, at a distance from wall intersections or corners not greater that one half the allowable spacing of control joints, and in composite walls at the same location as expansion joints in the brick masonry. In lieu of a control joint at each jamb of a wall opening, bed joint reinforcement may be placed in the first and second joints immediately above and below the wall openings, extending at least 2 ft. beyond the opening.

In large wall expanses, bond beams may be used instead of joint reinforcement. Trough or U-shaped CMU's are used in a continuous horizontal course, which is filled with grout and in which one or more reinforcing bars are placed. (Notched bond beam block are preferred.)

Slip joints are horizontal planes of weakness formed by breaking the bond of mortar bed joints with the CMU. Slip joints are placed at the top exterior corners of walls that support cast-in-place concrete roofs or floor slabs and at the CMU lintel bearings, where a control joint is located above the jamb at a wall opening. Be aware of structural discontinuity when using slip planes.

Foundations

Foundation movement may be caused by uneven settlement, moisture movement in plastic soils, or downhill creep of surface layers. Settlement is caused by soil consolidation, shear failure and variable soil types. Clays and silts increase in volume with increased moisture content and decrease in volume with reduced moisture. Water content changes with the season, trees and shrubs, localized watering and heat, and moisture migration. When ground water reduces the shear strength of sloped soil, downward slides can result. Masonry pavement on chalky or fine soil may be subject to upheaval due to ice during severe winters. In coal mining regions ground subsidence may cause a surface wave up to 2 or 3 ft. high to pass through entire communities. The influence of trees on house foundations in clay soils is also a potential problem. Cracks that take place from uneven settlement of foundations may take any form, but they are most often diagonal or vertical and are usually tapered. Vertical cracks wider at the top than at the base indicate flexure, sometimes due to foundation movement

OTHER CRACK CAUSES

Cracks in chimneys may be caused by sudden and wide temperature changes or by the freezing of condensation from the combustion of natural gas. Severe fire causes cracking and bulging of masonry as well as surface spalling of possibly vitrification (crystallizing) of clay brick. Although severe damage may be caused by earthquakes, well designed and built masonry may be structurally sound after imposition of seismic loads. This greatly depends on design. When steel corrodes, the ferric oxide (rust) occupies more than twice the volume of steel from which it was formed. Corrosion of imbedded reinforcing steel may cause a crack at the wall surface along the length of the steel. In walls, the horizontal cracks at regularly spaced vertical intervals may be due to corrosion of bed joint reinforcement or wall ties. Galvanizing, proper cover, and correct tooling help prevent this.

CRACK INSPECTION

Although no absolute determination as to the cause of masonry cracking can be made solely on the basis of visual inspection, cause clues are readily obtained. What to notice about cracks is (1) The direction or pattern; (2) extent (beginning and end); (3) Width (uniform of tapered); (4) depth; (5) alignment (in the same plane or laterally offset);(6)edge sharpness (rough, rounded, or broken edges may be indicative of compression failure; (7) cleanliness (new cracks have clean sides and are not coated with paint, dirt, or algae; (8)crack dynamics (static or changing in size, shape, or direction).

REPAIR

Tests made at the Building Research Station in England have shown that the capacity of 9 inch thick brick walls to carry vertical loads are reduced by more than 30% by a stepped or slanted crack up to 1 in. wide provided that the damage is not accompanied by considerable transverse movement.

Crack repair methods may be classified by those which do not significantly change wall appearance and those which do. Fine cracks (less than 1/16 of an in.) are not very conspicuous and in brick masonry would often be made to be more unsightly by repointing. Such cracks can be filled by surface grouting, which will prevent water penetration and not greatly change the wall appearance. Clear coatings for masonry normally do not bridge crack and therefore are not recommended to prevent water presence. They can be used in addition to the crack repair.

* This information is a result of collecting technical material from many sources, over many years and compiling it into a simple form. It is intended as a learning tool.

Recommendations for Quality Control and Quality Assurance for Mortar

Tom Slosser Essroc

What can be done to assure quality mortar on the jobsite?

This is a question that arises frequently when specifying mortar for a particular project. This is what I would like to specifically address with this article. Let's discuss a few things first. Mortar is one of the few materials that are actually manufactured on the jobsite. The manufacturer of the masonry cement and the sand quarry supplies the dealer with the ingredients to be mixed at the jobsite resulting in mortar. Most other building materials are made at a manufacturing facility under controlled conditions. Many products must adhere to standards. The American Society for Testing and Materials or ASTM is very familiar to most of us. ASTM sets standards that allow the designers, engineers and builders to determine what materials will suit the need of the building and structures. Recognizing and utilizing the facts about the materials being used results in a quality job. ASTM C 270 is the Standard Specification for Mortar for Unit Masonry. The scope of the specification is to cover mortars for use in construction of non-reinforced and reinforced unit masonry structures (Section 1. scope paragraph 1.1) Reading on, four types of mortar are covered in two alternative specifications. (1) Proportion specifications and (2) property specifications. Either shall govern when specified. When neither is specified, proportion specifications shall govern. A good question now is what is the difference between the proportion and the property specifications? The answer is simple the proportion specification is a recipe telling us how much volume of cementitous material and aggregate we should combine to get an acceptable mortar for the requirements of the job. The property specification tells up what the minimum psi the mortar needs to be to meet the minimum strength requirements for the mortar specified. In either case a key fact to remember is stated several times in ASTM C 270 and it states in Section 3 Specification Limitations 3.1 **"Specification C 270 is not a specification to determine mortar strengths through field-testing."** This is a very important statement to remember as well as Section 3.3 **"The compressive strength values resulting from field tested mortars do not represent the compressive strength of mortar tested in the laboratory nor that of the mortar in the wall.** Physical properties of field-sampled mortar shall not be used to determine compliance to this specification and are not intended as criteria to determine the acceptance or rejection of the mortar.

Another good question to ask at this time is "What is an acceptable standard for quality assurance?" If we read on a little further in C 270 Section 8 paragraph 8.1 states "Test method C 780 is acceptable for pre construction and construction evaluation of mortars for plain and reinforced unit masonry. Section 8.2 states **Compliance with Specification 270 is obtained in the field by verifying that the required proportions of the specified materials are added to the mixer.** This is another very important statement. C 780 gives us the tool to do this with. It is the **mortar to aggregate ratio** test.

- Section A7.1 Scope –Strength values for mortars obtained through these testing procedures are not required, nor expected, to meet strength requirements of laboratory Specification C 270…

KEY THINGS TO REMEMBER ABOUT MORTAR AND GROUT TESTING

When 780 testing is specified there must be a test(s) method named.

Mortar/aggregate ratio is a good test to specify in conjunction with the mortar water content test.

Mortar/Aggregate/Ratio gives immediate results.

There are no ASTM strength requirements for mortar that is tested in the field.

As part of its commitment to Total Customer Satisfaction, Essroc offers technical service to its customers. We have made every effort insure the accuracy of the information provided to you. While this advice is intended to ad value to your business, the formulation of Concrete, grout, and/or Mortars and the applications for which it is used must be the responsibility of the customer.

(ASTM C 780 A4.) Here is another very important fact to remember. It is necessary to run the mortar water content test (ASTM C 780 A5 in conjunction with the mortar aggregate ratio test.

I will outline what I feel is the proper procedure for field- testing on mortar.

Write the job specification requiring the mortar to meet ASTM C 270 proportion specification.

Require the cement manufacturer to provide a certification letter stating this.

Initiate ASTM C 780 Testing using the Mortar to Aggregate ratio test in conjunction with the mortar water content test. (This test confirms the proper amount of sand to cement ratio.)

As an additional option a few compressive strength tests can be done at the designers discretion, but remember the procedure is to do a **Preconstruction** test to establish a benchmark and then compare the construction tests to the preconstruction results in the form of a chart. **Remember, you are not comparing the psi to any particular number.** You are just tracking the variance. A few hundred psi in either direction is no cause for alarm. What you are looking for are abnormal spikes in the psi.

Note C 270 Section 3. Specification Limitations

- Section 3.1 "Specification 270 is not a specification to determine mortar strengths through field testing.
- Section 3.3 ".... field tested mortars do not represent the compressive strength of mortar as tested in the laboratory nor that of the mortar in the wall."
- Appendix Section X1.6.3.2 "... the importance of compressive strength of mortar is over emphasized. Compressive strengths should not be the sole criterion for mortar selection... Often overlooked is the size/shape of mortar joints in that the ultimate compressive load carrying capacity of a typical 3/8 inch bed joint will probably be well over twice the value obtained when the mortar is tested as a 2 inch cube* Mortars should be typically weaker than masonry units, so that any cracks will occur in the mortar joints where they can be easily repaired.

Note C 780 Section 1. Scope

- Section 1.4 The test results obtained under this test method are not required to meet the minimum compressive values in accordance with the property specifications in 270.
- Section 5.2.6 .... The measured value shall not be construed as being representative of the actual strength of the mortar in the masonry...
- Section 6. Test Method Limitations 6.3 "There is no ASTM standard method for measuring hardened mortars removed from a structure