prescribes by volume the proportions of cementitious materials and aggregate for each mortar type. The *property specifications* are based on minimum compressive strength, minimum water retention, and maximum air content of laboratory-prepared samples made with a specified ratio of job-site sand.

The proportion requirements are conservative and, for cement-lime mortars, will generally yield compressive strengths higher than the minimums given in the property specification. Conversely, the minimum compressive strengths required by the property specification generally can be achieved with a smaller proportion of cement and lime than that prescribed under the proportion specification. The property specifications encourage preconstruction testing of sample mortar cubes for a mix design to gain the economic advantage of meeting strength requirements at lower cost. On larger projects, the savings in mortar costs will more than offset the cost of the laboratory testing. Since it is generally recommended to use the mortar type with the minimum necessary compressive strength, specifying mortar by the property requirement method assures that the mortar is not any stronger in compression than it needs to be. On smaller projects where the volume of mortar is much less, using the proportion specification saves the cost of laboratory mix designs and provides a high factor of safety in attaining adequate mortar strengths. However, it will usually yield mortars with higher compressive strengths than needed at the sacrifice of other properties.

If ASTM C270 is referenced in project specifications without indication as to whether the property or proportion method should be used, the proportion method always governs. The volume proportions used in ASTM C270 are based on weights per cubic foot of materials as listed in *Fig. 6-9*. The volume measurements for cement, lime, and sand are listed in *Fig. 6-10*. Mortar proportions may be calculated on full- and half-bag measures.

Material	Weight (lb/cu.ft.)
portland cement	94
hydrated lime	40
damp, loose sand	18.25

Figure 6-9 Weights of materials on which the proportion specification of ASTM C270 is based.

Material	Volume (cu.ft.)
1 bag portland cement	1.0
1 bag hydrated lime	1.0
1 ton wet sand	20.25
1 ton damp, loose sand	18.25
1 ton dry sand	16.25

Figure 6-10 Volume measurement of mortar materials.

The property specifications in ASTM C270 are for laboratory-prepared samples only, and the values will not correlate with those obtained from field samples tested under ASTM C780, *Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry*. Laboratory samples are made with a very low water-cement ratio, to simulate the moisture content of mortar after unit suction has occurred. Mortars mixed at the job site are made with much higher water-cement ratios because the units are absorptive and will immediately extract much of the mixing water from the mortar paste. Field-sampled mortars therefore typically yield a much lower compressive strength than laboratory-prepared mortar because of the difference in water content. In order to compare apples to apples, the same testing procedure must be used. If the project will require field sampling of mortar during construction for laboratory testing, ASTM C780 must be used both to set the preconstruction benchmark and to perform the construction phase testing. Results from ASTM C780 tests cannot be compared to results from ASTM C270 tests or to the minimum property requirements listed in ASTM C270. Because of the different water-cement ratios in the two test methods, the compressive strength values resulting from C780 field-sampled mortars are neither required nor expected to meet the minimum compressive strength requirements of C270, and they also do not represent the actual compressive strength of the mortar in the wall.

Until recently, there was no standardized test for hardened masonry mortar. ASTM C1324, *Standard Test Method for Examination and Analysis of Hardened Masonry Mortar,* now provides a standardized procedure for the petrographic and chemical analysis of hardened mortar samples to determine the proportions of ingredients used in the mix. The petrographic analysis is based on similar methods used to examine hardened concrete using a petrographic microscope and a stereoscopic low-power microscope, as well as X-ray diffractometry and scanning electron microscopy. The standard also includes methods for chemical analysis. The interpretation and calculation of chemical test results are dependent on results of the petrographic analysis and are not intended to be used alone. The chemical data and the petrographic analysis together are intended to determine mortar composition as represented by the proportion specifications in Table 1 of ASTM C270 as Types M, S, N, and O. Failure of a tested mortar specimen to comply with the proportion requirements of ASTM C270, however, does not necessarily mean that the mortar is not in compliance. Even though the proportions are different, the mortar may still meet the ASTM C270 property requirements. As yet, there is no standardized test to determine the compliance of hardened mortar samples with the property requirements of ASTM C270. Samples removed from a wall can be tested for compressive strength, but there is no correlation between these test results and the compressive strength requirements of ASTM C270.

6.4 SPECIALTY MORTARS

In determining the requirements for mortar performance, two very specialized areas demand detailed project analysis. Refractory mortars and chemical-resistant mortars are used primarily in industrial applications where exposure to extreme heat or toxic chemicals requires extraordinary mortar performance. Refractory mortars are also used in residential and commercial fireplaces.