lubricants in promoting flow of the mortar particles, but maximum air content is limited in mortars to minimize the reduction of bond strength. When structural reinforcement is incorporated in the mortar, cement-lime mixes are limited to 12% air content, and masonry cement mixes to 18%. Unlike concrete, mortar requires a *maximum amount of water* for workability, and retempering to replace moisture lost to evaporation should be permitted.

Variations in unit materials and in environmental conditions affect optimum mortar consistency and workability. Mortar for heavier units must be more dense to prevent uneven settling after unit placement or excessive squeezing of mortar from the joints. Warmer summer temperatures require a softer, wetter mix to compensate for evaporation. Although workability is easily recognized by the mason, the difficulty in defining this property precludes a statement of minimum requirements in mortar specifications.

### 6.1.2 Water Retention and Flow

Other mortar characteristics that influence general performance, such as aggregate grading, water retention, and flow, can be accurately measured by laboratory tests and are included in ASTM Standards. *Water retention* allows mortar to resist the loss of mixing water by evaporation and the suction of dry masonry units (*see Fig. 6-2*) to maintain moisture for proper cement hydration. It is the mortar's ability to retain its plasticity so that the mason can carefully align and level the units without breaking the bond between mortar and unit.

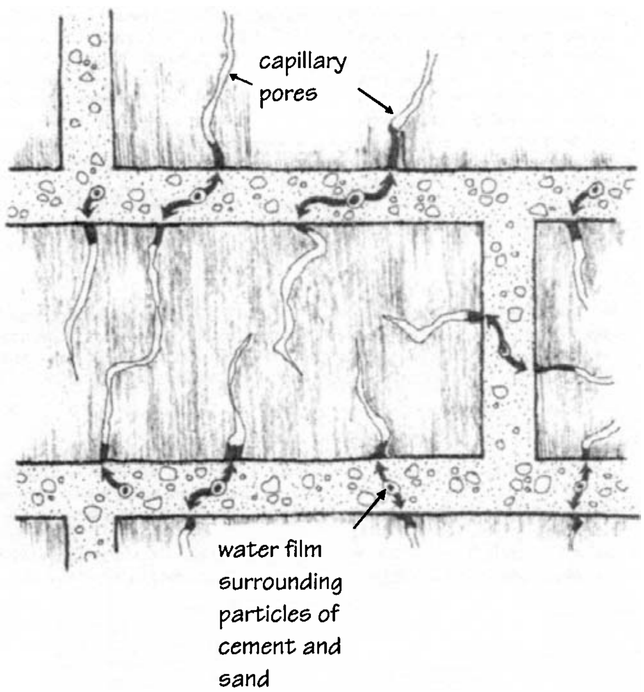


**Figure 6-2** Exaggerated section showing capillary suction of water from mortar mix by dry masonry units. *(Courtesy Acme Brick Company, Fort Worth, TX.)*

Highly absorptive clay units may be prewetted at the job site, but concrete products may not be moistened, thus requiring that the mortar itself resist water loss. Conversely, if low-absorption units are used with a highly retentive mortar, they may "float." Less retentive mortars may also "bleed" moisture, creating a thin layer of water between mortar and unit which can substantially reduce bond strength. Water retention generally increases as the proportion of lime in the mix increases (*see Fig. 6-3*). At one extreme, a mortar made with only portland cement and sand, without any lime, would have a high compressive strength but low water retention. At the other extreme, a mortar made with only lime and sand, without portland cement, would have low compressive strength but high water retention. High-suction units, especially if laid in hot or dry weather, should be used with a mortar that has high water retention (i.e., a higher proportion of lime). Low-suction units, especially if laid in cold or wet weather, should be used with a mortar that has low water retentivity (i.e., a lower proportion of lime). ASTM C91, *Standard Specification for Masonry Cements,* includes a water-retention test which simulates the action of absorptive masonry units, and mortar cements are tested for water retention in accordance with ASTM C1506, *Standard Test Method for Water Retention of Hydraulic Cement-Based Mortars and Plasters.*

Under laboratory conditions, water retention is measured by flow tests, and is expressed as the percentage of *flow after suction* to *initial flow*. The flow test is similar to a concrete slump test, but is performed on a "flow table" that is rapidly vibrated up and down for several seconds. Suction is

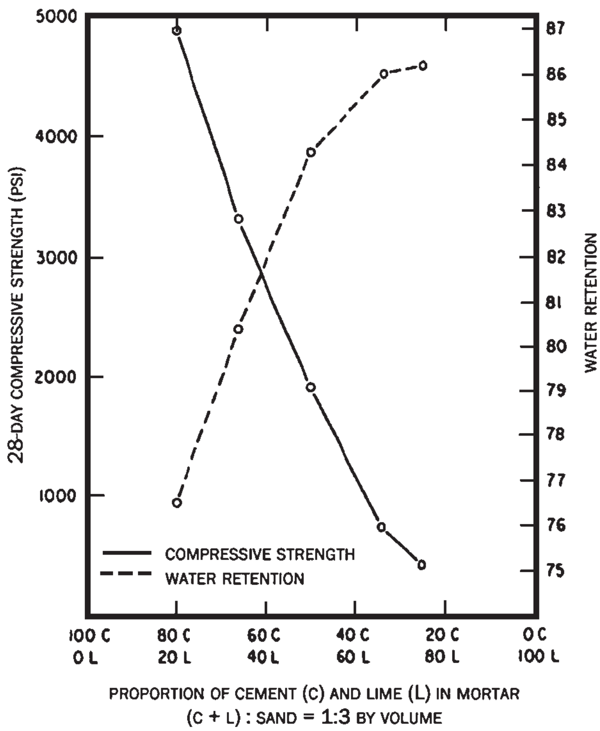


**Figure 6-3** As more lime is substituted for portland cement in mortar, water retention increases and compressive strength decreases. (*From Ritchie and Davison,* Cement-Lime Mortars, *National Research Council, Ottawa, Ont., Canada, 1964.*)