Prior to the 1900s, mortar used for masonry was composed of either lime or natural cement. These materials were soft, making them very compatible to the soft brick of the time. Mortar containing only lime and sand required carbon dioxide from the air to convert them back to limestone and harden. Lime with sand mortar hardened at a slow rate requiring longer periods of time to construct masonry structures. Natural cement had higher clay content than hydraulic lime products, which allowed for increased strength development. While not consistent, natural cement is used today on a limited basis.

Manufacture of portland cement began in the United States in 1871, in the Lehigh Valley of Pennsylvania. Consistency and higher strength levels of portland cement allowed it to replace natural cement in mortars. Portland cement by itself had poor workability, but when combined with lime, it provided an excellent balance between strength and workability. The addition of portland cement to lime mortars increased the construction speed for masonry building due to faster strength development.

The addition of portland cement to lime mortars increased the construction speed for masonry building due to faster strength development.

Portland-Lime Blend, Masonry Cement and Mortar Cement
Which is better? The only answer is the products are different, but when handled appropriately, each contributes to the production of quality masonry construction. Masonry cement and mortar cement have slightly different ingredients than portland-lime blend, but they all contain the same portland cement for strength development and each meets ASTM C270 Standard Specification for Mortar for Unit Masonry. Exhibit 2 describes the differences in materials used to produce each type of cement for mortar. Each product has slightly different ingredients and manufacturing processes. Therefore, each is covered under different ASTM specifications. They each have slight differences when it comes to bond, workability, durability and board life. Yet each of these products is similar in minimizing water migration, efflorescence potential and minimum water retention.

Portland-Lime Blend
Portland-lime blend is manufactured in a blending facility or batch mixed in the field using portland cement and hydrated Type S lime. Lime provides for workability, much as plasticizers do for masonry cement. Lime is made up of hexagonal shaped hydroxide crystals, thin, flat particles which slip and slide over one another acting as a lubricant. Particles of lime in a portland-lime blend are very fine, helping increase its ability to retain water. Portland-lime blends in Types N, S and M are covered by ASTM C270 only. Two ingredients, portland cement and lime, are each covered by its respective specification ASTM C150 Standard Specification for Hydraulic Lime for Masonry Purposes. Therefore, construction of masonry structures using mortar in accordance with ASTM C270 and a portland-lime blend using ASTM C150 portland cement and ASTM C207 lime renders an acceptable mortar. However, as with any mortar type, quality workmanship is the key to quality masonry structures.

Masonry Cement

### Exhibit 1 Mortar Usage Timeline in the United States

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All masonry cement must meet the physical requirements set forth in ASTM C91. Type N, S, M denotes compressive strength with N being the weakest and M being the strongest. Construction of masonry structures using mortar in accordance with ASTM C270 and masonry cement qualifying under ASTM C91 renders acceptable mortar.

Masonry cement is manufactured in a cement plant using portland cement, plasticizers and air-entraining agents ground together into a homogenous mixture. Items that may be used as plasticizers include limestone, clay and hydrated lime. Finely ground, they have the ability to absorb water, increasing workability. Air-entraining agents are also added to protect from freeze-thaw deterioration and provide additional workability. Air-entraining agents produce tiny, microscopic air bubbles in mortar which act as ball bearings, increasing workability. Any water that may freeze and expand will do so inside these bubbles, therefore prohibiting stresses to build within the mortar joint, enhancing freeze-thaw protection.

Masonry cement allows higher air content versus mortar cement and portland-lime blends. Therefore, masonry cement and Type N mortar are restricted from use in high seismic areas as part of the lateral force resisting system. ¹

<table>
<thead>
<tr>
<th>Portland Cement ASTM C150</th>
<th>Masonry Cement ASTM C91</th>
<th>Mortar Cement ASTM C1329</th>
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<tr>
<td><strong>Plasticizing Materials</strong></td>
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<td>such as limestone, hydrated or hydraulic lime</td>
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<td><strong>Additives</strong> to enhance setting time, workability, water retention and durability</td>
<td><strong>Additives</strong> to enhance setting time, workability, water retention and durability</td>
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**Exhibit 2 Three Types of Cement Used in Mortar**

All meet ASTM C 270

**Mortar Cement**

Mortar cement is the “newest” cement for mortar, developed for use in structural applications which require high flexural bond strength, i.e. high seismic areas. As you can see from Exhibit 2, mortar cement has similar ingredients to masonry cement. Where they differ is in the maximum air content which is allowed. Mortar cement is lower than masonry cement but equal to portland-lime mortar. Mortar cement is also unique because it is the only cement required to have minimum bond strength. Mortar cement has its own ASTM classification under C1329 Standard Specification for Mortar Cement. This specification includes the bond strength requirement developed to assure comparable or improved bond strength versus portland-lime mortar.

**Similarities Between Mortar Types**

Despite differences between mortar cement, masonry cement and portland-lime mortar, they are all cementitious materials that have the same ingredient: portland cement. In mortar, they have the same job, hold the brick and block together and keep water out of the wall as much as possible. One of the goals in exterior masonry wall design is controlling water migration. The three products discussed all have the capability of minimizing water migration when used effectively by the mason. The key is full, compressed bed and head joints for solid masonry units. A mason may prefer to use one cement for mortar over another because of experience and familiarity.

**Water Migration**

Professional designers who are reluctant to use masonry cement contend that the increased air bubbles in the mortar could interfere with bonding. They maintain that this could lead to increased water migration. Studies have been done to test bond with different cements. One such study performed under laboratory conditions found masonry cement mortar, Type S, to have the highest flexural bond strength for a brick with an IRA of 4.3g. ² When used under actual field conditions, masonry cement has the potential to achieve high bond strength depending on the unit properties, just like mortar cement and portland-lime mortar. All cement based products need water to hydrate all of the cement particles.

A study of water permeance in a low IRA brick (5g or less) wall found no water penetration after four hours with portland-lime mortar, masonry cement or mortar cement mortar. ³

**Shrinkage**

Portland cement shrinks over time as it dries. Data from the Portland Cement Association (PCA) shows that the drying shrinkage of masonry cement is about half that of portland-lime mortars. ⁴ A term which advocates of portland-lime mortar discuss is called “autogenous shrinkage.”

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³ Ibid

⁴ Portland Cement Association Masonry Cement Product Data Sheet, Mortar Cement Product Data Sheet; cement.org
healing” which they say corrects this problem. The theory is that if a crack develops in a portland-lime mortar, the lime is capable of filling it in. It is important to point out that it is the tiny micro-cracks that can be healed, not shrinkage cracks. This happens because water enters the micro-crack and dissolves some of the calcium in the lime. Carbon dioxide from the air reacts with the dissolved calcium producing calcium carbonate which plugs the micro-crack. This is plausible. However, micro-cracks are an issue when it comes to water penetration. Shrinkage cracks are much larger and cannot be healed. Also autogenous healing will not remedy cracks which are associated with excessively strong mortars.

Efflorescence is another quality issue routinely thought to be due to mortar. Efflorescence is a white deposit often confused with lime. It can appear on any masonry construction. However, efflorescence occurs due to soluble salts located in brick, block and mortar which are drawn to the surface by evaporation or hydrostatic pressure. This occurrence is not common, but can occur, on newly constructed masonry structures due to the moisture trapped within the structure itself. As the building dries out over time, efflorescence disappears and may never return.

Workability of mortar is the key attribute to the mason. Workability has significant importance when you consider that it is the catalyst to achieving quality masonry construction. Remember, a key to having a successful masonry project is a well-qualified mason who is comfortable with the product used for the job.

For more information
BIA Technical notes,
• Mortar for Brickwork
• Mortars for Brickwork – Selection and Quality Assurance; gobrick.com