Masonry mortar

Davison, J. I.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/40000694
Canadian Building Digest, 1974

Canadian Building Digest

Division of Building Research, National Research Council Canada

CBD 163

Masonry Mortar

Originally published 1974.

J.I. Davison

Please note

Masonry mortar is a versatile material capable of satisfying a variety of conflicting requirements. Contrary to popular belief, however, there is no "universal" mortar to satisfy all situations. Only an understanding of mortar materials and their properties will enable the designer to select a mix that will perform satisfactorily for each specific project.

Function

The prime function of mortar is to bond masonry units into a monolithic mass. Conversely, mortar keeps the units apart, filling all the cracks and crevices and providing a uniform bedding surface. Bonding must be accomplished in such a way that the structural properties of the units are consolidated, at the same time ensuring a barrier to the entry of wind-driven rain. This requires a complete "extent of bond." If it is successful, the wall will possess sufficient durability to withstand exposure to the elements.

Masonry mortar and concrete contain the same basic ingredients - cementitious material, aggregate and water. As a result, many people tend to think that mortar and concrete perform similar functions. This is not the case. In a masonry wall the mortar acts as the binder to unite the units (brick, stone, block, etc.) that provide the strength. Concrete, on the other hand, is a structural material in itself; it alone provides the strength to meet structural requirements. The difference between the two materials is illustrated by the manner in which they are handled on a construction site. Concrete is placed in non-absorbent metal or wooden forms so that all the water will be retained to ensure complete hydration and the development of maximum strength. Mortar is placed between absorbent masonry units, and as soon as contact is made it starts to lose water. Strength is a prime consideration in concrete, but it is only one of several important factors in mortar.

Properties

The properties of mortar fall into two distinct groups: those for plastic mortar, and those for hardened mortar.

Plastic Mortar

Workability is the most important property of plastic mortar. It can be defined as the ability of the mortar to spread, under the trowel, into all the cracks and crevices of the masonry unit. In reality, it is a combination of several properties, including plasticity, consistency, and cohesion.

It defies exact laboratory measurement, but the mason can assess it by observing the response of the mortar to his trowel.

Workability is the result of a roller-bearing effect of aggregate particles lubricated by the cementing slurry. Although largely determined by aggregate grading and material proportions, the final adjustment depends on water content, and this can be regulated by the mason at the working face. The capacity of a mortar to retain satisfactory workability under the influence of brick suction depends on its water retentivity, measured by laboratory test. Good workability and good water retention are essential for maximum bond with masonry units.

Hardened Mortar

A number of strength properties are of prime importance in hardened mortar. First among these is the strength of bond between mortar and unit. As for workability, however, there is no reliable method of measuring it and as a result mortars are assessed on the basis of compressive strength values obtained from 2-inch cubes cast and cured under conditions reflecting construction practice for concrete rather than mortar. The test method is simple, the results reproducible, and through the years masonry engineers have learned to relate compressive strength to desirable masonry properties.

Perhaps because of the previously noted confusion regarding mortar and concrete, the importance of compressive strength of mortar is over-emphasized. Bond strength is more important, as is good workability and water retentivity, both of which are required for maximum bond. Flexural strength is also important because it determines the ability of a mortar to resist cracking. Mortars should always be weaker than masonry units so that any cracks will occur in the mortar joints where they can more easily be repaired.

Mortar Materials and Their Effect on Properties

Essentially, mortars contain cementitious material, aggregate and water; but admixtures or colouring agents may also be added. Masonry units, as well, will be discussed briefly under this heading, since their effect on mortar properties is a basic consideration in mortar design.

Cementitious Material

Cementitious material may be portland cement, lime or masonry cement, or one of a number of combinations of these materials. All three must meet the requirements of their respective CSA Specifications.

Portland cement contributes strength to masonry mortar, particularly early strength, which is essential in an era where the speed of construction may require the wall built today to carry a substantial load tomorrow. Portland cement mortars lack plasticity, have poor water retentivity, and are "harsh" to work with.

Lime, the traditional mortar material, has excellent plasticity and water retentivity, but it is low in strength and slow to cure. Lime putty, made by slaking quicklime and allowing it to age, is the quality product, but the aging process is time consuming and the putty messy to work with. As a result, the more convenient, dry hydrated lime is generally used. Lime mortars cure slowly by carbonation under the influence of carbon dioxide in the air, a process seriously retarded by cold, wet weather.

Masonry cement is a proprietary product containing portland cement and an inert mineral filler (limestone) plus additives such as air entraining and wetting agents and water repellents. The additives provide the plasticity and water retentivity contributed by lime in cement-lime mortars. Some masonry cements are blended mixtures of portland cement and hydrated lime, plus additives.

Aggregate

Sand is the commonly used aggregate. It is inert and primarily contributes bulk. Grading limits are contained in CSA Specification A82.56. Unfortunately, most aggregates are selected on the basis of availability and cost; and it is well known that many of those used in Canada do not meet grading requirements since they generally contain too many fines. Mortar properties are not seriously affected by some variation in grading, but quality could undoubtedly be improved if more attention were paid to the aggregate.

Water

Water performs two functions: it is required for hydration of cement and, more important, contributes to workability. It should be noted that the water requirement for mortar is quite different from that for concrete where a low water/cement ratio is desirable. Mortars should contain the maximum amount of water consistent with optimum workability. It should be clean and free of deleterious materials such as acid, alkali or organic material. If it is fit to drink, it is fit to use.

Admixtures

Many admixtures are available for masonry mortars and undoubtedly there are special situations where they can be used to advantage. In general, however, their use is not recommended. Careful design of the mortar mix, use of quality materials, and good practice will usually result in sound masonry. Careless design, use of inferior materials and malpractice cannot be corrected by admixtures.

Colour

Colour can be added to mortar in aggregates or in inorganic pigments. The latter should be of mineral oxide composition and should not exceed 10 per cent of the weight of portland cement; carbon black is limited to 2 to 3 per cent. Pigments should be carefully chosen and used in the smallest amount that will produce the required colour. To minimize variations from batch to batch it is advisable to purchase cementitious materials to which colouring has been added at the plant and to mix the mortar in large batches.

Masonry Units

Masonry units are absorptive by nature, with the result that water is extracted from mortar as soon as mortar and units make contact. The rate of absorption, however, and hence the amount of water extracted from the mortar, varies considerably. As loss of too much water may reduce workability to a point where the mortar is incapable of forming a complete bond when the next unit is placed, workability and water retention should be designed to suit the absorption properties of the masonry units. Those with high absorption rates require mortars with maximum workability and water retention.

Weather conditions also should be considered when designing mortar. During warm, dry summer weather mortar must have good retentivity to minimize the effect of water loss by evaporation. In winter, a lower retentivity has merit because it facilitates water loss from the mortar before it freezes. A discussion of mortars and cold weather masonry can be found in **CBD 123**.

Mortar Specification

CSA Specification A179 includes five types of mortar permitting combinations of either portland cement and lime or portland cement and masonry cement (see Table I). Type M mortar contains predominantly portland cement and has high compressive strength. Types S, N, O and K mortars contain progressively higher proportions of lime or masonry cement. Minimum strength values for each type are shown. Although strength values decrease through mortars M to K, workability and water retentivity increase. The specification requires a minimum water retention of 70 per cent. Mortars may be specified under a proportion specification, where acceptance is based on the known properties of the cementitious materials and aggregate, or under a property specification where acceptance is based on the properties of the mortar.

Table I. Mortar Proportions by Volume

Type	Portland	Masonry	Hydrated	Aggregate	Min Comp

	Cement	Cement	Lime or Lime Putty		Strength at 28 Days (psi)
M	1	1	-	Not less than 2¼ and not more than 3 times the sum of the volumes of the cement and lime used.	2500
	1	-	¼		
S	½	1	-		1800
	1	-	½		
N	-	1	-		750
	1	-	1		
O	-	1	-		350
	1	-	2		
K	1	-	1		75
	-	-	1		

Tests for Mortar

Mortars are accepted on the basis of laboratory tests using the materials in the proportions specified for a particular job. It should be noted that laboratory mortars are mixed to a lower "flow" value than field mortars (i e. laboratory mortars have lower water content). The result is that mortars sampled on a construction site will have lower compressive strength values than mortars prepared in the laboratory. Failure to understand this basic difference between laboratory and field testing has resulted in considerable confusion. Field test methods are currently being developed and their inclusion in future specifications should eliminate this confusion.

Types of Mortar

Portland Cement-Lime

Figure 1 indicates the wide range of properties for the cement-lime mortars listed in CSA Specification A179. At the one extreme, a predominantly cement mortar has a high compressive strength and a low water retentivity. A wall containing this mortar will be very strong but may be vulnerable to rain penetration. At the other extreme, lime mortar has low compressive strength and high water retentivity. A wall containing it will have lower strength, particularly early strength, but it should be much more resistant to rain penetration.

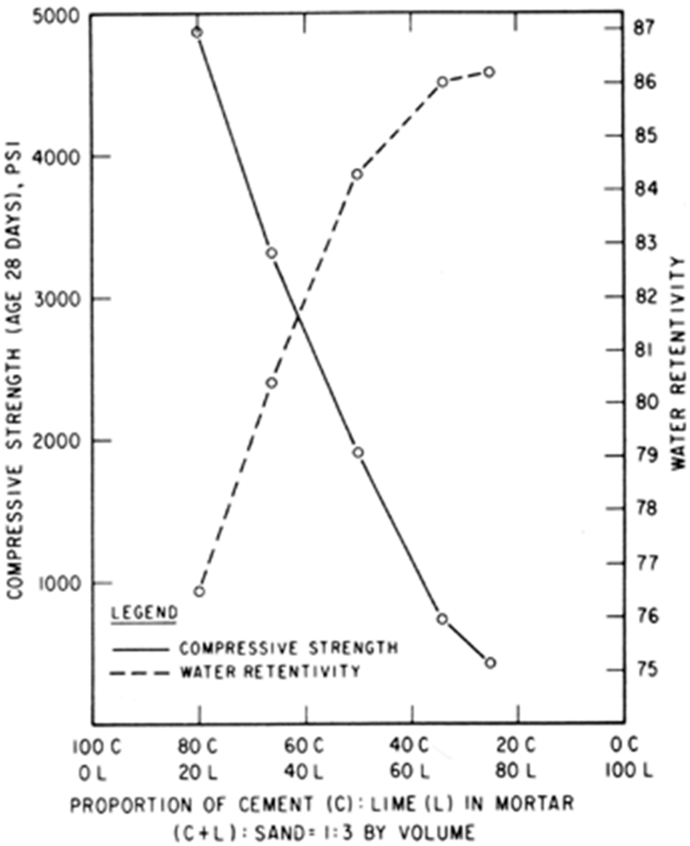

Figure 1. Relation of mortar composition, compressive strength, and water retentivity.

Between the two extremes, various combinations of cement and lime can provide a wide variety of properties - the "best of two worlds" - the high strength and early setting characteristics of cement modified by the excellent workability and water retentivity of lime. A designer who has clearly established his objectives should have no problem in identifying the mortar he wants by referring to Figure 1. The point at which the two curves cross, designating the mortar with the highest compressive strength compatible with optimum water retentivity, lies within the boundaries of a Type N mortar. This explains the extensive use of the 1:1:6 cement-lime mortar.

No discussion of cement-lime mortars is complete without mentioning their self-healing capability. In this process, sometimes referred to as autogenous healing, lime carried in solution in water moving through the masonry is deposited in cracks and crevices when the water evaporates. Successive deposits eventually fill the cracks.

Portland Cement-Masonry Cement

Masonry cement mortars generally have excellent workability and moderate strength. Small bubbles of entrained air contribute to the roller-bearing action and can, in fact, provide good workability with poorly graded aggregates. Increasing air content levels, however, are accompanied by decreasing compressive strength and, more important, by decreasing bond strength. This is a matter for concern because the specification does not contain a maximum air content value. Masonry cement mortars also have high sand-carrying capacities, and this feature is sometimes exploited to the detriment of the masonry. The addition of portland cement to masonry cement mortars increases their strength so that they can qualify as Types M and S.

It is difficult to predict the properties of masonry cement mortars because their composition is not published and may be altered without notice. Their use should be based on a knowledge of local performance.

On-Site Preparation

Careful attention to good practice on the construction site is essential in achieving the quality envisaged by the designer. Cementitious materials and aggregate should be protected from moisture, from both above and below. Proper batching procedures must be followed. Use of a shovel for measuring cannot be expected to produce mortar of consistent quality. A 1-cu-ft batching box is recommended, and sand quantities should be corrected for bulking.

Finally, more attention should be paid to mixing time. Too often it is determined by the demand at the working face rather than by what is good for the mortar. After the machine has been fully charged mixing time should be a minimum of 3 and a maximum of 10 minutes.