and fire resistance are also influenced, as well as color and texture. Lightweight aggregates increase the thermal and fire resistance of concrete masonry, but sound transmission ratings generally are lower because of reduced density. Moisture absorption is also generally much higher with lightweight aggregates. Lightweight aggregates are covered by ASTM C331, *Standard Specification for Lightweight Concrete Aggregates for Masonry Units.*

In an effort to recycle materials, reduce landfill demand, and economize production, some block manufacturers are now using crushed block as a portion of the aggregate content in manufacturing new units. Broken units are crushed and blended with new aggregate to save money on raw materials and to give contractors an alternative means for disposing of construction site debris. Currently about 50 to 60% of the block produced at some manufacturing plants uses at least some recycled material, and companies are finding new ways to blend aggregates in order to use more recycled material. Some federal agencies are already requiring certain percentages of recycled-content materials in new construction projects.

Concrete masonry colors resulting from the mix of aggregate and cement may range from white, to buff or brownish tones, to dull grays. Special colors may be produced by the use of selected crushed stones or the addition of special pigments. Color variation in units is affected by several things. Aggregate gradation should be carefully controlled during manufacture, but shipping of raw materials, particularly by rail, can cause separation of fine surface material from coarse aggregate. The degree of separation and resultant dust content varies from one shipment to the next, causing a variation in the color of the block (particularly with split face units). As ambient temperatures rise during the day, moisture evaporates from the aggregate. If the moisture content is not accurately monitored, particularly in hot climates, the drier aggregate effectively changes the water-cement ratio of the mix within a single day's production. Higher water-cement ratios produce lighter-colored block. Temperature and moisture variations in the kiln affect unit color, and units loaded first may also experience a slightly longer hydration period. Units which are air-dried can be significantly affected by changes in ambient temperature and relative humidity.

Surface textures depend on the size and gradation of aggregates. Classification of surface effects is only loosely defined as "open" or "tight," with either fine, medium, or coarse texture. Although interpretation of these groups may vary, an open surface is generally characterized by numerous large voids between the aggregate particles. A tight surface has few pores or voids of the size easily penetrated by water or sound. Fine textures are smooth, and consist of small, very closely spaced granular particles. Coarse textures are large grained and rough, and medium textures are, of course, intermediate. Both coarse and medium textures provide better sound absorption than the smoother faces, and are also recommended if the units are to be plastered.

The American Society for Testing and Materials (ASTM) has developed standards to regulate quality and composition. Within the limits of the required structural properties of the masonry, the architect may select different aggregates to serve other nonstructural functions required by building type, occupant use, or aesthetics.

### 2.2.2 Cements

The cementitious material in concrete masonry is normally Type I, all-purpose portland cement. Type III, high-early-strength cement, is sometimes used to provide early strength and avoid distortion during the curing process. The air-entraining counterparts of these two cements (Types IA and IIIA) are sometimes used to improve the molding and off-bearing characteristics of the uncured units, and to increase resistance to weathering cycles. Air entrainment, however, does cause some strength reduction.

### 2.2.3 Admixtures

Admixtures marketed chiefly for use in site-cast concrete have shown few beneficial or desirable effects in the manufacture of concrete masonry. Air entrainment facilitates compaction and the close reproduction of the contours of the molds, but increased air content always results in lower compressive strengths. Calcium chloride accelerators speed the hardening or set of the units, but tend to increase shrinkage. Water repellent admixtures are commonly used in decorative architectural block intended for exterior exposures without protective coatings. However, the bond between mortar and units (and consequently the flexural strength of the wall) will be seriously impaired unless the mortar is also treated with a chemically compatible admixture. ASTM Standards do not permit the use of any admixtures in concrete masonry without laboratory tests or performance records which prove that the additives are in no way detrimental to the performance of the masonry.

Architectural concrete masonry units are sometimes treated with an integral water-repellent admixture during manufacture to resist soil accumulations and to decrease surface water absorption. Some research indicates that calcium stearate–based products are more effective in creating hydrophobic surfaces than those based on oleic/linoleic acid chemistries, and are also less likely to leach out of the masonry. An integral water repellent which lasts the life of the masonry will provide more economical performance than a surface-applied water repellent which must be reapplied every few years. Whenever an integral water repellent is used in a concrete masonry product, compatibility and bond with mortar must be considered because the bonding characteristics of the unit are affected. CMU products that have been treated with an integral water repellent require mortar that has a compatible chemical admixture to promote better bond.

Special colors can be produced by using pure mineral oxide pigments, but many factors affect color consistency. Even in natural block, color variations can be caused by the materials, processing, curing, and weathering. In integrally colored units, such variations may be magnified. Natural aggregate colors are more durable, and more easily duplicated in the event of future additions to a building.

### 2.2.4 Manufacturing

Concrete masonry manufacturing consists of six phases: (1) receiving and storing raw materials, (2) batching and mixing, (3) molding unit shapes, (4) curing, (5) cubing and storage, and (6) delivery of finished units (*see Fig. 2-6*).

### 2.2.5 Material Preparation

Materials are delivered in bulk quantities by truck or rail. Aggregates are stored separately and later blended to produce different block types. Mixes will vary depending on aggregate weight, particle characteristics, and water absorp-