

Overview

Mortar is the bonding agent that integrates a masonry wall. It must be strong, durable, capable of keeping the wall intact, and it must create a water-resistant barrier. Mortar as recommended by the Brick Institute of America and other masonry experts is made from the following ingredients.

Mortar Ingredients

Mortar specification is covered by the ASTM C270 "Specification for Mortar for Unit Masonry" and CAN/CSA A179 "Mortar and Grout for Unit Masonry". Note that the Canadian equivalent references are included in brackets behind the US ASTM references.

Portland Cement

A hydraulic cement, contributes to durability, high early strength and high compressive strength. It is one of the principal cementitious ingredients for mortars. Only three of the eight types covered by ASTM C150, Standard Specifications for Portland Cement, are recommended by the BIA.

Three types recommended by the BIA:

- Type I (Type 10) - For general use when the special properties of Types II and III are not required.
- Type II (Type 20) - For use when moderate salt water resistance or moderate heat of hydration is desired; sometimes used in hot weather as an alternative to adding a retarder.
- Type III (Type 30) - For use when high early strength is desired; may be used in cold weather.

Hydrated Lime

Type S, covered by ASTM C207 sets only upon contact with air, contributes to workability, water retentivity (preventing water from evaporating too quickly from the mortar), elasticity, bond strength and resisting water penetration through the brickwork. It is also a cementitious ingredient, however it takes much longer than Portland cement to develop its strength.

High lime mortars create a phenomenon called autogenous healing. When rainwater, which always contains carbon dioxide, is absorbed into the mortar, it either absorbs directly into the mortar or dissolves minute amounts of hydrated lime or limestone. This solution penetrates into cracks or voids while the hydrated lime combines chemically with the carbon dioxide to form limestone which becomes slightly larger than the original hydrated lime.

The limestone hardens as the air dries it and bonds to adjacent surfaces in the voids. Eventually the voids or cracks may become filled. This slow process continues for years. The higher the lime content the more effective the healing process.

Sand

Sand specified by ASTM C144 acts as a filler, providing the most economic mix and contributing to strength.

Water

Water is the mixing vehicle which creates plastic workability and initiates the cementing action.

Pigments

Color can be achieved in a variety of ways:

- Grey or white Portland cement when mixed with local sands will create shades of grey or white mortar.
- Other colors should only be achieved using metallic oxides such as iron, manganese and chromium oxides, carbon black and ultramarine blue.
- Too much pigment will reduce strengths and durability, therefore maximum weight of pigments should not exceed 1% of the weight of the Portland cement except carbon black which should not exceed 2 to 3% of the cement weight.

Admixtures

Admixtures are sometimes added to the mortar but are not normally recommended due to the following:

- Air entraining admixtures are added to improve mortar workability and durability. However, research has shown that air contents in the mortar of over 12% show increased likelihood of moisture penetration and decreased bond strength.
- Antifreeze compounds or other similar substances are sometimes used to lower the freezing point of the mortar so that brick can be laid in cold weather. However, in order to be effective, a considerable amount must be added to the mortar and this greatly reduces bond strength and contributes to efflorescence and spalling in the brickwork.
- Accelerators such as calcium chloride are used to speed the hydration of the mortar in cold weather so that heating of the mortar materials is not necessary. Calcium chloride tends to corrode reinforcement embedded in the mortar. This steel holds the brick to the building. Accelerators, even those that do not contain calcium chloride, tend to create efflorescence.

Mortar Specifications

Mortar Type	Portland Cement	Hydrated Lime	Proportions Part by Volume		Aggregate, measured in a damp, loose condition	Property
			Masonry or Mortar Cement Type N	Type S		
M	1	1/4			Between 2 1/4 and 3 times the sum of the separate volumes of cementitious materials	Avg. 28 Day Compressive Strength PSI (MPa)
S	1	1/4 - 1/2		1		2500
	1/2		1			1800 (12.5)
N	1	1/2 - 1 1/4	1			750 (5)
O	1	1 1/4 - 2 1/2			350	

Note: Compressive strength applies to laboratory prepared samples.

Mortar Properties

Workability - which refers to the plastic properties - can be increased by:

- using a well graded sand of which approximately 10% passes a No. 100 sieve,
- using highly plastic lime, type S, and
- increasing the air content but not to exceed 12%.

Bond strength - which relates to the hardened properties - can be increased by:

- mixing maximum water consistent with good workability and permit retempering,
- wetting the brick when necessary,
- using type S mortar,
- keeping air content of the mortar to a minimum, and
- using mortars with high lime content.

Field Guidelines for Handling Mortar

- Water should be clean and mostly free of acids, alkalis or organic material.
- Bags of Portland cement and lime should be stored on pallets and covered with plastic.
- Sand should be placed on top of plastic and tarpins and covered with plastic.
- Measurement of sand should be done with volume or weight measures, not shovels. Boxes or five gallon paint containers can be used.
- Mixing of cement, lime, sand and water should be done for at least 3 minutes and not more than 5 minutes in a mechanical batch mixer, with the maximum amount of water to produce a workable consistency.

Mortar Uses

There are a variety of mortars, brick, exposure conditions and building uses. The following are many of the factors which influence how to choose the proper mortar for various conditions. The following recommendations are based on Portland cement-lime (PCL) mortars.

High strength mortars with high Portland cement content, are most effective when freeze/thaw action may be considerable. High lime content mortars have lower strengths but high resistance to moisture penetration. The following table suggest possible mortar choices.

Mortar Type Application

Mortar Type	Application
S	Exterior paving systems and brickwork below grade
S	Structural brickwork; i.e., high wind pressure, heavy load bearing or seismic designed walls
N	Exterior brickwork such as veneer, chimneys and parapets.

As a general rule, use the weakest (in compression) mortar that is consistent with the performance requirements of the project.

Initial rate of absorption of the brick affects the type of mortar used. A brick with a high suction rate (> 30g/min/30sq. in.) will absorb water from the mortar very quickly, potentially leaving the mortar too dry to hydrate properly and bond to the brick. Wetting the brick prior to laying or using a mortar with high water retentivity, a high lime content mortar, (type N), will compensate for the high suction brick. For low suction brick, (3 to 4 grams), a higher cement content mortar, (type S), may be more effective.

Test for Wetting Brick

The following test is useful for determining the necessity of wetting brick prior to use:

A circle approximately 1" (25mm) in diameter is drawn on the bed surface of the brick, using a wax pencil and a twenty-five cent coin as a guide. Twenty drops of water are placed into the circle using an eye dropper. If after 90 seconds all of the water has been absorbed, wetting the brick prior to placement is recommended.

The air temperature at time of installation also affects the mortar choice. For example, in hot weather a high lime content mortar will help to retain the moisture in the mortar for a longer time. In cold weather a lower lime content, a type S mortar with lower water retentivity, may improve bond strength. Also, a type III (type 30) Portland cement, a high early strength, will provide extra heat from hydration to enable the mortar to hydrate sufficiently to bond with the brick.

If there is any doubt about which mortar to use, independent testing should be conducted to verify bond strength and moisture resistance for the brickwork.

All these variables need to be considered in choosing a mortar. In addition, workmanship is a critical factor. Preconstruction meetings with the mason should be arranged to impress upon him the need for quality workmanship.

Masonry Cements

Masonry cement mortars are widely used because of their convenience and generally good workability. However, there has been considerable debate concerning whether or not masonry cement mortars are as effective as PCL mortars with respect to bond strength and moisture penetration resistance.

The following are some of the concerns:

- First, the manufacturers of masonry cements which are proprietary products do not disclose their product formulae. Different producers use different amounts and types of ingredients which leads to inconsistent properties. In a bag of masonry cement, only about half the bag is Portland cement while the other half is ground inert limestone (a fine non-cementitious aggregate) as a filler. Additives are added to provide workability, water retentivity and air entrainment.
- The second reason is that masonry cement mortars have air contents around 20% which makes the mortar very workable. However, the high air content means that there will be less cementitious material in contact with the brick causing less surface adhesion and reduced bond strength. Also, the voids created by the air will allow moisture to more easily penetrate through the mortar.

- A third reason is that masonry cements contain little or no hydrated lime although some may contain an inert limestone. Without hydrated lime, autogenous healing can not occur to seal voids or cracks caused by poor workmanship or shrinkage cracks.

The lime also provides some additional strength. A frequent comment from masons is that they prefer masonry cement mortars over PCL mortars because PCL mortars are too hard to get off the brick - the PCL mortar bonds to the brick too well. Masonry cements have performed reasonably well for many years, however, they should be used with caution.

Mortar Cements

Mortar cement mortars are covered by ASTM C1329 "Standard Specification for Mortar Cements". Mortar Cements are similar to Masonry Cements, but have a limit on the maximum air content (14% for types M & S, 16% for types N & O) and a minimum bond strength specified. Mortar Cements were developed to overcome some of the concerns of the Masonry Cement.

References

1. Technical Note 8, "Mortar for Brickwork", Brick Industry Association, January 2008.
2. Technical Note 8B, "Mortar for Brickwork - Selection and Quality Assurance", Brick Industry Association, October 2006.