Guide to Portland Cement-Based Plaster

Reported by ACI Committee 524

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This guide provides information on the plastering process. The facets of plastering covered are the prequalification of materials, plaster tool and equipment requirements, plaster mixture proportions, plaster application procedures, types of finishes, and troubleshooting and repair. Portland cement-based plastering differs in many ways from that of the concrete trade. Differences in terminology are of key importance; therefore, a familiarization of plastering terminology is needed. Definitions of plastering terms are provided for this reason. This guide is intended for use by architects, engineers, designers, specification writers, contractors, plasterers, laboratory personnel, and public authorities for familiarization with the plastering processes and as an aid in specification writing.

Keywords: admixture; base; bond; brown coat; cement; cracking; curing; finish coat; furring; hydration; masonry; plaster; proportion; reinforcement; scratch coat; shrinkage; stucco; texture.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Portland cement-based plaster is a versatile and weather-resistant surfacing material. Portland cement-based plaster may be applied to flat, curved, or rusticated bases made from concrete, clay masonry, concrete masonry, woven or welded-wire mesh, or expanded metal lath. It can be applied by hand or pumped directly from a mixer hopper and sprayed onto a wall. Portland cement-based plaster has a long history of satisfactory performance. Proportions and workability of the plaster mixture allow for a variety of shapes, designs, and textures to be created. When plaster hardens, these features are preserved in a rigid, permanent form.

Plaster is categorized by the type of cement binder, number of coats, and total thickness. Traditional materials include portland cement and lime, blended cement and lime, masonry cement, or plastic cement mixed with sand and water. Additives to control time of set, reduce shrinkage cracking, increase workability, or increase durability can also be present.

This guide provides information and recommends minimum expectations for satisfactory lathing and plastering. Architects, engineers, designers, specification writers, contractors, plasterers, and public authorities can use this guide for familiarization with the plastering processes and as an aid in specification writing. Stricter requirements based on long-term successful field service or controlled laboratory experimentation and documentation can be imposed when a project warrants such treatment. This guide also addresses the prequalification of plaster materials, tool and equipment requirements, mixture proportions, application procedures, types of finishes, and troubleshooting and repair.

This guide refers to the structural integrity of plaster only when referring to the ability of plaster to perform the intended function as a coating. Plaster is not a member of construction having structural value, except as provided by local code.

The terms “stucco” and “portland cement-based plaster” are often used interchangeably in the trade. This guide, however, refers to stucco as plaster that is applied to an exterior surface, and portland cement-based plaster as plaster that is applied to either an interior or exterior surface.

1.2—Scope

Exterior insulation and finish systems (EIFS) are exterior wall-cladding systems that consist of an insulation board covered with an integrally reinforced base coat and a textured protective finish coat. Portland cement may be used in these systems, but their application and suitability are not covered in this guide. *Exterior Insulation and Finish Systems Design Handbook* (Robert 1997) provides useful information on this class of product.

The use of one-coat portland cement-based plastering systems and other such proprietary portland cement-based systems are acknowledged; however, they are beyond the scope of this document, which addresses only traditional two-coat or three-coat portland cement-based plastering systems. Alternative nontraditional and proprietary portland cement-based plastering systems are addressed in special reports, such as those written by the International Code Council (ICC Evaluation Service, Inc. 2006). One-coat systems and other proprietary systems typically rely on a proven performance history within the environment and region they are intended to be used and, where required by code, proprietary products may have special approval via a published Evaluation Services Report that specifies the installation procedure and allowed locations for its use.

Swimming pool plastering is considered an alternative nontraditional form of portland cement-based plastering in this guide. While many aspects of this guide are relevant to swimming pool plastering, information specific to swimming pool plastering can be found in reports by the Portland Cement Association's *Portland Cement Plaster/Stucco Manual* and the National Plasterers Council's *Technical Manual*.

CHAPTER 2—DEFINITIONS

Note: Asterisk after definition = term not found in text but defined for the benefit of the reader.

acid etching—the partial removal of a cementitious surface through controlled dissolution to expose sand or aggregates, roughen a smooth cementitious surface in preparation for cementitious coating material application, or create art, or an architectural finish.

acid washing—the cleansing of the plaster surface through controlled dissolution of surface deposits to remove efflorescence, dirt, or other unwanted stains.

adhesion—1) the state in which two surfaces are held together by interfacial effects that may consist of molecular forces, interlocking action, or both; and 2) the ability of a fresh plaster coat to adhere to a plaster base.

arris—the sharp, external corner edge that is formed at the junction of two planes or surfaces.

atomizer—a device that introduces air into the plaster during placement using a machine-applied plaster pump and gun. The atomizer, or air stem, of the plastering gun can be adjusted at the nozzle of the gun to regulate the spray pattern, which in turn alters the texture or pattern of the plaster that is sprayed onto the surface.

base screed—a preformed metal screed with perforated or expanded flanges to provide a guide for thickness and planeness of plaster and to provide a separation between plaster and other materials.

bead, arch corner—corner bead designed so that it can be job-shaped for use on arches.

bead, casing—a fabricated shape preinstalled where plaster terminates or around openings such as doors, windows, tops of walls, or dissimilar materials, to provide a stop or separation; sometimes called a plaster stop.

bead, metal corner—fabricated metal with flanges and nosings at the juncture of flanges, used to protect or form an arris. Refer to Table 7.1 for the minimum thickness of various bead assemblies.

bead, plaster—1) a member of a runner or support track; and 2) a precast plaster molding.

bleeding—the autogenous flow of mixing water within, or its emergence from, a newly placed cementitious mixture caused by the settlement of the solid materials within the mass; also called water gain.

blistering—the irregular raising of a thin layer at the surface of placed cementitious mixtures during or soon after completion of the finishing operation, or in the case of pipe, after spinning; also bulging of a finish coat as it separates and draws away from a base coat.

blocking (or **blocking in**)—1) a method of joining or filling between two intersecting planes of plaster. To fill with plaster, the entire thickness, from the base coat plaster or substrate up to the outer surface of the finish coat; and 2) a method of joining, reinforcing, securing, or providing thermal protection between two intersecting planes. To fasten a membrane or metal flashing that covers over the space between two intersecting planes.

bond, chemical—bond between materials that is the result of cohesion and adhesion developed by chemical reaction.

bond, mechanical—physical interlock created when a plastic cementitious mixture is placed and hardens to conform with the surface of the existing solid material.

bracket—1) an overhanging member projecting from a wall or other body to support weight acting outside the wall or a similar piece to strengthen an angle; and 2) formed shapes of channel or pencil rod used as structural reinforcement in erecting furred assemblies.

bridging—member sections sized to fit inside the flanges of studs and channels that act as braces to stiffen the members.

buckles—1) large lifted areas of a plaster coating that failed to properly bond to the substrate or to the plaster undercoat; and 2) raised hollow spots under a plaster, usually visible before rupture by tensile stress cracks within the portion of plaster over the buckle. See also **delamination**.

bull-nose—external angle that is rounded to eliminate a sharp arris or corner; may be tool-formed during the plaster application or an accessory that is fastened to the plaster base before plastering. See also **nosing**.

burnishing—1) to hard trowel the surface of concrete or plaster up to final set; and 2) to otherwise produce a very smooth surface.

butterflies—white spot imperfections that can occur in a lime-portland plaster finish due to lumps of lime that do not dissolve during mixing. These lumps can become incorporated into the plaster coating and subsequently dissolve, leaving a white spot on the plaster surface.

butterfly reinforcement—strips of metal reinforcement placed diagonally over the plaster base at the corner of openings before plastering.

catface*—1) blemish or rough depression in surface of a hard-troweled finish or other smooth texture finish caused by inadequate finishing techniques; and 2) blemish or rough depression in the finish plaster coat caused by variations in the base coat thickness.

ceiling track, ceiling runner track, or ceiling runner—1) a formed metal section anchored to the ceiling into which metal studs, or hollow or solid partitions, are set; 2) a structural reinforcement section or member to which lath is attached for studless partitions; and 3) the metal channel or angle used for anchoring the partition to the ceiling.

cement, air-entrained hydraulic—a hydraulic cement containing sufficient amounts of air-entraining agent to produce a cementitious mixture containing entrained air within specified limits.

cement, blended—a hydraulic cement essentially consisting of portland cement, slag cement, or both, uniformly mixed with each other or a pozzolan through intergrinding or blending.

cement, hydraulic—a binding material that sets and hardens by chemical reaction with water and is capable of doing so underwater. For example, portland cement and slag cement are hydraulic cements.

cement, masonry—a hydraulic cement used in masonry and plastering construction, containing one of more of the following materials: portland cement, slag cement, portland-pozzolan cement, natural cement, or hydraulic lime; and in addition usually containing one more materials such as hydrated lime, limestone, chalk, calcareous shale, talc, slag, or clay as prepared for this purpose.

cement, plastic—cement manufactured expressly for the plaster industry; a blended cement consisting of cement, lime, sometimes pozzolans, fillers, or additives that give plasticity, workability, and crack resistance to the cement and the plaster.

cement, polymer-modified—a hydraulic cement blended with a monomer or polymer.

cement, portland—a hydraulic cement produced by pulverizing clinker formed by heating a mixture, usually of limestone and clay, to 1400 to 1600 °C (2550 to 2900 °F). Calcium sulfate is ground with the clinker to control set.

channels—cold-rolled steel sections used as structural reinforcement in construction that attach to studs, furrings, or joists, of the walls or ceilings. Structural rolled metal that is attached to other channels or runners as a furring or stud. Channels are made of varying gauges of thickness that correlate directly with each channel's structurally intended use in construction. Refer to Table 5.3 for the various sizes allowed and their respective minimum allowable weights.

channels, carrying—main runners that are supported by hangers attached to the building structure and support the furring channels or pencil rods that support the lath.

channels, furring—1) the horizontal members of a suspended ceiling that support the lath. The channels are perpendicular to and supported by carrying channels or attached to a solid structural substrate; 2) the smaller horizontal members of a furred ceiling, also known as cross furring; and 3) the channels used to create space between the lath and a solid substrate.

chase*—space provided in a masonry or concrete wall for pipes or conduit.

clip—wire or sheet-metal device used to attach various types of lath to supports or to secure adjacent lath sheets.

clip, furring—a metal fastener used to attach cross furrings to main runners of ceilings.

coat—a film or layer as of paint or plaster applied in a single operation.

coat, base—any plaster coat or coats applied before application of the finish coat.

coat, bedding—a thick plaster coat that receives aggregate or other decorative materials that are manually placed or shot into the surface. Bedding coats are used to produce exposed aggregate finish or marblecrete finish.

coat, brown—the leveling coat plaster. The second coat of plaster in a three-coat application or the entire base coat of plaster in a two-coat application.

coat, dash-bond—a thick slurry of portland cement, sand, and water flicked on surfaces with a paddle or brush to provide a base for subsequent portland cement plaster coats, sometimes used as a final finish on plaster.

coat, finish—1) final thin coat of shotcrete in preparation for hand finishing; and 2) final exposed coat of plaster or stucco.

coat, flash—a light coat of shotcrete used to cover minor blemishes on a concrete surface.

coat, fog—a light coat of cement and water or plaster, with or without aggregate or color pigment, rapidly and uniformly spray-applied to a plaster finish to improve texture, improve color consistency, level low areas, maintain a workable surface, or prevent surface drying on double-back coats.

coat, scratch—the first coat of a plaster or stucco applied with sufficient pressure to create a good mechanical bond with the base, and usually cross-raked to provide a mechanical key with the brown coat.

cohesion—the ability of a cementitious mixture to hold together and remain consistent during mixing, pumping, placing, and finishing processes.

cold joint*—see **joint, cold**.

combing tool—1) a tool used to scarify, cross-scratch, or score the surface of a scratch coat or undercoat of plaster. See also **scarifier**; and 2) a tool used to create the combed plaster finish and other scored texture finishes.

contact ceiling*—a ceiling that is secured in direct contact with the construction above without use of furring.

corner lath—an inside corner reinforcement section for interior plastering or exterior stuccoing where the corner bead is cut, or is not continuous, around an internal corner or at intersecting planes.

cove*—a curved or concave surface created on the inside corner transition from wall to ceiling or from step to riser. The inside curve, or cove, is created by using a cove molding or formed with plaster using a cove tool.

cracking, check—1) random crack pattern of a plaster surface that may self-heal through ongoing hydration and curing process. Also known by the slang terms of map cracking, chip cracking, pattern cracking, or eggshell cracking; and 2) small cracks associated with normal moisture loss from within plaster during set and overall consolidation; and 3) the development of shallow cracks at closely spaced but irregular intervals at the surface.

cracking, craze—fine random cracks or fissures in the surface of a plaster.

cracking, hairline—surface cracks having widths so small as to be barely perceptible.

cracking, plastic—cracking that occurs in the surface of a fresh mixture soon after it is placed and while it is still plastic.

cracking, shrinkage—cracking of a cementitious material due to failure in tension caused by external or internal restraints as reduction in moisture content develops, carbonation occurs, or both.

cracking, structural movement—the cracking of a plaster coat due to the structural movement of the supporting member, metal lath, wood frame, or solid substrate.

craze cracks—see **cracking, craze**.

cross furring—the smaller horizontal members that attach at right angles to the underside of main runners or other structural supports.

cross scratching—the scoring of the surface of a coat of plaster on a ceiling in different directions before applying the next coat of plaster to provide a better mechanical bond.

curing—action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur so that the potential properties of the mixture may develop (refer to ACI 308R). See also **hydration** and **setting**.

curtain wall*—a non-load-bearing exterior wall supported by the structural elements of a building.

dado*—the lower portion of a wall that is usually separated from the upper portion by a molding or other material.

darby—a hand-manipulated straightedge, usually 3 to 8 ft (1 to 2.5 m) long, used in the early-stage leveling operations of concrete or plaster, preceding supplemental floating and finishing.

delamination—splitting, cracking, or separation of a cementitious material in a plane roughly parallel to, and generally near, the surface. Delamination generally affects large areas and can often only be detected through nondestructive tests such as tapping or chain dragging across the surface.

diamond mesh—see **metal lath, diamond mesh**.

discoloration—departure of color from that which is normal or desired. See also **mottling**.

dot—a small lump of plaster placed onto the base coat, or small pieces of metal, wood, or nails can be set and perform similar function, as a ground or depth gauge to assist the plasterer in obtaining proper plaster thickness and surface plane.

double-back—method of plastering that is characterized by the application of two or more coats in succession with little or no setting or drying time between coats.

double-up—two or more coats of plaster, characterized by the double-back method of plastering, that form one integral coat.

efflorescence—a generally white deposit formed when water-soluble compounds emerge in solution from concrete, masonry, or plaster substrates and precipitate by reaction such as carbonation, or crystallize by evaporation.

elastomer—any macromolecular material, such as rubber or a synthetic material having similar properties, that returns rapidly to approximately the initial dimensions and shape after substantial deformation by a weak stress and release of stress.

enrichments*—any cast ornament that cannot be executed by a running mold.

expanded metal lath—see **metal lath, diamond mesh**.

finish coat—see **coat, finish**.

fireproofing membrane*—1) a lath and plaster system that is designed to separate the structural steel members, in most cases by furring or suspension, creating a hollowed area that acts as a fire stop or resistance to the spread of fire; and 2) a material or assembly designed to withstand fire or give protection from it; as applied to elements of buildings, it is characterized by the ability to confine a fire or, when exposed to fire, to continue to perform a given structural function, or both, for a given time period of one, two, or occasionally more hours.

flaking—see **spalling**.

flash coat—see **coat, flash**.

float—1) a flat, trowel-like tool with varying surface textures of metal, wood, plastic, or sponge that allows a plaster technician to properly work, open, level, or finish plaster; 2) a soft float, typically made of sponge rubber, used to roughen or open up the plaster surface, or to retemper the plaster surface, or to promote even drying time across a plaster coating; 3) a hard float, typically made of hard rubber, hard plastic, or wood, used for smoothing, compacting, and fine-tuning the leveling process after a screed, straightedge, or darby is used; and 4) a float that is used to create the float finish and other textured plaster surface finish.

floating—1) the operation of finishing the surface of a fresh cementitious mixture using a float, preceding troweling when that is to be the final finish; and 2) the operation of finishing a plaster surface to achieve float-finish texture.

floor track, **floor runner track**, or **floor runner***—1) formed metal section, anchored to the floor, into which metal studs for hollow or solid partitions are set; 2) a structural reinforcement section or member to which lath is attached for studless partitions; 3) a wood member into which lath is inserted for studless partitions; and 4) the metal channel used for anchoring the partition to the floor.

fog coat—see **coat, fog**.

framing—structural members such as columns, beams, girders, studs, joists, headers, and trusses.

fresco*—art or decorative method consisting of a water-soluble paint that is applied to freshly spread plaster before it dries.

furred ceiling—a ceiling composed of lath and plaster that is attached to the structure by means of steel channels, rods, or furring strips in direct contact with the construction above.

galvanized—coated with zinc to inhibit rusting.

gauge—thickness of sheet metal or diameter of wire (refer to Table 5.2 for U.S. steel wire gauge diameters and their respective inch-pound and metric conversion factors).

glazing*—a condition created by the fines of a machine-applied, dash-textured plaster migrating to the surface and producing a flattened texture and shine or discoloration. This may be caused by excessive mixing water in the base coat, acoustical mortar, or other finishes of lean mixture proportions having excessive mixture water. Glazing can also occur from working a plaster that is wet, or overworking a plaster.

glitter*—reflective material, such as certain mineral sands, glass, or other materials that are either forced into the surface of a fresh finish coat of plaster or added as an integral part of the mixture proportions. It is sometimes necessary to expose the glitter by washing, power washing, acid washing, or sandblasting the surface.

grillage*—the ceiling framework composed of main runner channels and furring channels to support the plaster.

ground—wood or metal strips attached to the framing or plaster base that protrude outward, acting as a gauge to aid the plasterer in maintaining a given thickness and plane of the plaster.

gusset*—wood or metal plate connecting two or more members, such as truss members, to transfer stresses between the members.

hairline cracking—see **cracking, hairline**.

hangers—1) vertical members that carry the steel framework of a suspended ceiling; 2) the vertical members that support furring under concrete joist construction; and 3) the wires used in attaching lath directly to concrete joist construction.

hawk—a tool used by plasterers to hold and carry plaster mortar; generally a flat piece of wood or metal approximately 10 to 12 in. (250 to 300 mm) square, with a wooden handle centered and fixed to the underside.

hog ring*—a fastening mechanism using a heavy, galvanized-wire staple applied with a pneumatic gun that clinches the staple in the form of a closed ring around a stud, rod, pencil rod, or channel.

hydration—formation of a compound by the combining of water with some other substance; in cementitious materials, the chemical reaction between hydraulic cement and water. See also **curing** and **setting**.

isolation joint—see **joint, isolation**.

joining—the juncture of two separate plaster applications of the same coat, usually within a single surface plane.

joint, cold*—a joint or discontinuity resulting from a delay in placement of sufficient duration to preclude the intermingling and bonding of the material where mortar of plaster rejoin or meet.

joint, control—1) a separation joint that limits cracking of plaster by reducing stress using a designed joint that allows dimensional reduction of the plastered area or a designed joint that allows complete separation of the plaster and a dissimilar material, including the interruption of the metal lath; and 2) formed, sawed, or tooled groove in a concrete structure to create a weakened plane to regulate the location of cracking resulting from the dimensional change of different parts of the structure.

joint, isolation—a separation between adjoining parts of a plaster that allows the least interference of relative movement to the structure in three directions, usually a vertical plane, yet avoids formation of cracks in the plaster. Typically, all or part of the bonded reinforcement is interrupted.

key—1) to create a mechanical bond between a plaster coat and another surface by roughening, scratching, scoring, etching, or otherwise creating a surface that the plaster can interlock into; and 2) to mechanically fasten or fix into position in a notch, score, or other recess.

laitance—a layer of weak material derived from a cementitious material and aggregate fines either: carried by bleeding to the surface or to internal cavities of freshly placed cementitious mixture; or separated from the cementitious mixture and deposited on the plaster surface or internal cavities during placement of a cementitious mixture under water.

lath—a framework that is secured to the framing, furring, or other members of a structure, providing a base and reinforcement for the plaster. See also **metal lath**.

lather—a technician who installs lath.

leveling coat—see **coat, brown**.

lime—specifically, calcium oxide (CaO); loosely, a general term for the various chemical and physical forms of quicklime, hydrated lime, and hydraulic hydrated lime. See also **lime, hydrated**.

lime, hydrated—calcium hydroxide, a dry powder obtained by treating quicklime with water.

line wire*—see **string wire**.

lubricate—the act of applying moisture to a plaster surface or to a trowel that enables a plasterer to perform the hard-trowel finish.

main runners—the heaviest suspended ceiling supporting members, or carrying channels, that support the furring channels or rods to which the lath is fastened and are supported by hangers attached to the building structure.

marblecrete—see **seeding**.

masonry cement—see **cement, masonry**.

mechanical application—the application of a cementitious mixture directly onto a ceiling or wall using a pumping machine that transports the fresh mixture through hoses to a nozzle or spray gun.

mechanical bond—see **bond, mechanical**.

mechanical trowel—a motor-driven tool with orbiting steel trowels used to produce a dense finish coat.

metal arch*—sheet steel-formed arch used as a plaster base or corner reinforcement at arched openings in partitions.

metal base—a fabricated metal section attached to framing members or masonry, to reinforce the plaster, and also serves as a ground for gauging plaster thickness. See also **plaster base**.

metal lath—a galvanized steel network to which plaster can be applied. Metal lath is of three types: diamond mesh (expanded or flat-expanded), woven-wire mesh, or welded-wire mesh. Refer to Tables 5.4, 5.5, and 5.6 for the minimum specifications for spacing and support factors of various metal laths.

metal lath, 3/8 in. (10 mm) rib—combination of expanded metal lath with roll-formed ribs of a total depth of approximately 3/8 in. (10 mm), measured from top inside of the lath to the top outside of the rib.

metal lath, diamond mesh or **flat expanded**—a metal network, often used as reinforcement in construction, formed by suitably stamping or cutting sheet metal and stretching it to form open meshes, of either diamond-shaped or rhomboidal-shaped openings.

metal lath, flat rib—combination of expanded metal lath with roll-formed ribs in which the rib has a total depth of approximately 1/8 in. (3 mm) measured from top inside of the lath to the top outside of the rib, and galvanized.

metal lath, paper-backed or **expanded stucco mesh**—a factory-assembled combination of any of the defined types of metal laths or expanded stucco mesh laths with a paper, or other backing, the assembly being used as a plaster or stucco base.

metal lath, self-furring—metal lath that includes a means of holding the lath away from the supporting surface to allow for full embedment of the metal into the cementitious material.

metal lath, sheet—metal lath formed from sheet metal that is slit and expanded or stamp-punched.

mottling—uneven color shading or blotchiness across a surface. See also **discoloration**.

nosing—a rounded edge formed by shaping freshly placed material or by attaching a preformed molding.

nozzle operator—the technician who manipulates the nozzle of a placing machine and controls placement of the fresh cementitious mixture.

orifice*—an attachment to the nozzle of a plastering gun. Orifices of various sizes aid the plasterer by establishing the spray pattern of the plaster as it is projected onto the surface being plastered.

plaster—1) a mixture consisting essentially of a cementitious material or materials, fine aggregate, and water that forms a plastic mass. When applied to a surface, the mixture adheres to it and subsequently hardens; 2) the placed and hardened mixture; and 3) the act of placing such material.

plaster base—any surface that is suitable for the application of plaster. Metal lath, wire mesh, concrete or clay masonry units, shotcrete, and plaster undercoats are examples of potential structural substrates. See also **metal base** and **solid base**.

plaster membrane—the total thickness of all the plaster coats, including any embedded reinforcement such as metal lath or wire mesh.

plastering machinery—machinery that allows plaster to be mixed and transported directly to the placement area. The plaster is first mixed in a mortar mixer that empties into a plaster pumping machine, which then forces the plaster through flexible hoses to a plastering gun or nozzle, allowing the nozzle operator to spray the plaster directly onto a wall or ceiling.

plastic cement—see **cement, plastic**.

plasticizer—a material that increases the plasticity of fresh cementitious mixture.

polymer-modified plaster—a mixture of water, hydraulic cement, sand, and a monomer or polymer.

pop-offs*—1) the separation of a coat of plaster from itself; 2) the separation of the plaster from the plaster base. See also **buckles**.

pop-outs—the breaking away of small portions of a concrete, mortar, or plaster surface due to localized internal pressure that leaves a shallow, typically conical, depression.

portland cement-based plaster—a plaster mixture containing portland cement as the primary or only binder.

pozzolan—a siliceous or siliceous and aluminous material that of itself possesses little or no cementitious value but that will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties; there are both natural and artificial pozzolans.

racking*—the forcing out-of-plumb of a panel, wall, or structural component by external forces such as wind, thermal expansion or contraction, or other stresses over the plane of the structural section.

relief—a carving, embossing, or ornamental figure that either projects through, or is fastened onto, the surface of the plaster.

retemper—to add water and remix a cementitious mixture to restore workability to a condition in which the mixture is placeable or usable. See also **temper**.

return—the turn and continuation of a wall or projection in a different direction.

rock gun*—a tool used for propelling aggregate into a fresh plaster coat.

rod—1) a tool that is used as a straightedge or screed to provide a uniform and level surface across a plaster coat usually by trimming to a ground or dot; and 2) a tool used as a guide for the scoring (combed) finish or similar repeating pattern finish; or 3) a sharp-edged cutting screed used to trim shotcrete to forms or ground wires.

runner—a metal structural support member that is attached to the main structure or to concrete. See also **ceiling track** or **floor track**.

saddle tie—1) a specific method of wrapping hanger wire around main runners; and 2) a specific method of wrapping tie wire around the juncture of a main runner and a cross furring.

scarifier—a tool with flexible steel tines used to scratch or rake the first coat of plaster before final set. See also **cross scratching**.

scoring—1) the grooving, usually horizontally, of the scratch coat to provide mechanical bond between a scratch coat and a brown coat or leveling coat; and 2) a decorative horizontal grooving of the finish coat. See also **scarifier**.

scratch coat—See **coat, scratch**.

scratching tools—any hand tool used to scratch, notch, or roughen a coat of plaster to provide a mechanical bond for the following coat of plaster. A scoring tool, drag, devil float, scarifier, comb tool, and stiff-bristled broom or stiff-bristled brush are all examples of scratching tools.

screed—1) to strike off a cementitious mixture lying beyond the desired shape; 2) a tool for striking off the cementitious mixture surface, sometimes referred to as a strikeoff; and 3) a ribbon or pad of a cementitious mixture that is preplaced to act as a guide for maintaining the desired level as more material is placed.

screed, ventilating—a prefabricated bead accessory, also known as a draft bead or draft stop, that permits circulation of air from the outside and allows escape of water and moist air from inside while preventing air draft.

screeding—the operation of forming a surface using a screed.

seeding—embedding aggregate into the plaster coat just after initial set or as soon as the plaster can receive the aggregate without sagging. Seeded aggregate is also called exposed-aggregate finish or marblecrete finish.

set—1) the reaction mechanism that takes place in which the physical, chemical, or mechanical properties develop as a cementitious material changes from a fresh plastic phase to a hardened solid phase in the presence of adequate moisture. See also **hydration**; and 2) the condition reached by a cementitious material when it has lost plasticity to an arbitrary degree usually measured by resistance to penetration or deformation.

setting—1) the time required for a cementitious material to go from being freshly mixed or plastic to rigid or hard; and 2) the degree to which a cementitious material has set. For plaster, setting times of importance are: initial set, midset, and final set as the timing of each troweling or tooling is determined by the setting of the plaster. See also **hydration**.

shielding*—a method of protecting adjacent work by positioning temporary protective covering or taping off. The plastering spray gun application is of particular concern due to the potential overspray.

shoe—a formed metal section that is used to attach metal studs to floors and ceiling tracks.

shrinkage cracking—see **cracking, shrinkage**.

skim coat—see **coat, fog**.

slobber*—any unnecessary plaster overspray, dropped or splattered plaster, or accidental wiping off of excess plaster from a tool or trowel onto the surface. These blemishes are typically easy to remove by sanding or grinding the excess plaster off the surface of the plaster after it has hardened.

solid base—a solid cementitious or clay structure that is able to receive a plaster coating, as opposed to a lath plaster base, which attaches to a frame or solid structure but is not itself a structural member. Examples of potential solid substrates are brick, block, gunite, shotcrete, and concrete.

spall—a fragment usually in the shape of a flake, detached from a larger mass by a blow, the action of weather, pressure, or by expansion within the larger mass.

spalling—the development of spalls.

sponge float—a soft trowel-like tool used for floating the plaster finish. See also **float**.

staff*—a plaster cast ornamental design or detail made in a mold and reinforced with fiber. A staff is generally wired, nailed, glued by adhesive, or cemented into place before the plastering application.

stiffener*—a horizontal metal shape tied to vertical structural members (studs or channels) or to partitions or walls to brace and stiffen the framework.

straightedge—see **rod**.

string wire*—soft annealed steel wire placed horizontally around a building of open stud construction that supports waterproofing paper or felt.

stucco—a portland cement-based plaster used for coating exterior walls or other exterior surfaces. See also **plaster**.

suction*—the capacity for absorption possessed by a solid plaster base substrate or a plaster undercoat. A solid surface having a good suction capacity can increase the bonding capability of the plaster being applied; however, too much suction capacity can remove critical mixing water from a plaster and affect the bond and the strength of the plaster negatively.

surface hardener—a chemical, including certain fluosilicates or sodium silicate, applied to the surface of a hardened plaster to reduce chemical attack and dusting.

suspended ceiling—a ceiling suspended from, but not in direct contact with, the overhead construction.

temper—to add water to a cementitious mixture as necessary to initially bring the mixture to the desired workability. See also **retemper**.

three-coat plastering—a method of plastering in three successive coats: the bond coat or scratch coat; the double, leveling coat, or brown coat; and the texture coat or finish coat.

tie, butterfly*—a method used to attach lath, using tie wire. The butterfly tie is a method of fastening whereby the tie wire is twisted together, then cut, leaving tails. These tails of the tie wire are then bent outward in opposite directions.

tie, stud*—a method used to attach lath, using tie wire. The stud tie, or saddle tie, is a method of fastening whereby the tie wire is twisted together then cut at the twist, leaving no tails.

tie wire*—a soft annealed steel wire used to join support members and attach lath to supports and accessories such as staffs and certain ornamental moldings.

trowel—1) a flat, broad-blade steel hand tool used in the final stages of finishing operations to impart a relatively smooth surface to concrete floors and other unformed concrete surfaces; 2) a flat, triangular-blade tool used for applying mortar to masonry; or 3) a flat, broad-blade steel hand tool used to place, spread, shape, finish, or otherwise apply materials.

turtle back*—1) a term synonymously used with blistering; and 2) a term used regionally to denote a small, localized area of wind crazing.

two-coat plastering—a method of plastering in two successive coats usually done by performing a double-up, or double-back, procedure. This can be achieved in one of two ways: the bond coat or scratch coat, followed by the double, leveling coat, or brown coat, which also acts as the texture or finish coat; or the bond coat or scratch coat, which also acts as the double, leveling coat, or brown coat followed by the finish coat or texture coat.

wainscot*—the lower portion of an interior wall that is finished differently from the remainder of the wall, generally in wood.

washout—1) a lack of proper coverage and texture buildup in an area of the plaster coat of a machine-applied dash-texture caused by the mortar being too soupy; and 2) the washing away of an applied plaster coating in an area where the plaster base or substrate was too wet or continues to weep water.

welded-wire mesh lath—see **metal lath**.

wire cloth lath*—a plaster reinforcement consisting of a wire mesh having a minimum wire thickness of 19 gauge

(0.041 in. [1.04 mm]), with at least 2-1/2 meshes per in. (25 mm) and coated with zinc or rust-inhibitive paint. Wire cloth lath should not be used as reinforcement for exterior plastering.

woven-wire mesh lath—see **metal lath**.

zinc alloy—a metal made of 99% zinc and only enough alloying elements to provide durability and formability.

CHAPTER 3—DESIRABLE PROPERTIES OF PORTLAND CEMENT-BASED PLASTER

3.1—Introduction

Portland cement-based plaster should have fresh properties that promote proper application and hardened properties that provide long-term service. A properly proportioned plaster should possess the fresh plaster properties of adequate adhesion, cohesion, and retain workability long enough to achieve the desired finish. A hardened plaster should establish and maintain bond with the substrate and be weather resistant and durable. The color and texture of the finish coat should be uniform in appearance.

3.2—Fresh plaster

Fresh portland cement-based plaster should exhibit adequate adhesion, cohesion, and workability characteristics.

3.2.1 *Adhesion*—Adhesion is achieved by employing proper application techniques, using appropriate mixture proportions, and properly preparing the plaster base or substrate that is to receive the fresh plaster. Proper application techniques include forcing the initial coat, or scratch coat, into the plaster base using a trowel or float. In this manner, a good mechanical bond is created with a solid substrate or around a lath or wire mesh support network. Appropriate mixture proportions should be adjusted to optimize the adhesion capability of plaster. Supplemental or retemper water may be necessary when highly absorptive solid substrates or evaporation levels cause plaster to dry before setting. Mixture proportions can be adjusted within guidelines of ASTM C926 to optimize adhesion under various conditions. The cementitious material-to-sand ratio (*cm/s*), selection of cementitious materials, shape and gradation of sand, and quantity of lime and water can all be adjusted to produce the desired adhesion characteristics.

Preparation of a solid substrate is important. Surfaces should be clean and free of debris. Solid surface substrates should be chipped, scabbled, acid washed, waterblasted, sandblasted, or otherwise prepared to achieve the roughness needed to create a proper bond. Solid substrates that are capable of absorbing mixing water from plaster should be moistened before application of the initial plaster coat. Prewetting a highly-absorptive solid substrate lowers its absorptive capacity. Prewetting also aids in initiating the absorption process, which enhances adhesion of the initial plaster coat, permitting it to absorb or penetrate into the substrate. Wetting the substrate also allows the plaster to retain more of the mixing water for a longer period of time (Section 3.2.3).

Preparation of a hardened undercoat to receive a subsequent fresh plaster coat includes: cross scratching, scoring horizontally, floating, or otherwise creating roughness to permit plaster to interlock and bond to the undercoat. As with other solid substrates, the materials, mixture proportions, and preparation of the plaster-surface undercoat enhance adhesion characteristics. The undercoat should be free of laitance or surface efflorescence, which can inhibit adhesion. The undercoat should be moistened before applying fresh plaster.

3.2.2 *Cohesion*—Cohesion is important during mixing, placing, and finishing applications. Application techniques having little or no time passing between placement of successive coats, such as double-back and flash-coat applications, rely on the cohesion ability of both fresh plaster coats to become integrally combined.

3.2.3 *Workability*—Workability is the ease with which the plaster is placed, shaped, floated, tooled, and finished. To achieve the best workability, materials used in the plaster should be properly proportioned and thoroughly combined during mixing. Any changes to the mixture, such as *cm/s*, cementitious materials, shape and gradation of sand, and quantity of lime or water in the plaster mixture, can influence workability. A more workable plaster can be obtained by including certain additives in the mixture proportions. Plaster having poor workability requires greater effort to properly place and finish the material, which in turn lessens the quality, durability, and aesthetic appearance of the plaster.

3.3—Hardened plaster

Hardened portland cement-based plaster should have the following characteristics:

3.3.1 *Weather resistance*—Hardened portland cement-based plaster should have the ability to withstand weathering, including resistance to wind and rain, freezing and thawing, and temperature and moisture gradients. Anticipated exposures to acid rain, aggressive chemicals, harmful soils, and other deleterious environmental factors should be considered when selecting a plaster mixture proportions that will be durable to exposure conditions (ACI 201.2R).

Plaster should shed most rainwater, and should subsequently release any absorbed water or water vapor. To achieve a proper installation and reduce failures associated with moisture intrusion, the following practices are recommended:

- Two layers of weather barrier backing or other moisture barrier;
- Flashing at doors and around windows, vents, and all other openings or wall penetrations through the plaster;
- Weep screed or other similar drainage accessory; and
- Caulking or sealing of doors, windows, and other openings or penetrations through the plaster.

3.3.2 *Sulfate resistance*—Hardened plaster exposed to a sulfate environment can experience severe deterioration. Chemical sulfate attack is usually found where plaster is exposed to soil containing soluble sulfate. In the presence of moisture, soluble sulfate can enter a plaster or solid-base substrate.

Resistance to sulfate environments can be enhanced using an ASTM C150 Type II portland cement, an ASTM C150 Type V portland cement, a masonry cement, a plastic cement that is designed for sulfate resistance, or an ASTM C595 or ASTM C1157 blended hydraulic cement designed for sulfate resistance, as defined in ACI 201.2R. A suitable pozzolan, slag cement, or other admixture, as defined in ACI 201.2R, may also be used in combination with an ASTM C150 Type I or II portland cement to provide sulfate resistance. Additional precautions may include application of a water-resistant surface coating or penetrating sealer to the portion of plaster below grade, termination of the plaster approximately 6 in. (150 mm) above grade, or both.

3.3.3 *Durability*—Proper plaster mixture proportions (Chapter 10), proper placement, troweling and tooling techniques (Chapter 11), additives such as pozzolans and polymers (Sections 4.6 through 4.9), and proper curing techniques (Chapter 13) are all important to the durability of plaster.

3.3.4 *Tensile strength*—Tensile strength is the ability of a material to resist internal stress created when an applied force is directed away from a given plane or point within the material. Hardened portland cement-based plaster generally has a low tensile strength compared with the tensile stress that is generated by structural movement, warping of a plaster base, or thermal expansion and contraction. Incorporating control joints to relieve or redistribute tensile stress is recommended (Section 5.5). Also, the tensile strength of hardened plaster can be increased with the addition of certain polymers, pozzolans, and alkali-resistant fibers into the mixture proportioning. Increasing tensile strength can increase plaster's resistance to cracking and its ability to resist flexural movements or warping of the structure. Proper curing is also important (Chapter 13).

CHAPTER 4—PORTLAND CEMENT-BASED PLASTER MATERIALS

4.1—Introduction

Portland cement-based plaster materials should comply with building codes and project specifications. Packaged materials should be labeled properly, indicating the manufacturer, brand name, and recommendations for use. Packaged materials that can be damaged by moisture should be protected. Proprietary plaster materials should be mixed in accordance with manufacturer's recommendations. Each ingredient of a plaster mixture should be compatible with all other ingredients of the plaster mixture. Materials should be selected that are suitable for a given environment.

4.2—Cements

The cements used in a portland cement-based plaster mixture can include any of the following:

1. Portland cement, conforming to ASTM C150 or C1157 (gray or white), type as required;
2. Blended cement, conforming to ASTM C 595 or C1157 (gray or white), type as required;
3. Masonry cement conforming to ASTM C91, Types N, S, and M, or UBC Standard 21-11;
4. Plastic cement conforming to ASTM C1328, Types S or M, or UBC Standard 25-1; and
5. Mortar cement conforming to ASTM C1329, Types N, S, and M, or UBC Standard 21-14.

Sulfate-resistant cement, masonry cement, or supplementary cementitious materials (SCMs) may be considered where a plaster, or a plaster substrate, is in contact with an aggressive sulfate soil or an aggressive sulfate groundwater condition (ACI 201.2R). Low-alkali portland cements conforming to ASTM C150 or blended cements conforming to ASTM C595 or C1157 should be used when an aggregate contains potentially reactive material. Alternatively, suitable combinations of cement and SCMs that have been proven effective against sulfate attack or reactive aggregates, and having reference documentation available, may be used.

Air-entraining cements may be used where available. Masonry cements, mortar cements, and air-entrained portland cements, however, should be pretested when used in combination with air-entraining admixtures.

4.3—Lime

The lime used in a portland cement-based plaster mixture should be a hydrated lime conforming to ASTM C206 or C207, Type S, or Type S with air entrainment. Hydrated lime promotes plasticity, water retention, and workability, and aids in controlling shrinkage cracking. Air-entrained lime should not be used in combination with air-entrained cement.

4.4—Aggregates

The aggregates used in a portland cement-based plaster mixture should be either natural or manufactured sand conforming to ASTM C897. Aggregates should be clean and free of elements that cause discoloration, rust, or deleterious reaction with cementitious materials when in the presence of moisture. Lightweight aggregates, such as perlite or vermiculite, should conform to Table 1 of ASTM C35. Perlite and vermiculite can be advantageous in ceiling applications due to their lower mass per unit volume and in other applications due to their sound absorbing and insulating qualities. They should not be used, however, in the base coat of plaster. Lightweight aggregate tends to be more absorptive than normalweight aggregate, and highly absorptive aggregate can behave poorly in freezing-and-thawing situations.

When ASTM C897 aggregates are not available, ASTM C144 aggregates can be substituted. The use of substandard aggregate can result in a weaker and less-durable plaster. Aggregates that are frozen should be thawed before use.

4.5—Water

Potable water is generally acceptable to use as plaster mixing water. Water used in mixing and curing portland cement-based plaster should be clean and free from damaging amounts of deleterious materials such as oils, acids, alkalies, organic matter, or salts. Such substances may impair the setting or curing characteristics of the plaster. Certain minerals or metals can stain or discolor the plaster when present in appreciable amounts.

4.6—Admixtures

The following admixtures can be added when permitted by the project specifications.

4.6.1 *Air-entraining admixtures*—Air-entraining admixtures that conform to ASTM C260 reduce water demand, absorption, and water penetration, while improving workability and resistance to freezing-and-thawing damage. Air-entraining admixtures should be pretested when used with masonry cement or lime, as certain air-entraining admixtures could behave adversely. Household-type soaps or detergents should not be substituted for appropriate air-entraining admixtures.

4.6.2 *Calcium chloride*—Calcium chloride should conform to ASTM D98. Calcium chloride is available in liquid, powder, flake, and prill (pea-sized granule) form. When calcium chloride is in flake or prill form, it should be dissolved in water before being added to the plaster mixture. Calcium chloride, or accelerating admixtures containing significant amounts of calcium chloride, should not be used when portland cement-based plaster will come into contact with metal lath, anodized aluminum, galvanized steel, or zinc accessory products. Calcium chloride can accelerate the corrosion rate of metals. Prolonged embedment of metal within a high-chloride plaster can cause corrosion expansion of the metal and cracking of the plaster. Noncorrosive accelerating admixtures meeting ASTM C494/C494M are recommended in situations where acceleration of set is desired, but corrosion to embedded metal is a risk. Calcium chloride can also cause mottling to be more exaggerated (Section 15.5).

4.6.3 *Water reducers*—Water-reducing admixtures and certain plasticizers that conform to ASTM C494/C494M can be used to reduce the water-cementitious material ratio (w/cm) of a portland cement-based plaster. Water reducers can potentially increase strength, increase workability, and reduce shrinkage cracking. Manufacturer's recommendations should be observed when using water-reducers or plasticizers. Small changes in admixture quantities can have significant effects on the properties of portland cement-based plaster.

4.6.4 *Water-repellent admixtures*—Stearate emulsions, not to exceed 2% by mass of cement, may be used to improve water repellency and decrease absorption of the hardened plaster. Some of these emulsions may also entrain air. Stearates can reduce bond between plaster coats, and stearates' water-repellent effects can degrade with time.

4.6.5 *Pigments*—Coloring agents should be uniform in color, free of lumps, and should conform to ASTM C979. To avoid strength reductions, the pigment content should not exceed 10% of the weight of the cement, and the use of lamp black or carbon black is not recommended. Only mineral pigments should be used as coloring agents. Darker-colored pigments tend to absorb light and heat, while lighter-colored pigments tend to reflect light and heat.

4.6.6 *Supplementary cementitious materials*—SCMs, such as certain clays or pozzolans conforming to ASTM C618, can be used as plasticizers to improve the workability of a plaster, facilitating mixing, pumping, placing, and finishing. Certain SCMs can aid in the control of plaster's set. SCM can also improve the durability characteristics of plaster by adding resistance to sulfate attack, acid attack, carbonation, leaching of cement compounds, and other durability-related properties. Refer to ACI 232.1R for more information. The manufacturer's recommendations should be observed for all admixtures or additives that are used as new ingredients to a plaster mixture.

4.7—Fibers

Fibers used in plaster should conform to ASTM C1116/C1116M and may consist of glass, nylon, polypropylene, or carbon fibers. Glass fibers that are used in a portland cement-based plaster mixture should be alkali resistant. Glass fibers that are not alkali resistant can deteriorate in the presence of alkalis that are present in plaster. Fibers are used to improve cohesion, reduce shrinkage, and reduce plastic cracking. Fibers can increase the impact resistance and tensile strength properties of a plaster. Fibers can, however, make plaster more difficult to pump and finish. When specified, fibers should be added to the mixture in the manner and amount recommended by the manufacturer.

4.8—Bonding agents

Bonding agents are used to increase the adhesive bond between a clean, structurally sound substrate surface, such as concrete, brick, clay masonry or concrete masonry units, and plaster coating. Surface-applied bonding agents can be applied directly to the substrate surface (see Section 9.6). Integral bonding agents are added into the plaster during mixing to increase the ability of plaster to adhere to the substrate (see Section 9.7). Bonding agents should be used in accordance with the manufacturer's instructions.

4.8.1 *Surface-applied bonding agents*—Surface-applied bonding agents are single-component, ready-to-use liquids that are applied by brush, roller, or spray. Surface-applied bonding agents should conform to the requirements of ASTM C631 for interior plaster, or ASTM C932 for exterior plaster. The manufacturer's recommendations should be referenced for specific application instructions. Latex bonding agents for interior plaster should conform to ASTM C1059 Type I or II, ASTM C932, and ASTM C631. Surface-applied nonredispersible latex bonding agents that conform to ASTM C1059 Type II can be used for exterior plaster or where resistance to rehydration from high humidity or water-immersion environments is needed.

4.8.2 *Integral bonding agents*—Integral latex-based bonding agents are generally added into the mixing water at the job site to promote bond. Doses of integral bonding agent can vary from manufacturer to manufacturer, but are generally based on percent solids by weight of cementitious materials. Latex bonding agents should also conform to ASTM C1059 (Type II) nonredispersible. Nonredispersible latex bonding agents can be used in exterior applications exposed to high moisture or high humidity and have been shown to be resistant to rehydration in high humidity or water-immersion environments.

4.9—Polymers

Polymers used as admixtures to modify the properties of traditional cementitious binders are within the scope of this guide. These polymers enhance water repellency (Section 4.6.4), bonding (Section 4.8), plasticity, and workability (Sections 3.2.3 and 4.6.1).

Polymers that are the primary binder component, or a cobinder with traditional cementitious binders, are not in the scope of this guide. These products are typically marketed as polymer-modified plaster or polymer-based plaster; however, the cementitious portion of the mixture proportions, if any, is generally present as cobinder or filler. Many proprietary prepackaged products fall into this category.

CHAPTER 5—DESIGN CONSIDERATIONS FOR PLASTER BASES

5.1—Introduction

Lath and plaster may be applied over open framing, framing with sheathing, masonry, or monolithic concrete. Structural substrates should be evaluated for structural integrity, compatibility with portland cement-based plaster, and ability to achieve satisfactory mechanical bond with plaster. Plaster can also be applied without lath, directly onto masonry and concrete (Chapter 9). Conventional open framing consists of wood or metal studs. Wood studs that are not kiln dried can have as much as 19% moisture content. As moisture is lost, the wood studs can shrink and distort as they dry, resulting in deformation of the structure and cracking of the plaster. To minimize moisture content, wood studs and wood sheathing should be protected from wetting during job-site storage. Conventional open-frame construction is also subject to variations in plaster thickness across a wall or panel, which increases the potential for cracking.

Line wire should be installed to support paper backing and woven-wire mesh lath. Wherever rounded corners are desired, the edges of wood studs and beams should be chamfered to a 45-degree angle, enabling a full thickness of plaster at the corners.

Deep-set windowsills, tops of parapets and handrails, and any wall surface installed in a plane of less than 60 degrees from the horizontal should be given special consideration. These surfaces are considered horizontal members, and should be protected or otherwise treated to inhibit moisture intrusion, much like a roof. Lath and plaster on a horizontal, or a nearly horizontal, surface should be considered only as a cosmetic finish coating because they will provide little or no moisture protection.

5.2—Design considerations for ceilings

Non-load-bearing ceilings should be isolated; constructed without having direct attachment to the main structure to prevent the transfer of movement or vibration. Allowances should be made for deflection of overhead beams and slabs. Proper hanger placement is necessary for ceiling channels to support lath and plaster while being kept free from abutting walls. Suspended ceilings should not be restricted from free movement, and should terminate without attaching to the walls. Various codes and standards have established support requirements. Tables 5.1 through 5.3 give support spacing and material requirements for ceiling runners, as specified in

Table 5.1—Allowable support or hanger wire spacing, ft-in. (mm) and cold-rolled channel main runner spans, ft-in. (mm)*†‡ (ASTM C1063-99, Table 2)

Member size, in. (mm)	Member weight, lb/1000 ft (kg/m)	Span condition†‡	Uniform load = 12 lb/ft^2 (0.57 kPa)				
			Member spacing, in. (mm)				
			24 (610)	36 (914)	48 (1220)	60 (1520)	72 (1830)
			Allowable hanger wire or support spacing, ft-in. (mm)				
1-1/2 (38.1)	414 (0.615)	Single	3-6 (1070)	3-1 (940)	2-9 (840)	2-7 (790)	2-5 (740)
		Two or more	4-11 (1500)	4-2 (1270)	3-7 (1090)	3-2 (970)	2-11 (890)
2 (50.8)	506 (0.753)	Single	3-9 (1140)	3-3 (990)	3-0 (910)	2-9 (840)	2-8 (810)
		Two or more	5-2 (1570)	4-6 (1370)	4-1 (1240)	3-10 (1170)	3-7 (1090)
2-1/2 (63.5)	597 (0.888)	Single	3-11 (1190)	3-5 (1040)	3-2 (970)	2-11 (890)	2-9 (840)
		Two or more	5-5 (1650)	4-9 (1450)	4-4 (1320)	4-0 (1220)	3-10 (1170)
Member size, in. (mm)	Member weight, lb/1000 ft (kg/m)	Span condition†‡	Uniform load = 15 lb/ft^2 (0.72 kPa)				
			Member spacing, in. (mm)				
			24 (610)	36 (914)	48 (1220)	60 (1520)	72 (1830)
			Allowable hanger wire or support spacing, ft-in. (mm)				
1-1/2 (38.1)	414 (0.615)	Single	3-3 (990)	2-10 (860)	2-7 (790)	2-4 (710)	2-2 (660)
		Two or more	4-6 (1370)	3-8 (1120)	3-2 (970)	2-10 (860)	2-7 (790)
2 (50.8)	506 (0.753)	Single	3-6 (1070)	3-1 (940)	2-10 (880)	2-7 (790)	2-5 (740)
		Two or more	4-10 (1470)	4-3 (1300)	3-10 (1170)	3-6 (1070)	3-3 (990)
2-1/2 (63.5)	597 (0.888)	Single	3-8 (1120)	3-3 (990)	2-11 (890)	2-9 (840)	2-7 (790)
		Two or more	5-0 (1520)	4-5 (1350)	4-0 (1220)	3-9 (1140)	3-6 (1070)

*Allowable span notes:
1. Bare metal thickness of cold-rolled main runners shall be not less than 0.0538 in. (1.367 mm).
2. Inside corner rail shall not be greater than 1/8 in. (3.19 mm).
3. Spans based on upper flange of main runners laterally unbraced.
4. Maximum deflection limited to 1/360 of the span length.
5. Steel yield stress F_y shall be not less than 33,000 psi (228 MPa).
6. Uniform load 12 lb/ft^2 (dry density) shall be used for portland cement plaster ceilings with plaster thickness up to 7/8 in. (22 mm) and 15 lb/ft^2 shall be used for ceilings with plaster thickness over 7/8 in. (22 mm) and not more than 1-1/4 in. (32 mm).
7. "Two or more" spans refers to two or more continuous, equal spans,
8. For the "Two or more" span condition, listed spans represent the center-to-center distance between adjacent supports.

†This table is designed for dead loads. Specific conditions, such as exterior installations in high-wind areas, require additional engineering.

‡Where uplift assistance is required for suspended ceiling to resist negative forces, the architect or engineer of record should select the method to be used.

ASTM C1063. The standard also provides detailed information on fastening attachments.

5.3—Spacing considerations for supports

Building codes and other regulations stipulate the maximum allowable span for each type of metal base, based on the mass per unit area and configuration. The requirements of ASTM C1063 are shown in Table 5.1. Some manufacturers have tested their products on spans greater than those shown in these references; therefore, approvals by model or local building codes have been granted for longer spans as well.

In addition to stating maximum allowable spans for runners, ASTM C1063 also stipulates maximum allowable support spacings for metal bases as shown in Table 5.4. The Uniform Building Code stipulates maximum allowable support spacings for various types of lath and for various types of fastening attachments, as shown in Tables 5.5 and 5.6.

5.4—Sheathing

A more uniform plaster thickness can be obtained when open framing is covered with solid sheathing, such as exterior gypsum wall board, insulation board, expanded polystyrene, oriented strand board, or plywood. Plywood or oriented strand board sheathing should be installed with a minimum

Table 5.2—United States steel wire gauge diameters (ASTM C 1063-99, p. 507, inset table)

Wire gauge (U.S. steel wire gauge)	Diameter, in.	Diameter, mm
No. 20	0.0348	0.88
No. 19	0.0410	1.04
No. 18	0.0475	1.21
No. 17	0.0540	1.37
No. 16	0.0625	1.59
No. 14	0.0800	2.03
No. 13	0.0915	2.32
No. 12	0.1055	2.68
No. 11	0.1205	3.06
No. 10	0.1350	3.43
No. 9	0.1483	3.77
No. 8	0.1620	4.12

Table 5.3—Channels (adapted from ASTM C1063-99, p. 506, inset table)

Channels—Shall be cold-formed from steel with minimum 33,000 psi (228 MPa) yield strength and 0.0538 in. (1.37 mm) minimum bare steel thickness. Channel should have a protective coating confirming to Specification A653-G60, or have a protective coating with an equivalent corrosion resistance for exterior applications, or shall be coated with a rust inhibitive paint, for interior applications, and shall have the following minimum weights in pounds per 1000 linear feet (kg/m).

Sizes, in. (mm)	Weight, lb/1000 ft (kg/m)	Flange width, in. (mm)
3/4 (19)	277 (0.412)	1/2 (13)
1-1/2 (38)	414 (0.616)	1/2 (13)
2 (51)	506 (0.753)	1/2 (13)
2-1/2 (64)	597 (0.888)	1/2 (13)

Note: Channels used in areas subject to corrosive action of salt air shall be hot-dipped galvanized, G-60 coating.

Table 5.4—Types and weights of metal plaster bases and corresponding maximum permissible spacing of supports (adapted from ASTM C1063-99, Table 3)

Type of metal plaster base	Minimum weight of metal plaster base, lb/yd^2 (kg/m^2)	Maximum permissible spacing of supports center to center, in. (mm)				
		Walls (partitions)			Ceilings	
		Wood studs or furring	Solid partitions*	Steel studs or furring	Wood or concrete	Metal
U.S. nominal weights:						
Diamond mesh†	2.5 (1.4)	16 (406)‡	16 (406)	16 (406)‡	12 (305)	12 (305)
	3.4 (1.8)	16 (406)‡	16 (406)	16 (406)‡	16 (406)	16 (406)
Flat rib	2.75 (1.5)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)
	3.4 (1.8)	19 (482)	24 (610)	19 (482)	19 (482)	19 (482)
Flat rib (large opening)	1.8 (0.95)	24 (610)	24 (610)	24 (610)	16 (406)	16 (406)
3/8 in. (9.5 mm) rib	3.4 (1.8)	24 (610)	N/A§	24 (610)	24 (610)	24 (610)
	4.0 (2.1)	24 (610)	N/A	24 (610)	24 (610)	24 (610)
3/4 in. (19 mm) rib	5.4 (2.9)	24 (610)	N/A	24 (610)	36 (914)	36 (914)
Welded wire†	1.4 (0.8)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)
	1.95 (1.1)	24 (610)	24 (610)	24 (610)	24 (610)	24 (610)
Woven wire†	1.1 (0.6)	24 (610)	16 (406)	16 (406)	16 (406)	24 (610)
	1.4 (0.8)	24 (610)	16 (406)	16 (406)	24 (610)	16 (406)
Canadian nominal weights:						
Diamond mesh†	2.5 (1.4)	16 (406)	12 (305)	12 (305)	12 (305)	12 (305)
	3.0 (1.6)	16 (406)	12 (305)	12 (305)	12 (305)	12 (305)
	3.4 (1.8)	16 (406)	16 (406)	16 (406)	16 (406)	16 (406)
Flat rib	2.5 (1.4)	16 (406)	12 (305)	12 (305)	12 (305)	12 (305)
	3.0 (1.6)	16 (406)	16 (406)	16 (406)	16 (406)	13-1/2 (343)
3/8 in. rib	3.0 (1.6)	19 (482)	N/A	16 (406)	16 (406)	16 (406)
	3.5 (1.9)	24 (610)	N/A	19 (482)	19 (482)	19 (482)
	4.0 (2.1)	24 (610)	N/A	24 (610)	24 (610)	24 (610)

*Where plywood is used for sheathing, a minimum of 1/8 in. (3.2 mm) separation shall be provided between adjoining sheets to allow for expansion.

†Metal plaster bases shall be furred away from vertical supports or solid surfaces at least 1/4 in. (6.3 mm). Self-furring lath meets furring requirements, except furring of metal lath is not required on supports having a bearing surface of 1-5/8 in. (41.3 mm) or less.

‡These spacings are based on unsheathed walls. Where self-furring lath is placed over sheathing or a solid surface, the permissible spacing of supports shall be not more than 24 in. (610 mm).

§Not applicable.

Table 5.5—Types of lath: maximum spacing of supports (UBC Table 25-B)

Type of lath[*]		Minimum weight per square yard (× 0.38 for kg/m^2) Gauge and mesh size (× 25.4 for mm)	Vertical, in. (× 25.4 for mm) Wood	Vertical, Metal: Solid plaster partitions	Vertical, Metal: Other	Horizontal, in. (× 25.4 for mm) Wood or concrete	Horizontal, Metal
1. Expanded metal lath (diamond mesh)		2.5	16[†]	16[†]	12	12	12
		3.4	16[†]	16[†]	16	16	16
2. Flat rib expanded metal lath		2.75	16	16	16	16	16
		3.4	19	24	19	19	19
3. Stucco mesh expanded metal lath		1.8 and 3.6	16[‡]	—	—	—	—
4. 3/8 in. (9.5 mm) rib expanded metal lath		3.4	24	24[§]	24	24	24
		4.0	24	24[§]	24	24	24
5. Sheet lath		4.5	24	24[§]	24	24	24
6. Wire fabric lath	Welded	1.95 lb, 0.120 in. (No. 11 B. W. gauge), 2 x 2 in.	24	24	24	24	24
		1.16 lb, 0.065 in. (No. 16 B. W. gauge), 2 x 2 in.	16	16	16	16	16
		1.4 lb, 0.049 in. (No. 18 B. W. gauge), 1 x 1 in.[ǁ]	16[§]	—	—	—	—
	Woven	1.1 lb, 0.049 in. (No. 18 B. W. gauge), 1-1/2 in. hexagonal[ǁ]	24	16	16	24	16
		1.4 lb, 0.058 in. (No. 17 B. W. gauge), 1-1/2 in. hexagonal[ǁ]	24	16	16	24	16
		1.4 lb. 0.049 in. (No. 18 B. W. gauge), 1 in. hexagonal[ǁ]	24	16	16	24	16

[*]Metal lath and wire fabric lath used as reinforcement for cement plaster shall be furred out away from vertical supports at least 1/4 in. (6.4 mm). Self-furring lath meets furring requirements. **EXCEPTION:** Furring of expanded metal lath is not required on supports having a bearing surface width of 1-5/8 in. (41 mm) or less.
[†]Span may be increased to 24 in. (610 mm) with self-furred metal lath over solid sheathing assemblies approved for this use.
[‡]Wire backing required on open vertical frame construction except under expanded metal lath and paperbacked wire fabric lath.
[§]May be used for studless solid partitions.
[ǁ]Woven wire or welded wire fabric lath not to be used as base for gypsum plaster without absorbent paperbacking or slot-perforated separator.

Table 5.6—Types of lath: attachment to wood and metal[*] supports (UBC Table 25-C)

Type of lath	Nails[†‡] Type and size	Nails Maximum spacing[#] Vertical	Nails Maximum spacing[#] Horizontal	Screws[‡§] Maximum spacing[#] Vertical	Screws[‡§] Maximum spacing[#] Horizontal	Staples[‡ǁ] (round or flattened wire) Wire gauge no.	Staples Crown	Staples Leg	Staples Maximum spacing[#] Vertical	Staples Maximum spacing[#] Horizontal
	in. (× 25.4 for mm)					in. (× 25.4 for mm)				
1. Diamond mesh expanded metal lath and flat rib metal lath	4d blued smooth box 1-1/2 in.[**] No. 14 gauge 7/32 in. head (clinched)[††]	6	—	6	6	16	3/4	7/8	6	6
	1 in. No. 11 gauge 7/16 in. head, barbed	6	—							
	1-1/2 in. No. 11 gauge 7/16 in. head, barbed	6	6							
2. 3/8 in. (9.5 mm) rib metal lath and sheet lath	1-1/2 in. No. 11 gauge 7/16 in., barbed	6	6	6	6	16	3/4	1-1/4	At ribs	At ribs
3. 3/4 in. (19.1 mm) rib metal lath	4d common 1-1/2 in. No. 12-1/2 gauge 1/4 in. head	At ribs	—	At ribs	At ribs	16	3/4	1-5/8	At ribs	At ribs
	2 in. No. 11 gauge 7/16 in., barbed		At ribs							
4. Wire fabric lath[‡‡]	4d blued smooth box (clinched)[††]	6	—	6	6					
	1 in. No. 11 gauge	6	—							
	7/16 in. head, barbed					16	3/4	7/8	6	6
	1-1/2 in. No. 11 gauge 7/16 in. head, barbed					16	7/16	7/8	6	6
	1-1/4 in. No. 12 gauge	6	6							
	3/8 in. head, furring	6	6							
	1 in. No. 12 gauge 3/8 in. head	6								

[*]Metal lath, wire lath, wire fabric lath, and metal accessories shall conform to approved standards.
[†]For nailable non-load-bearing metal supports, annular threaded nails or approved staples should be used.
[‡]Approved wire and sheet metal attachment clips may be used.
[§]Screws should be an approved type long enough to penetrate into wood framing not less than 5/8 in. (15.9 mm) and through metal supports adaptable for screw attachment not less than 1/4 in. (6.4 mm).
[ǁ]With chisel or divergent points.
[#]Maximum spacing of attachments from longitudinal edges shall not exceed 2 in. (51 mm).
[**]Supports spaced 24 in. (610 mm) on center. Four attachments per 16 in. (406 mm) wide lath per bearing. Five attachments per 24 in. (610 mm) wide lath per bearing.
[††]For interiors only.
[‡‡]Attach self-furring wire fabric lath to supports at furring device.

1/8 in. (3 mm) clearance on all sides, in accordance with ASTM C1063, Table 3, Footnote A, to allow for expansion in case the plywood or oriented strand board gets damp. Sheathing board that is not water resistant should have an additional layer of water-resistant building paper under the paper-backed metal base to prevent the absorption of moisture from the plaster. The Engineered Wood Association (APA) (2006) provides recommendations for the use and installation of wood structural panel wall sheathing as a substrate for exterior stucco.

5.5—Stress relief

Control joints are required when plaster is applied over a metal base. Control joints should be used over existing joints in the substrate and at changes in the substrate materials. Control joints divide or reduce the size of the plaster panel, which provides relief from stress, as described in Section 3.3.4. There are three types of control joints used in plastering.

1. *Scoring the plaster surface or cutting the plaster.* Scoring is the partial severing or notching of the plaster coating. Cutting is the total severing of the plaster membrane, including lath and plaster. Cutting is considered to be the more effective method;

2. *Grooving the plaster using a temporary control joint.* Grooving is used at the juncture of a solid substrate and a frame support network or at the juncture of dissimilar plaster bases. Grooving is created by installing a temporary ground or control joint into the fresh plaster finish coat and then removing the ground or control joint when the plaster has attained sufficient strength. The groove that remains should be filled with a weather-resistant caulk material; and

3. *Insertion of a permanent control joint or expansion joint accessory.* Control joint accessories are typically one-piece accessories that allow for the expansion and contraction of the plaster and minor movement of the structure. Expansion joints accessories are typically two- or three-piece accessories that allow for moderate stress relief in areas anticipated to crack, such as intentionally designed structural movement of the substrate, unbridged framing, movement occurring in more than one direction, story shift, and thermal expansion. Lath and plaster systems cannot accommodate unexpected or excessive movements. Expansion joint accessories used in plastering should not be confused with expansion joints used in concrete, or in the structure itself. Plaster expansion joint accessories are not intended for use in structural applications, and have no fire rating.

The weather-resistant paper backing, or other barrier backing, should continue uninterrupted behind stress-relief joints; however, the lath should be interrupted and tied on each side of stress-relief joints so that the joints can function properly and completely separate the plaster membrane. Stress-relief joints can be fabricated by installing casing beads back-to-back with a flexible barrier of caulking or sealant behind the casing beads and on the back side of flanges. Terminations or splices in stress-relief joints should be embedded within a weather-resistant elastic sealant to prevent moisture penetration.

The spacing between control joints should conform to ASTM C1063. Control joints for walls or vertical members should be installed to delineate the plaster into sections having a maximum of 144 ft^2 (13.4 m^2) of surface area. Control joints for ceilings or horizontal members should be installed to delineate the plaster into sections having a maximum of 100 ft^2 (9.3 m^2) of surface area. The distance between control joints should not exceed 18 ft (5.4 m) in either direction. The desired aspect ratio allows for panels to be as near to square as possible. The longer dimension of a ceiling or wall panel, or other surface area, should not exceed the shorter dimension by more than a factor of 2-1/2 times.

Stress-relief joint accessories should be installed where ceiling framing or furring changes direction and wherever joints occur in the framing or junctures between the framework and a dissimilar plaster base material. Control joints in plaster coatings that have masonry, shotcrete, or other solid substrate may be spaced farther apart than control joints in plaster coatings having a metal lath, wire mesh, or welded-wire mesh plaster base over open framing; however, stress-relief joints should be placed over existing stress-relief joints in the solid substrate.

The type of plaster finish should be considered when selecting control joint locations because certain finishes can lessen the extent to which cracks and control joints are visible or noticeable. The visibility of cracks and control joints is reduced by finishes that are rough, have a coarse depth of texture, or a thickness variation of multileveled high and low depths of texture across the surface of the plaster. Cracks and control joints are more noticeable in a plaster coating having a smooth, consistent, and level surface finish. Closer control joint spacing may reduce the size and noticeability of cracking in some plaster finishes.

The designer should show the selected location of stress-relief joints on the contract drawing elevations. Stress-relief joints should be located as near as possible to the area or plane of greatest structural stress or weakness, where cracking is more likely to occur. Locations that are likely to crack are:

1. Headers and sill corners of windows, doors, and other architectural projections or penetrations into plaster;

2. Edges and corners of ventilation or heating vents;

3. Structural plate lines or concentrations of large timber members in wood construction;

4. Midpoints between frame supports or midpoints between maximum control-joint spacings;

5. Junctures where main columns or structural beams meet walls or ceilings;

6. Plastering over expansion joints or control joints of a solid plaster base; or

7. Plastering over junctures of dissimilar plaster bases.

Generally, plastering is done from multistage scaffolding. Each plaster coat is generally applied one staging level at a time. Unsightly laps can be avoided if horizontal stress-relief joints are designed and placed at the scaffold staging levels. Changes in the plane of a panel or the addition of other construction materials across the panel can also serve as a stopping point between staging levels.

5.6—Design considerations for reduction of water intrusion

The designer should consider the following recommendations as a precaution against water intrusion:

1. Specify and detail the installation of flashing, weep screeds, and sealant at doors and around windows, vents, and all other wall penetrations to ensure that water will be diverted or channeled to the outside of the wall assembly in accordance with ASTM C1063 and E2112;

2. Specify and detail measures to minimize plaster cracking, including:
   a. Proper location of stress-relief joints in accordance with ASTM C1063; additionally, control joints at re-entrant corners may be recommended, though not required by code;
   b. Proper curing in accordance with ASTM C926 with consideration for local climatic conditions; and
   c. Usage of fibers in the scratch and brown coats;

3. Specify and detail the use of sealant at stress-relief joint terminations and splices;

4. Specify and detail the use of sealant at all wall penetrations to prevent leakage at these points;

5. Specify and detail the use of building papers, house wraps, and other weather-resistant barriers that have shown proven performance within the region, when used with local methods and construction materials;

6. Specify and detail compliance to thickness tables of ASTM C926 as metal lath, like concrete reinforcing steel and masonry joint reinforcement, should have a certain amount of cover to provide protection from water intrusion and subsequent corrosion, deterioration, and expansion; and

7. Where necessary, the use of an appropriate coating material (see ACI 515.1R), which will provide adequate resistance to water intrusion, should be applied in accordance with manufacturer's instructions and recommendations.

CHAPTER 6—METAL LATH PLASTER BASES

6.1—Introduction

Three types of metal lath plaster bases are commonly used for the application of portland cement-based plaster:

1. Expanded metal laths, either diamond mesh (Fig. 6.1) or rib lath (Fig. 6.2).

2. Woven-wire mesh lath (Fig. 6.3).

3. Welded-wire mesh lath (Fig. 6.4).

6.1.1 *Expanded metal lath (ASTM C841, C847, and C1063)*—The expanded metal lath plaster base is fabricated from coils of steel that are slit and then expanded, forming a diamond-shaped mesh-like pattern. Expanded metal lath is available in a flat, self-furred, or rib style, and with or without a weather-barrier backing (Section 6.2).

Finished sheets should be 27 in. (685 mm) wide by 96 in. (2440 mm) long. The mass per unit area is determined by the thickness (gauge) of the base steel. Nominal mass per unit area can be 1.75, 2.5, or 3.4 lb/yd^2 (0.95, 1.4, or 1.8 kg/m^2), respectively.

Metal lath that is used for interior plastering is coated with a corrosion-resistant film such as asphalt or electroplated galvanizing. Metal lath used for exterior plastering is a hot-dipped galvanized metal and should have a G-60 coating in accordance with ASTM A653/A653M.

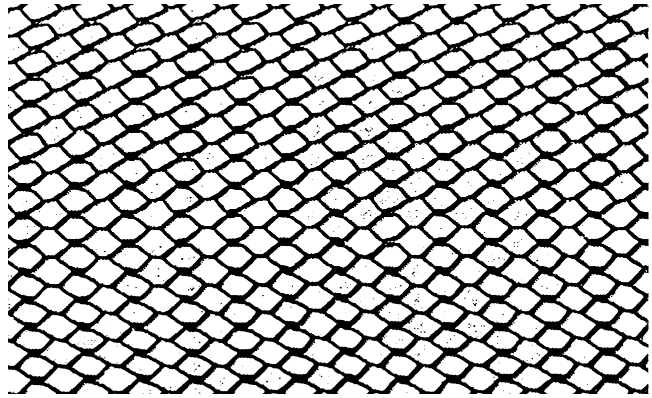


Fig. 6.1—Diamond mesh lath.

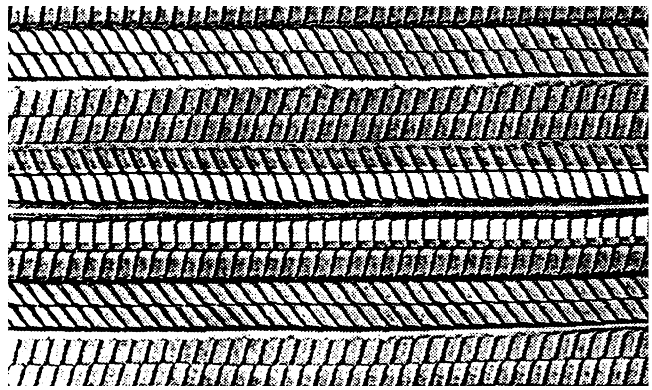


Fig. 6.2—3/8 in. (9.5 mm) rib lath.

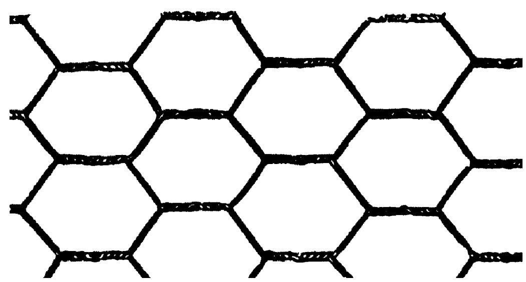
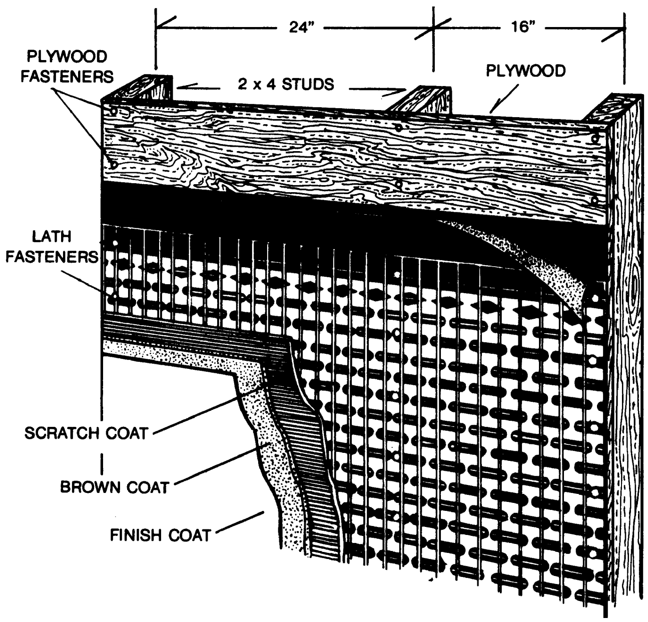


Fig. 6.3—Woven-wire mesh lath (figure courtesy of K-Lath, Monrovia, CA).

6.1.2 *Woven-wire mesh lath (ASTM C841, C1032, and C1063)*—Woven-wire mesh plaster base, flat or self-furred, is fabricated from galvanized steel wire by the reverse-twist method into a hexagonal pattern mesh. Woven-wire mesh lath is available in rolls or sheets, with or without stiffener-wire backing.

The minimum gauge wire for woven-wire openings is as follows: 20 gauge (0.86 lb/yd^2 [0.47 kg/m^2]) for 1 in. (25 mm) openings; 17 gauge (1.4 lb/yd^2 [0.76 kg/m^2]) for 1-1/2 in. (38 mm) openings; and 16 gauge (2.02 lb/yd^2 [1.09 kg/m^2]) for 2 in. (50 mm) openings. The width of a woven-wire plaster base should be a minimum of 34.5 in. (875 mm). Flat sheets should be a minimum of 100 in. (2540 mm) long. Rolls of



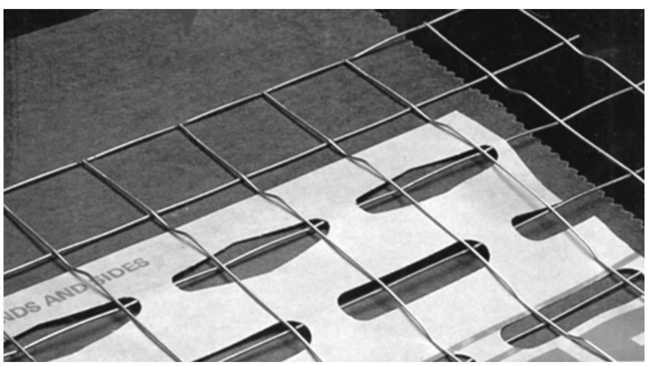


Fig. 6.4—Welded-wire mesh lath (photo courtesy of K-Lath, Monrovia, CA).

woven-wire mesh lath without backing are 150 ft (45.7 m) long, while rolls with backing are 100 ft (30.5 m) long.

6.1.3 *Welded-wire mesh lath (ASTM C841, C933, and C1063)*—Welded-wire mesh plaster bases, flat or self-furred, with or without backing, are fabricated from not less than 15 gauge (0.072 in. [1.82 mm]) copper-bearing, cold-drawn galvanized steel wire conforming to ASTM A641/A641M. The wire is welded into an intersecting grid or mesh pattern, forming openings of not more than 2 in. (51 mm) in either direction. Stiffener wires of 14 gauge (0.080 in. [2.03 mm]) are installed at not more than 6 in. (150 mm) on center parallel to the long dimension of the sheets. The sheets have a nominal size of 28 in. (710 mm) wide by 96 in. (2440 mm) long, and a mass per unit area of 1.14 lb/yd^2 (0.62 kg/m^2).

6.2—Weather-barrier backing

Most metal reinforcement is available with attached weather-barrier backing. The weather-resistive material may be netting, film, kraft paper, impregnated kraft paper, or felt. It is attached at the factory to prevent accidental removal during shipment, handling, or installation.

A water-resistant barrier should consist of at least two layers of minimum Grade D paper over plywood sheathing or other wood, one layer over other sheathing products, or as otherwise required by local building codes. Whether the additional layers of paper are applied by the manufacturer or at the job site, a weather barrier equivalent to asphalt-saturated kraft paper, as described in the following paragraph, should be installed behind the lath. Such paper should be applied in weatherboard fashion, lapped not less than 2 in. (50 mm) at horizontal joints, and not less than 6 in. (150 mm) at vertical joints. Federal Specification UU-B-790a differentiates weather-resistive kraft papers by water resistance, vapor permeability, and tensile strength. Water-resistant papers are differentiated by the length of time that they can resist water penetration and by their vapor permeability.

UU-B-790a differentiates water-resistant backing paper by those that are absorptive and those that are water resistant. Grade A paper should resist water penetration for 24 hours; Grade B paper should resist water penetration for 16 hours; Grade C paper should resist water penetration for 1 hour; and Grade D paper should resist water penetration for 10 minutes. Grade A and B papers, such as polyethylene fibrous fabric, polyethylene film, and felt, are vapor retarders. Vapor retarders can slow the evaporation process of water within the plaster membrane. This delay in evaporation could allow that water to freeze. Grades A and B papers should be used with caution where freezing occurs and should not be used where prohibited by the local building code. Grade D paper allows for the minimum water vapor permeability rate to be at 35 perms in 24 hours. This is desirable in many types of construction because it allows the trapped moisture to escape from the wall cavity. Specifications for determining the tensile breaking strength of a backing paper can be found in Federal Specification UU-P-31 B/171, and specifications for determining vapor permeability can be found in Federal Specification UU-P-31 B/Gen.

CHAPTER 7—LATHING ACCESSORIES

7.1—Introduction

Properly designed and installed lathing accessories can contribute significantly to the ease with which the plastering application takes place. Lath accessories can serve as plaster grounds or a gauge of thickness. Lath accessories can also stiffen the underlying structural framework and create an even plaster base or level backing surface. Lath accessories indirectly bond the plaster coating to the structural member.

Accessories are fabricated from various types of metals, vinyl plastic, or polyvinyl chloride (PVC). Environmental or climatic conditions can determine the type of accessories that should be used. Some manufacturers produce sections of stainless steel for special applications. Zinc alloy or PVC accessories should be used in exterior work where corrosion is a concern, such as in humid coastal regions or heavy industrial pollution areas. PVC accessories can be used in most weather conditions, but should not be used in extremely hot or cold temperatures. Only those PVC accessories manufactured to resist ultraviolet light and aggressive chemical

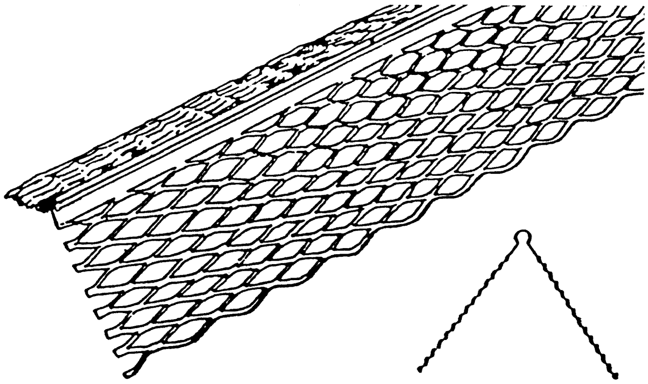


Fig. 7.1—Expanded-flange corner bead (courtesy of Alabama Metal Industries Co., Birmingham, AL).

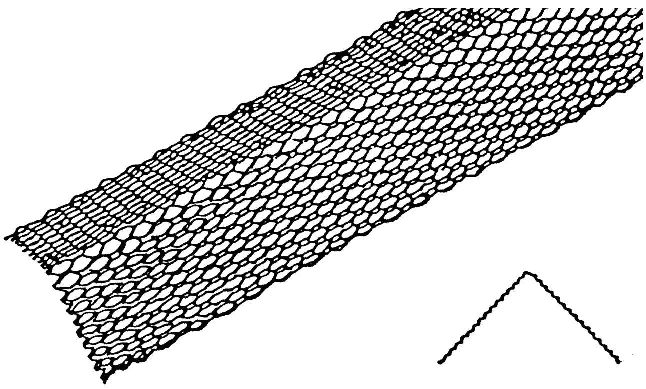


Fig. 7.2—Expanded metal corner lath (courtesy of Alabama Metal Industries Co., Birmingham, AL).

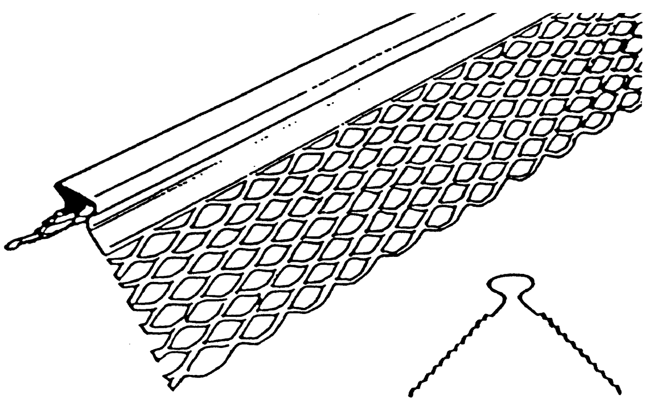


Fig. 7.3—Bull-nose corner (courtesy of Alabama Metal Industries Co., Birmingham, AL).

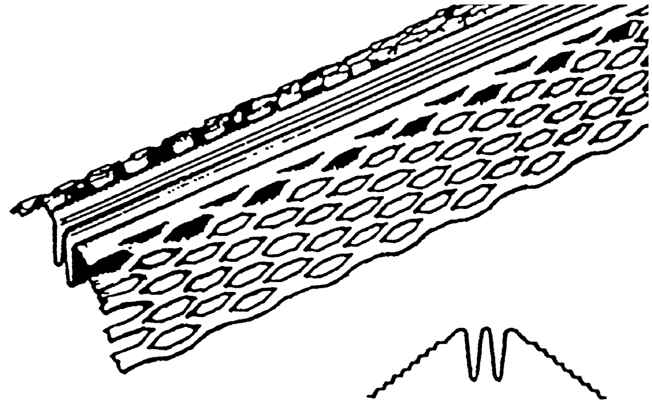


Fig. 7.4—Inside corner joint (courtesy of Alabama Metal Industries Co., Birmingham, AL).

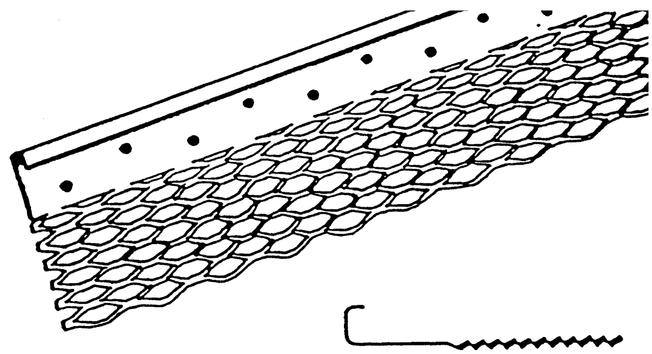


Fig. 7.5—Casing beads (courtesy of Alabama Metal Industries Co., Birmingham, AL).

attack should be used. ASTM C1063 establishes a minimum thickness for accessories, as shown in Table 7.1.

7.2—Outside corner reinforcements

Arris reinforcements, or outside corner reinforcements, can be expanded-flange corner beads (Fig. 7.1), welded steel wire or woven steel wire using minimum 18 gauge (0.0475 in. [1.21 mm]) wire, vinyl plastic bead, or expanded metal corner lath (Fig. 7.2). They are made of corrosion-resistant materials. The corner reinforcement should allow plaster to fill the hollow areas behind the corner bead.

Table 7.1—Minimum thickness of accessories (ASTM C1063-99)

	Base material, in. (mm)		
Accessory	Steel	Zinc alloy	PVC
Corner beads	0.0172 (0.44)	0.0207 (0.53)	0.035 (0.89)
Casing beads	0.0172 (0.44)	0.0207 (0.53)	0.035 (0.89)
Weep screeds	0.0172 (0.44)	0.0207 (0.53)	0.050 (1.27)
Control joints	0.0172 (0.44)	0.018 (0.46)	0.050 (1.27)

Bull-nose corners are reinforced by a strip of expanded metal lath or a wire lath of at least 6 in. (150 mm) in width (Fig. 7.3).

7.3—Inside corner accessory

The inside corner accessory is designed to provide stress relief at internal angles (Fig. 7.4). Therefore, its shape is similar to a control joint accessory.

7.4—Casing beads

Often called plaster stops, casing beads should be installed wherever plaster terminates or abuts dissimilar material. Casing beads are manufactured with solid flanges and expanded flanges. Short-flange casing beads are nailed or screwed to framing members, whereas expanded-flange casing

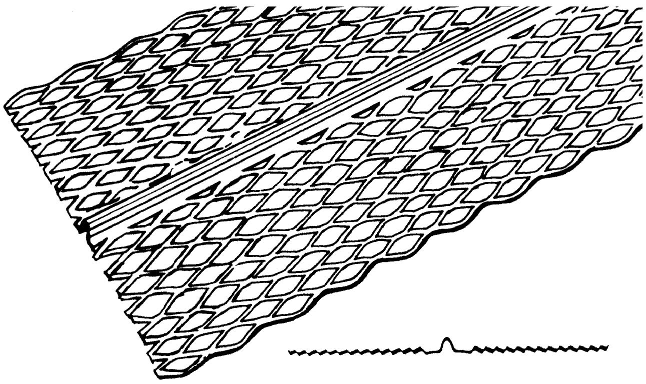


Fig. 7.6—Base screed (courtesy of Alabama Metal Industries Co., Birmingham, AL).

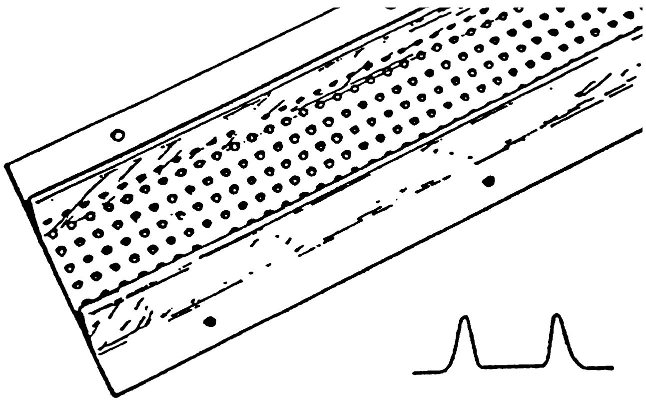


Fig. 7.7—Soffit ventilating screed (courtesy of Alabama Metal Industries Co., Birmingham, AL).

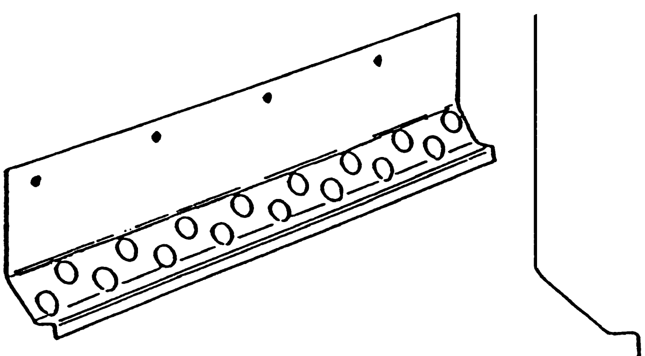


Fig. 7.8—Drip screed (courtesy of Alabama Metal Industries Co., Birmingham, AL).

beads are usually nailed to the framing members and wire-tied to the metal lath. Casing beads are formed from 26 gauge (0.0172 in. [0.44 mm]) galvanized steel or from 26 gauge (0.0207 in. [0.53 mm]) zinc alloy. Flanges establish a plaster ground or a gauge for depth of plaster. Flanges can create plaster ground at 1/2, 3/4, 1, 1-1/8, or 1-1/4 in. (13, 19, 25, 29, or 32 mm) and have either a 90- or 45-degree return (Fig. 7.5).

7.5—Screeds

Plaster screeds are used to establish plaster thickness or to create decorative motifs by bending and shaping the screed.

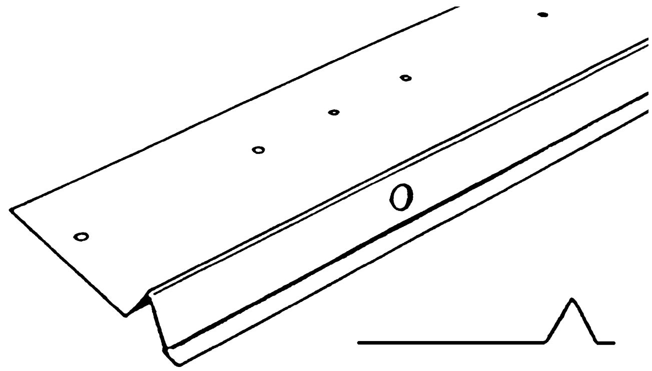


Fig. 7.9—Foundation weep screed (courtesy of Alabama Metal Industries Co., Birmingham, AL).

Screeds are also used to separate portland cement-based plaster from other surfaces, such as gypsum plaster, concrete, or terrazzo. A base screed (Fig. 7.6), also called a parting screed, is often installed for the same purpose.

Screeds are usually manufactured from 26 gauge (0.017 in. [0.43 mm]) galvanized steel in 10 ft (3 m) lengths. Base screeds are designed to provide a 1/2 in. (13 mm) plaster ground, but can be installed to accommodate other depths of ground. Screeds are not suitable for use as stress-relief joints. Screeds can be used to provide decorative reveals in plaster, and are available in a variety of widths and materials (Section 7.1), including extruded anodized aluminum and extruded PVC.

7.5.1 *Ventilating screeds*—Ventilating screeds (Fig. 7.7) have perforated webs to allow free passage of air from the outside. Ventilating screeds are commonly used as exterior soffits where they prevent water from running from vertical surfaces to horizontal surfaces. They also establish a ground for plaster thickness.

7.5.2 *Drip screeds*—Drip screeds (Fig. 7.8), or soffit drip screeds, are installed in exterior plaster ceilings to prevent water that has run down the face of a structure from returning to the plaster soffits and the ceiling.

7.5.3 *Foundation weep screeds*—Foundation weep screeds (Fig. 7.9) are required by most building codes and are installed at the foundation plate line (also called mud-sill). They should be located no less than 4 in. (100 mm) above the finished grade or no less than 2 in. (50 mm) above paved surfaces. Weep screeds provide the dual functionality of serving as a plaster stop while allowing moisture within the plaster membrane to escape, or evaporate, from the space between the backing paper and plaster.

7.5.4 *Decorative screeds*—Decorative screeds include reveals for corners, angles, and intersecting sections.

7.6—Stress-relief joints

Stress-relief joints (that is, control joints and expansion joints) are designed and installed to relieve stress in areas where cracking is likely to occur in a plaster coating (Fig. 7.10 to 7.13). Stress-relief joints should be installed at proper intervals per ASTM C1063 to relieve induced stresses

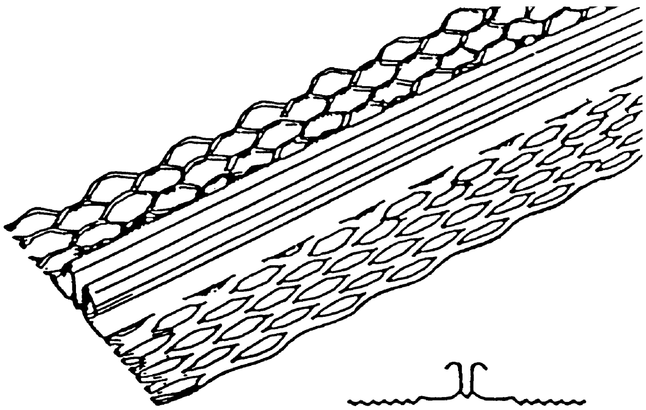


Fig. 7.10—Expansion control joint (courtesy of Alabama Metal Industries Co., Birmingham, AL).

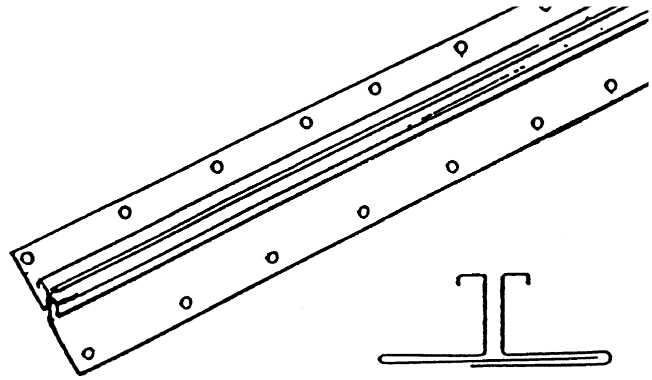


Fig. 7.12—Two-piece expansion joint (courtesy of Alabama Metal Industries Co., Birmingham, AL).

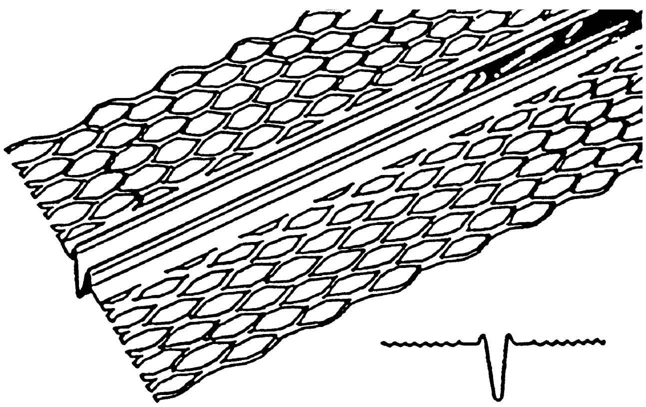


Fig. 7.11—Deep groove joint (courtesy of Alabama Metal Industries Co., Birmingham, AL).

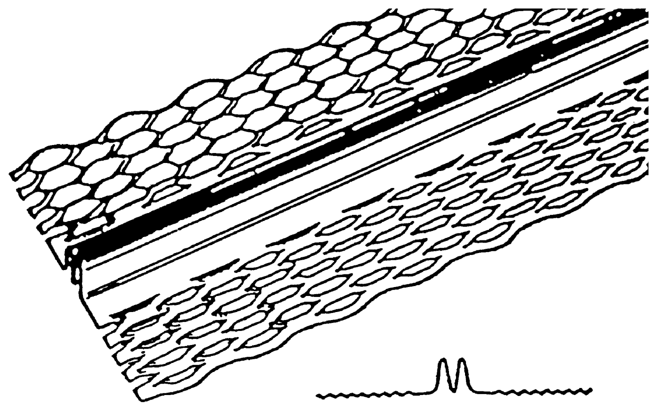


Fig. 7.13—Expansion joint (courtesy of Alabama Metal Industries Co., Birmingham, AL).

(Section 5.5). Care should be taken to ensure proper installation of stress-relief joints.

Galvanized steel is the most extensively used formed-section material. Galvanized steel, as a general rule, should not be used in areas exposed to aggressive chemicals, ocean spray, or significant moisture.

Zinc alloy stress-relief joints or less rigid vinyl stress-relief joints can be used in many adverse or aggressive environments.

CHAPTER 8—INSTALLATION OF METAL LATH

8.1—Introduction

Metal lath, including expanded metal, woven-wire mesh, and welded-wire mesh, can be applied over a variety of substrates. Metal lath may be applied directly to wood or metal-stud framing. This type of open framing is often covered with solid sheathing such as exterior gypsum board, plywood, oriented strand board, or particle board.

Fasteners used to attach metal lath should be long enough to penetrate through the lath, sheathing, and into the framework a minimum of 3/4 in. (19 mm) to ensure structural integrity. Staples, nails, or screws are commonly used as fasteners for attaching metal lath to wood or steel framing. Manufacturers of approved fastening tools, such as screw guns, staple guns, and power drivers or powder-driven fastening guns, should have reference tables that provide pullout and shear values for different-sized fasteners in various substrates. Designers should specify fastener spacing based on these tables. Wire ties are seldom used in walls or panels. They are, however, recommended for certain installations, such as hanging ceiling construction.

8.2—Installation of metal lath plaster base

Expanded metal lath, woven-wire mesh lath, and welded-wire mesh lath should be applied with the long dimension of the sheets perpendicular to the supports. Expanded metal lath should overlap itself 1/2 in. (13 mm) at the sides (horizontal) and 1 in. (25 mm) on the ends (vertical). Wall ties are also used to join laps at 9 in. (230 mm) intervals between rows of fasteners. Where end laps do not occur over supporting framework, they should be tied together securely or laced with not smaller than 18 gauge (0.0475 in. [1.21 mm]) galvanized wire or annealed-steel wire. Rib metal lath with edge ribs greater than 1/8 in. (3 mm) should overlap at the sides by nesting, or matching up and coupling, those ribs within the lapped areas. When edge ribs are 1/8 in. (3 mm) or less, the rib metal lath should overlap 1/2 in. (13 mm) at the sides (horizontal) and 1 in. (25 mm) on the ends (vertical).

Woven-wire mesh lath and welded-wire mesh lath should overlap by at least one mesh width at the sides and ends, and should never be lapped less than 1 in. (25 mm). The ends of the returning horizontal sheets or rolls of lath should be staggered. Where end laps do not occur over supporting framework, they should be tied together securely or laced with not smaller than 18 gauge (0.0475 in. [1.21 mm]) galvanized wire or annealed-steel wire.

When a metal plaster base with factory-applied paper backing is used, the vertical and horizontal overlaps should be paper backing on paper backing and metal on metal by splicing the lapped areas. The backing should be lapped at least 2 in. (50 mm). Laps should be installed so that upper pieces lap over places that are lower on the wall. Lapped areas should be tight and secure so that moisture will not flow to the interior. The moisture-barrier paper backing should be continuous behind control joints. The metal lath, however, should be interrupted at the control joints so that control joints are not hindered from their intended function of separating the plaster membrane.

Metal lath of a furred or suspended ceiling that intersects with, or is penetrated by, a column, wall, beam, or another element of construction should be terminated with casing bead. Casing bead should also be used where metal lath terminates to isolate plaster from other elements of construction. A 3/8 in. (9.5 mm) clearance should be maintained between the bead and all such elements of construction to keep metal lath and plaster of the ceiling separated from adjoining elements. A casing bead, control joint, or similar device should overlap the internal angle where vertical metal lath ends and horizontal metal lath ends meet. Ends of adjoining plaster bases should be staggered.

The metal lath should be true to line, level, plumb, and square or curved as necessary to provide a proper base for plaster.

8.3—Attachment of metal lath to framework

Expanded metal lath, welded-wire mesh lath, or woven-wire mesh lath, used as a plaster base, should be furred outa nominal length of 1/4 in. (6 mm) from the vertical supports. Self-furred lath is premanufactured to meet this requirement. Furring is not required for expanded metal lath on supports having a bearing-surface width of 1-5/8 in. (40 mm) or less. Metal lath should be attached to the support framework with fasteners that are installed not more than 6 in. (150 mm) apart.

8.4—Attachment of metal lath to solid base

When it is anticipated that a plaster coating would have little or no adhesive bond capability if applied directly to a solid base, such as a dense clay brick surface or a smooth concrete surface, the use of self-furring metal lath reinforcement anchored to the substrate is recommended. A paper-backed, self-furred lath should be used over these substrates. A paper-backed metal lath isolates the solid base from the lath-reinforced plaster and can serve to isolate stresses in the solid base that could otherwise cause plaster to crack. Self-furred metal lath should also be used when substrate is monolithic concrete, shotcrete, or masonry having little or no mechanism of stress relief.

On vertical surfaces, the metal lath should have a mass per unit area of not less than 2.5 lb/yd^2 (1.5 kg/m^2). On horizontal surfaces, the metal lath should have a mass per unit area of not less than 3.4 lb/yd^2 (2 kg/m^2). Power-driven or powder-driven fastener tools are preferred over hand-driven concrete stub nails or cut nails for attaching self-furring lath.

Fasteners should have large heads capable of securing the thickness of at least three strands of the metal lath reinforcement, or washers should be used. Washers should be made of metal, neoprene, or vinyl plastic. For attaching metal lath to solid bases without furring, forced-entry fastener tools such as a power driver or powder-driven fastener tool with compatible fasteners are recommended. Forced-entry tools in combination with hardened concrete stub nails, however, can be used. The size and type of fastener selected should be based on type of substrate, weight of the metal lath, and thickness and weight of any additional materials that are to be supported by the fastener.

Metal lath plaster bases should be attached with at least five fasteners at a spacing of not less than nominal 16 in. (405 mm) on center horizontally, a distance not more than nominal 7 in. (180 mm) on center vertically, and at an equal spacing and pattern in ceilings to match the furring. Side overlaps of horizontal rows should be tied or laced. End overlaps should be fastened.

CHAPTER 9—SOLID SUBSTRATE PLASTER BASES

9.1—Introduction

Plaster bases that are solid substrates, such as cast-in-place or precast concrete, concrete masonry, clay masonry, and shotcrete, should be true to line and plane when plaster is applied directly, without having metal lath or wire mesh network. Solid substrate plaster bases should be structurally sound and able to withstand pressures and stresses that cause movement of the structure and cracking of the plaster coating. Solid substrates should be clean, free of loose debris, porous, and chipped, scarified, etched, or otherwise roughened to ensure good mechanical bond.

Cleaning agents can be used to remove most oil-based surface contaminants and dirt. Hydrochloric acid can also be used to remove dirt, efflorescence, and carbonated minerals, and to etch the surface of the substrate. Manufacturer's directions should be followed when using chemical surface treatments. Particular care should be taken to ensure complete washing down and neutralization of the solid base after using a cleaning agent, acid wash, or other chemical treatment of the surface that can adversely affect the adhesive bond between plaster and substrate.

Wire brushes, hammers, chisels, or other hand or power tools, such as a scabbler, can be used to chip or otherwise roughen the solid surface substrate. Waterblasting or dry blasting are also effective methods of removing contaminants from a solid substrate surface. Care should be taken to avoid removal of the solid substrate structure beyond the amount necessary to ensure proper bond of plaster to substrate. The standards or specifications for surface preparation of solid substrates mentioned herein can be found in ASTM D4258, D4259, D4262, and D4263. The techniques described in these standards and specifications are applicable to the preparation of all solid bases to receive plaster.

9.2—Concrete

9.2.1 *New concrete*—New concrete placed specifically as a base should be permitted to age at least 28 days before applying plaster. The new concrete should be cured properly (ACI 308R) and be free from laitance, form-release agents, and curing compounds before applying plaster. A cementitious solid substrate that is not properly cured can have an abnormally high absorptive capacity, and can absorb critical mixing water from the plaster during application, causing the drying rate of plaster to exceed the rate of set. This rapid loss of mixing water from fresh plaster can promote shrinkage and plastic cracking, reduce the ability of plaster to bond with concrete, and cause self-desiccation within plaster.

9.2.2 *Existing concrete*—Unlike new concrete structures, existing concrete structures generally require more surface preparation to be suitable to receive plaster. Concrete surfaces should be clean, rough, and free of bond inhibitors such as moss, mold, paint, oil, mineral deposits, and dirt. Chemical cleaners or acid cannot always remove these inhibitors. Chipping, sanding, chiseling, grinding, or other methods of mechanically removing the bond inhibitor by removing the surface of the concrete may be necessary. Spalled, delaminated, or debonded areas on the surface of an existing concrete substrate should be mechanically removed, surrounding loose or unsound materials removed, and the surface cleaned before plaster application. Voids, form-tie holes, and other surface defects should be patched and brought level to the surface before applying plaster. Minor adjustments can be made to the alignment of an untrue line and a warped plane of a concrete substrate using a leveling coat. Major surface preparations may require a leveling coat on the entire structure to restore a plane surface.

9.3—Concrete masonry

Due to the open-texture and porous nature of most concrete masonry, a good mechanical bond can be established. It can be more difficult to establish good bond between plaster and concrete masonry substrates that are dense or have low permeability. Concrete masonry plaster bases should be clean and free from bond inhibitors. Refer to ASTM D4261 for recommended practice for cleaning concrete unit masonry.

New concrete masonry joint mortar should be cut flush or even-level with masonry and not tooled or floated. Misplaced and loose mortar should be removed from the surface of masonry units. The masonry mortar joints should be properly cured, sufficiently hydrated, and capable of supporting the masonry members' designed dead load before plaster application. Existing concrete masonry walls that have protruding joints should be chiseled, ground, cut, or otherwise removed to be level with, or below, the surface plane of the concrete masonry units.

Concrete masonry walls should be properly aligned before plastering minor deviations from true plane; however, they can be fixed using leveling coats of plaster. Excessive deviation of the surface plane or misalignment may require furring and lathing to restore true plane. Concrete masonry units that are chipped, broken, or out of line should be patched and brought level to the plane of the substrate surface.

9.4—Clay masonry

Clay masonry substrates and joints should be examined, and crumbling or friable material should be removed and replaced before plastering. Clay masonry substrates that are structurally sound, but whose surface is disintegrated so that good bond cannot be achieved, should have metal lath installed to establish a mechanical bond and support network for the plaster. Dense clay tile and glazed clay brick substrates should be roughened or abraded to promote a good mechanical bond. Water-resistant surface coatings, mineral deposits, and other bond inhibitors should be removed.

9.5—Surface-applied bond coatings

Surface-applied bond coatings, also known as bond coats, are cementitious mixtures applied to solid substrates for the purpose of improving bond between solid substrate and plaster. Surface-applied bond coatings are useful for smooth, dense, nonporous, and nonabsorptive solid substrates, or when little to no bond would be expected between base and plaster. Surface-applied bond coatings are generally cement-rich materials, often comprising a bonding agent and fine sand. The coating is applied in slurry form, either by spattering by gun, or dashing by brush, onto the solid substrate. This application, also known as a dash-bond coat, creates a bumpy, dappled surface affect. Application can also be achieved by scratch coat or skim coat, which is broomed or scarified before final set. Surface-applied bond coatings should not be trowel-finished or smoothed, but should be left as rough, uneven surfaces. This, in turn, increases mechanical bond by providing a key for plaster.

9.6—Surface-applied bonding agents

Surface-applied bonding agents should be used on all smooth or dense substrates such as clay masonry or unglazed-fired brick. Surface-applied bonding agents should also be used on all soft or damaged substrates after any loose or friable materials have been removed. Surface-applied bonding agents can be used where hot, dry, or windy conditions cause wetting or misting of the substrate to be less effective. They can also be used on porous substrate surfaces to reduce wicking of mixing water from fresh plaster. Surface-applied bonding agents can be sprayed onto the substrate or applied by brush or roller. They are generally water-based, single-component formulations that are applied undiluted. Some surface-applied bonding agents can be applied and remain exposed for several days before plaster application, whereas others may require plaster application within a 24-hour period. Some surface-applied bonding agents require the plaster application to begin as soon as the bonding agent becomes tacky to the touch. Surface-applied bonding agents should be used in accordance with manufacturer recommendations.

9.7—Integrally mixed bonding agents

Integrally mixed bonding agents are generally water-based acrylic or styrene-butadiene latex formulations that are added to the portland cement-based plaster mixture during the mixing process. Integrally mixed bonding agents are usually diluted by adding one part bonding agent to three parts potable water. Integrally mixed bonding agents can improve the plaster bond and flexural and tensile strengths of plaster. Unless otherwise specified, integrally mixed bonding agents can be used in conjunction with some surface-applied bonding agents. Integrally mixed bonding agents should be used in accordance with manufacturer recommendations.

CHAPTER 10—PROPORTIONING AND MIXING OF PORTLAND CEMENT-BASED PLASTER

10.1—Introduction

Proportioning and mixing significantly affect the final quality and serviceability of hardened portland cement-based plaster. The plaster mixture should be proportioned in accordance with project specifications, local building codes, and ASTM C926, and should be mixed in accordance with industry recommendations.

10.2—Mixture proportions

Plaster mixture proportions should be compatible with the plaster base and of a consistency that allows plaster to be applied in coats of the proper thickness. Table 10.1 gives ASTM recommendations for mixtures for the scratch coat and brown coat. Mixture proportions for each symbol in Table 10.1 are defined in Table 10.2. ASTM recommendations for mixture proportions for the finish coat are shown in Table 10.3. Additionally, industry standards and local codes may provide mixture proportioning recommendations, tables, or charts for specific plaster applications.

10.3—Batching and mixing

10.3.1 *General*—Plaster mixing tools typically include shovels, hoes, mortar boxes, drill mixers, and wheelbarrows for smaller plastering applications, and motor-driven mixers and plaster pumping machines for larger plastering applications. Plaster mixing should be designed to create a plaster mixture in which each ingredient is thoroughly dispersed and integrally blended. The method used to measure the ingredients of a plaster mixture should ensure uniform proportions from batch to batch. Measurement of materials to be added to the plaster mixture should be based on full-bag increments of materials when possible.

The suggested sequence for adding the ingredients of a plaster's mixture proportions is to introduce approximately 2/3 of the required water into the mixer, followed by 1/3 of the required sand. The total amount of cementitious materials is then added into the mixer, followed by the balance of sand and water. Enough water should be added to the mixture proportions to reach a consistency that allows plasterers to properly pump, place, trowel, and otherwise achieve the desired finish before final set.

10.3.2 *Sand*—Several methods can be used for volumetric measuring of the sand. The tub or bowl of the mixer can be used as a gauge by filling the mixer with sand to a level that is a predetermined measurement of the mixture proportions. The mixer reference level can be determined by using a container of known volume, such as a 5 gal. (19 L or 0.67 ft^3) pail, or a 1 ft^3 (28 L or 0.028 m^3) box. Known volume devices can also be used to load a specified volume of sand directly into the mixer. Other methods, such as counting the number of full shovels of sand introduced into the mixer, can be used accurately as long as the volume of a full shovel has been quantified or standardized. A full shovel, or other such

Table 10.1—Plaster bases: permissible mixtures (ASTM C926-98a, Table 2)

Property of base	Mixtures for plaster coats: First (scratch)	Mixtures for plaster coats: Second (brown)
Low absorption, such as dense, smooth clay tile, brick, or concrete	C CM or MS P	C, CL, M, or CM CM, MS, or M P
High absorption, such as concrete masonry, absorptive brick, or tile	CL M CM or MS P	CL M CM, MS, or M P
Metal plaster base	C CL CM or MS M CP P	C, CL, M, CM, or MS CL CM, MS, or M M CP or P P

Note: Refer to Table 10.2 for plaster mixture symbols.

Table 10.2—Base-coat proportions,* parts by volume† (ASTM C926-98a, Table 3)

Plaster mixture symbols	Cementitious materials: Portland cement or blended cement	Plastic cement	Masonry cement: N	Masonry cement: M or S	Lime	Volume of aggregate per sum of separate volumes of cementitious materials: First coat	Second coat‡
C	1	—	—	—	0 to 3/4	2-1/2 to 4	3 to 5
CL	1	—	—	—	3/4 to 1-1/2	2-1/2 to 4	3 to 5
M	—	—	1	—	—	2-1/2 to 4	3 to 5
CM	1	—	1	—	—	2-1/2 to 4	3 to 5
MS	—	—	—	1	—	2-1/2 to 4	3 to 5
P	—	1	—	—	—	2-1/2 to 4	3 to 5
CP	1	1	—	—	—	2-1/2 to 4	3 to 5

*The mixture proportions for plaster scratch and brown coats to receive ceramic tile should be in accordance with the applicable requirements of ANSI A108.1 series applicable to specified method of setting time.

†Variations in lime, sand, and perlite contents are allowed due to variation in local sands and insulation and weight requirements. A higher lime content will generally support a higher aggregate content without loss of workability. The workability of the plaster mixture will govern the amounts of lime, sand, or perlite.

‡The same or greater sand proportion shall be used in the second coat than is used in the first coat.

Table 10.3—Job-mixed finish coat proportion, parts by volume (ASTM C926-98a, Table 4)

Plaster mixture symbols	Cementitious materials: Portland cement or blended cement	Plastic cement	Masonry cement: N	Masonry cement: M or S	Lime	Volume of aggregate per sum of separate volumes of cementitious materials*
F	1	—	—	—	3/4 to 1-1/2	1-1/2 to 3
FL	1	—	—	—	1-1/2 to 2	1-1/2 to 3
FM	—	—	1	—	—	1-1/2 to 3
FCM	1	—	1	—	—	1-1/2 to 3
FMS	—	—	—	1	—	1-1/2 to 3
FP†	—	1	—	—	—	1-1/2 to 3

*In areas not subject to impact, perlite aggregate shall be permitted to be used over base-coat plaster containing perlite aggregate.

†Additional portland cement is not required when Types S or M masonry or plastic cement are used.

loading device, can be quantified or standardized by pouring the loading device volume of sand into a container having a known volume. Measurements of loading devices can change depending on the wetness of sand, type of sand, a change of personnel loading the mixer, or changing loading devices. Such devices should be retested on a daily basis or any time that one of the aforementioned changes occurs.

10.3.3 *Cementitious materials*—The cementitious materials of the mixture proportions should be added in full-bag increments when possible. Splitting bags of material into half sections and quarter sections is an acceptable practice, but can lead to slight volume inaccuracies. It is common practice to add a large portion of sand to the mixer before adding cementitious material to avoid lumping together or balling. Sand aids in breaking down lumps and dispersing the cementitious materials. Enough sand should be introduced into the mixer before adding any cementitious materials to ensure that the cementitious materials are properly and thoroughly mixed. Typically, 1/3 to 1/2 of the required sand is loaded into the mixer, followed by the total volume of the cement, followed by the remaining amount of sand. Enough sand should be introduced into the mixer before adding any cementitious materials to ensure that the cementitious materials are properly and thoroughly mixed. The mixing time for the ingredients of plaster should be between 3 to 10 minutes in a paddle-drum mixer. Overmixing can be detrimental to plaster and can lead to an accelerated rate of set. Overmixing can have a negative effect on workability, certain additives and admixtures, and can cause excessive air entrainment of plaster. Overmixing can also lead to overtempering, which causes a delay in set time and increased shrinkage cracking, and weakens plaster. Undermixing can have a negative effect on workability, pumpability, and lower air entrainment.

10.3.4 *Water*—The amount of water added to a plaster mixture depends on the moisture content of the sand, plaster pumping requirements, richness or quantity of cementitious material in the mixture proportions, additives or admixtures, absorptivity of the solid plaster base, thickness of the plaster coat, ambient evaporation rate, and adverse weather conditions. A high *w/cm* can increase porosity within a plaster matrix. High porosity can affect a plaster's ability to resist shrinkage stress. Therefore, a high *w/cm* could result in plaster that is less durable and more susceptible to tensile stress. The amount of mixing water for a given mixture proportion generally increases as the amount of cementitious material increases in relation to the other ingredients of the plaster mixture. Additional mixing water might also be needed to accommodate application procedures such as pumping, placing, and troweling, or to otherwise produce a workable material. Supplemental water may be added to the plaster mixture after initial mixing, but before application, to compensate for conditions such as excessive absorption of a plaster base, high winds, low humidity, or stiffening of the mixture. The process of working supplemental water in with initial mixing water is known as retempering. Without the proper amount of mixing water and appropriate retempering, certain plaster applications can dry-harden before they set, which can result in difficult or improper finishing, increased cracking, weak plaster, decreased mechanical bond to the substrate, delamination, or self-desiccation of the plaster. Retempering to allow for these situations is accepted practice for mortar and for plaster (ASTM C270 and C926). The decision of how much additional mixing water, if any, is to be added to the mixture proportions should be made by an experienced plasterer or foreman who understands the importance of adjusting water content and has sufficient field experience to know how much water is needed.

10.3.5 *Color pigments*—Color pigments should be added in accordance with the manufacturer's recommendations. Color pigments should be mixed in such a way as to thoroughly and uniformly blend and incorporate the colorant throughout the mixture. There should be no clumps or concentrations of color pigment remaining within the plaster mixture, or adhering to the tub or paddles of the mixer. Mixing-water proportioning should be maintained from batch to batch when color pigments are used. Retempering can change the color of plaster.

10.3.6 *Admixtures and additions*—Admixtures and additions, such as those found in Section 4.6, should be introduced into the mixture in accordance with manufacturer's recommendations. The proper time and optimum dosage rate of each admixture and additions added into the mixing sequence should be in accordance with manufacturer recommendations. All admixtures or additions should be thoroughly and uniformly dispersed throughout the plaster mixture. There should be no lumps or concentrations of these additions remaining within the plaster mixture or adhering to the tub or the paddles of the mixer.

CHAPTER 11—APPLICATION OF PORTLAND CEMENT-BASED PLASTER

11.1—Approval and acceptance of plaster base

The plaster base should comply with project specifications and applicable codes and standards. A representative from the plastering contractor should carefully examine and evaluate the base before application of plaster. ASTM C926, Section A1.6, stipulates: "Surfaces and accessories to receive plaster shall be examined before plastering is applied thereto. The proper authorities shall be notified and unsatisfactory conditions shall be corrected prior to the application of plaster. Unsatisfactory conditions shall be corrected by the party responsible for such conditions." ASTM C926, Section A1.6.2, further stipulates: "The plasterer shall use this portion of the construction specifications for acceptance or rejection of such surfaces."

11.1.1 *Metal-reinforced plaster base*—The installation of lathing should be checked for proper orientation, furring direction, fastening, overlaps, flatness, and surface condition, ensuring nothing impairs the plaster application or the quality and final appearance of the plaster. Lathing over metal or wood studs should be checked to verify proper installation of lath and backup paper. Water-resistant paper should be installed shingle-style, with the first layer applied at the bottom of the surface to be plastered. Paper and lath should be tight, on a level plane to the framework, and attached at the proper spacing across the framework. Refer to Chapters 6 and 8 for detailed instructions.

11.1.2 *Solid plaster base*—Solid plaster bases, including concrete, concrete masonry, and clay masonry, should be examined, evaluated, and prepared as necessary in accordance with the procedures described in Chapter 9. If the concrete or masonry construction does not meet tolerances as outlined in the codes and standards to the extent that the plastering contractor cannot execute his work, the solid plaster base should be brought into compliance before the plaster is applied. The plastering contractor may perform the repair of the base, but this repair work should not be considered part of the originally specified plaster application, unless agreed to contractually by the contractor. Repair methods and materials can be found in ACI 546R.

The plaster substrate should be checked for absorption characteristics by spraying water or misting the surface before application. Knowing the absorptive ability of a solid plaster base allows the plaster technician to determine if additional water is needed in the plaster mixture, as described in Section 10.3.4. Ideally, the rate of absorption should be as uniform as possible across the entire surface. Highly absorptive surfaces should be moistened before applying the scratch coat. Satisfying the absorptive capacity of a substrate can reduce the loss of mixing water from the fresh plaster.

11.2—Application of plaster

11.2.1 *Hand application*—Hand applications are typically performed by the plasterer using a hawk and trowel. The plasterer scoops the plaster from the hawk with various tools and applies it to the plaster base. Plaster is typically supplied to the plasterer by a worker, known as a hod or hoddy, who places it onto a hawk or plaster board near the plasterer. The hoddy uses buckets, wheelbarrows, and shovels to convey material from the mixer to the plasterer.

11.2.2 *Machine application*—Machine application of plaster is performed using a pumping machine, which pumps plaster to plaster boards for hand placement, or to a nozzle gun for spraying directly onto a wall, ceiling, or other plaster base. The machine-applied method allows for continuous batching of plaster and continuous spraying of plaster. The person operating the mixer controls the mixture proportions and consistency of each batch according to the instruction of the foreman. The person operating the plaster gun, or nozzle operator, controls placement of plaster and fine-tunes the spray pattern by adjusting the air or changing the orifice size. The flow of plaster to the gun is controlled at the pumping machine by adjusting the speed of the pump. The nozzle operator should strive for uniform dispersion of the plaster, which can be optimally achieved when the nozzle is held approximately 1 ft (0.3 m) away from, and perpendicular to, the working surface.

11.2.3 *Scaffolds*—Scaffolds are often necessary to provide working platforms to bring the workers within reach of the surfaces to be lathed or plastered. Scaffolds can be rigid-planked frames supported with cross and wall bracings. Rigid-planked frame scaffolds are generally set up in sections at the job site. They typically remain in place during the plastering application, or they can be taken down and set up at another section of the job site as work progresses. Mechanized scaffolds, such as aerial lifts, rail-mounted scaffolds, suspended or slung scaffolds, man-lifts, and rolling towers, can sometimes be used. To be considered safe, a scaffold should consist of the proper materials and be set up in a manner that allows the scaffold structure to support its own weight plus the weight of the machinery, tools, or persons that will be working on it. The scaffold should be sufficiently braced to be steady. Scaffolding requirements are governed by the Occupational Safety and Health Administration (OSHA). The scaffold should be a significant distance from the plastering surface to give the plastering technician unimpeded access to the panel, section, or member.

11.3—Application of coats

Plaster is usually applied in two or three coats. The first coat, or scratch coat, is followed by a brown coat, or leveling coat. Most applications call for a third coat, or finish texture coat, as well. The thickness of each coat should be stated in the project specifications. The number and thickness of each plaster coat should conform to the requirements of International Building Code (IBC) Section 2512, Uniform Building Code (UBC) (Table 11.1) or ASTM C926 (Table 11.2).

11.3.1 *Scratch coat*—The scratch coat on a metal lath base should be thick enough to fully key into and embed the lath. The scratch coat on a solid substrate base should be sufficiently trowel-forced into the solid substrate to promote a good mechanical bond. Excessive troweling during scratch coat application should be avoided. The scratch coat surface should be rodded to a level plane. Ceilings should be cross-scratched and vertical surfaces should be cross-scratched or scored horizontally to provide a mechanical interlock between scratch coat and brown coat. Scoring should be shallow and not exceed approximately 1/8 in. (3 mm) in depth. Deep score lines can show through certain plaster finish coats as lines of discoloration on the surface directly above the location of each score line.

11.3.2 *Delays between the applications of coats*—The traditional method of plastering onto metal lath requires that there be a delay between the applications of the scratch and brown coats (Table 11.1). The intent of delay is to allow the scratch coat to harden and dry, and to allow for the initial volume change from hydration and mixing-water loss. The brown coat is then applied and troweled with force to fill any shrinkage cracks and to key into the scratch coat.

The double-back is an alternative method of application where successive applications of plaster coats are applied with little or no delay between each coat. Typically, each coat is applied as soon as the prior fresh-plaster undercoat hardens enough to support another coat without sliding, sagging, or falling away. This method eliminates delay between coats and curing requirements for the scratch coat. In addition, the double-back method promotes intimate bonding between coats and facilitates uniform hydration of the coats. When using the double-back method, scratch and brown coats should be applied to full and final thickness as rapidly as possible. This method should be restricted to plastering on solid bases or on lathing applied over sheathed-frame construction.

11.3.3 *Brown coat*—The brown coat usually contains more sand than the scratch coat, and should be proportioned

Table 11.1—Cement plasters[*] (UBC Table 25-F)

Coat	Volume cement	Maximum weight (or volume) per volume cement	Maximum volume sand per combined volumes cement and lime[†]	Approximate minimum thickness (× 25.4 for mm)	Minimum moist curing period	Minimum interval between coats
Portland cement plaster						
First	1	20 lb (9.07 kg)	4	3/8 in.[‡]	48 hours	48 hours[§]
Second	1	20 lb (9.07 kg)	5	First and second coats total 3/4 in.	48 hours	7 days[‖]
Finish	1	1[#]	3	First, second, and finish coats total 7/8 in.	—	‖
Portland cement-lime plaster[**]						
Coat	**Volume cement**	**Maximum volume lime per volume cement**	**Maximum volume sand per combined volumes cement and lime**	**Approximate minimum thickness (× 25.4 for mm)**	**Minimum moist curing period**	**Minimum interval between coats**
First	1	1	4	3/8 in.[‡]	48 hours	48 hours[§]
Second	1	1	4-1/2	First and second coats total 3/4 in.	48 hours	7 days[‖]
Finish	1	1[#]	3	First, second, and finish coats total 7/8 in.	—	‖
Portland cement plaster[**]						
Coat	**Volume cement**	**Maximum weight (or volume) per volume cement**	**Maximum volume sand per volume cement[†]**	**Approximate minimum thickness (× 25.4 for mm)**	**Minimum moist curing period**	**Minimum interval between coats**
First	1	—	4	3/8 in.[‡]	48 hours	48 hours[§]
Second	1	—	5	First and second coats total 3/4 in.	48 hours	7 days[‖]
Finish	1	—	3	First, second, and finish coats total 7/8 in.	—	‖

*Exposed aggregate plaster should be applied in accordance with Section 2509. Minimum overall thickness should be 3/4 in. (19 mm).
†When determining the amount of sand in set plaster, a tolerance of 10% may be allowed.
‡Measured from face of support or backing to crest off scored plaster.
§Twenty-four-hour minimum interval between coats of interior cement plaster.
‖Finish coat plaster may be applied to interior portland cement base coats after a 48-hour period.
#For finish coat plaster, up to an equal part of dry hydrated lime by weight (or an equivalent volume of lime putty) may be added to Types I, II, and III standard portland cement.
**No additions of plasticizing agents should be made.

Table 11.2—Nominal plaster thickness* for three- and two-coat work, in. (mm) (ASTM C926-98a, Table 1)

Base			Vertical				Horizontal			
			First coat	Second coat	Third coat[†]	Total	First coat	Second coat	Third coat[†]	Total
			Interior/exterior							
Three-coat work[‡]	Metal plaster base		3/8 (9.5)	3/8 (9.5)	1/8 (3)	7/8 (22)	1/4 (6)	1/4 (6)	1/8 (3)	5/8 (16)
Three-coat work[‡]	Solid plaster base	Unit masonry	1/4 (6)	1/4 (6)	1/8 (3)	5/8 (16)	Use two-coat work			
Three-coat work[‡]	Solid plaster base	Cast-in-place or precast concrete	1/4 (6)	1/4 (6)	1/8 (3)	5/8 (16)	Use two-coat work			3/8 (9.5), maximum
Three-coat work[‡]	Metal plaster base over solid base		1/2 (12.5)	1/4 (6)	1/8 (3)	7/8 (22)	1/2 (12.5)	1/4 (6)	1/8 (3)	7/8 (22)
Two-coat work	Solid plaster base	Unit masonry	3/8 (9.5)	1/8 (3)	—	1/2 (12.5)	—	—	—	3/8 (9.5)
Two-coat work	Solid plaster base	Cast-in-place or precast concrete	1/4 (6)	1/8 (3)	—	3/8 (9.5)	—	—	—	3/8 (9.5)

*Exclusive of texture.
†For solid plaster partitions, additional coats should be applied to meet the finished thickness specified.
‡For exposed aggregate finishes, the second (brown) coat may become the “bedding” coat and shall be of sufficient thickness to receive and hold the aggregate.

in accordance with Table 10.2. The required thickness of a brown coat may vary within allowed tolerances in accordance with Tables 11.1 and 11.2 and local codes.

Before applying the brown coat, the dry plaster scratch coat should be moistened with water to begin the absorption process and, if necessary, satisfy the absorptive capacity of the scratch coat. Water applied to the scratch coat should be allowed to absorb until no water sheen is visible on the scratch coat surface. The brown coat should be hand-troweled with enough force to key the coat into the scored scratch coat. The brown coat should then be leveled by rod, darby, or screed to achieve a surface plane of desired thickness. Floating can begin after sufficient stiffening of the brown coat. The floating process reconsolidates the plaster and uniformly redistributes moisture at the surface. This can reduce visible cracking caused by shrinkage by allowing more uniform drying and setting across the surface of the plaster. Floating can improve the true plane of the coating, and provides a key for the finish coat. The brown coat, regardless of application method, should be moist cured for a minimum of 2 days. Local codes, standards, and project specifications should be checked for variations of the moist-curing time period.

11.3.4 *Finish coat*—The plastering technician should be familiar with the finish coat, including the mixture proportions, color, application method, finish coat texture, and techniques necessary to achieve the finish coat texture. The chosen method of placement and application of the scratch coat and brown coat can, in turn, have an effect on the final appearance of the finish coat. Sample panels, if required, should be completed and accepted before any job-site plastering begins.

Before applying the finish coat, moisture should be applied to the brown coat to begin the absorption process and, if necessary, to satisfy the anticipated absorptive capacity of the brown coat during application and tooling of the finish coat. The finish coat should be applied in one continuous application. Terminations in the application of the finish coat should occur at control joints, beads, section or panel stops, or natural breaks in the surface plane. Makeshift joints should not be carved or notched into the field of a coating during plastering. On multiple-level staged walls, lower levels of plaster in the same panel should be continued immediately to avoid joining stains, shouldering, and texture variation. In machine-dashed textures, the gun nozzle should be maintained perpendicular to the wall plane in all areas. The finish coat should not be applied immediately after rain or when rain is imminent.

CHAPTER 12—PLASTER FINISHES

12.1—Introduction

The finished surface of portland cement-based plaster is an aesthetic expression of color, texture, form, contours, ornamentation, and decoration. Plaster affords an infinite variety of surface treatments, limited only by the imagination and skill of the plasterer, and subject only to the inherent characteristics of the materials. Plaster has evolved for usage in a variety of environments, and can be finished in a variety of patterns and colors. Plaster finishes and textures are applied by different techniques in various regions of the United States and are subject to differences in local nomenclature, making it difficult to cross reference finishes. Textures or colors should not be selected on the basis of verbal description.

Sample panels should be made available to ensure that plaster colors and textures are mutually acceptable and serve as a basis for comparison to the actual work. Sample panels should be made by a plasterer who will do the actual work using specified project materials. The sample panels should be large enough to incorporate every component of the wall assembly, including joints, metal trim, and other aspects of the desired plaster appearance. Sample panels should remain at the job site until the project is completed and accepted. Fabrication of the sample panels is particularly important when a colored finish is specified.

12.2—Color pigment finishes

Colored pigments, colored aggregates, or both, are added to the plaster mixture to achieve the desired color finish coats. Most proprietary or prepackaged plasters are preblended dry mixtures that contain color pigments added during the manufacturing process.

Finely ground pigments of metallic oxides can be added at the job site during the mixing process. Dry color pigments are typically added in the early stages of mixing to ensure proper dispersion and thorough incorporation within the plaster mixture.

Color pigment slurries are typically added after most of the plaster mixture ingredients have been introduced into the mixer and thoroughly mixed, leaving a small amount of mixing water remaining to be added. The final amount of mixing water is then added, subsequent to the addition of the color pigment slurry, to achieve a desired consistency.

In all cases, dry, liquid, or slurry color pigments should be added in accordance with manufacturer recommendations.

12.2.1 *Job-site mixing*—When mixing color into plaster on the job site, mixture proportioning, concentration of colorant, and manner of mixing should remain consistent to ensure color uniformity. Packets of premeasured color pigment for specific color tones provide the best job-site control. Uniform water content from batch to batch is critical. The sand should be covered with a tarp or other protective covering during rainy, hot, or dry periods to ensure that the moisture content of the sand remains consistent. Materials that vary in moisture content, or by source, on the same job site can alter water demand and change drying and setting characteristics of plaster. Plaster that varies in water content from batch to batch can exhibit shade variations in those areas where batching changes occur. Consequently, each material should be from a single source, and care should be taken to ensure consistency.

12.2.2 *Premixed plaster mixtures*—Factory-produced, prepackaged finish mixtures produce the most consistent colored finishes. Premixed plasters can be formulated specifically for certain finishes. Obtaining uniform or deep color tones with any portland cement-based plaster is difficult, and some color variation or mottling is normal.

12.2.3 *Curing*—Moist curing colored portland cement-based plaster finishes is seldom advised or specified because any variation in wetting and drying may cause color variations. Covering portland-cement plaster finishes with plastic sheeting is seldom advised or specified because discoloration can occur where the covering makes contact with the plaster. This phenomenon is known as the greenhouse effect. Noncolored undercoats of colored plaster finishes are generally water cured for a 48-hour period and then left to air dry for a minimum of 5 days before the colored finish coat is applied. This delay should improve color uniformity of the colored finish coatings and provide a plaster base that has a moderate and uniform absorptive capacity. Moist curing also reduces the potential for soluble materials in the basecoat to migrate to the surface. Refer also to Chapter 13.

12.3—Finish-coat textures

12.3.1 *General*—Finish-coat textures can be applied to interiors or exteriors. Typically, the heavy finish, deep relief, rough, or variable-depth finishes are used for exteriors. Thick or deep textures may require adding coarse sand that allows the plasterer to achieve a desired finish and minimize cracking.

The following textures or pattern-finish coatings are examples. Each texture may be modified in an application or finishing technique to achieve a desired design concept.

Fig. 12.1—Fine-sand float finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.3—Rock-n-roll float finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.5—Light-dash finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.2—Coarse-sand float finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.4—Heavy-dash or tunnel finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.6—Knock-down dash finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

12.3.2 *Fine-sand or coarse-sand float finishes*—The fine-sand float finish (Fig. 12.1) and coarse-sand float finish (Fig. 12.2) are applied in two coats. The first coat is a scratch coat. The second coat is both the leveling coat and the finish coat. The second coat is troweled to achieve a smooth surface and uniform depth. The plaster is allowed to set to a point that each trowel pass eliminates trowel lines or marks left from the previous trowel pass.

Floating should begin after the midset point and before final set. The floating process exposes the sand granules at the surface. The coarseness and depth of sand finish and float finish are governed by sizing of sand aggregate. Uniform texture is achieved by rubbing the plaster in a circular motion with a moistened sponge float. The rock-n-roll finish (Fig. 12.3) is achieved with the addition of larger sand aggregate as a portion of the plaster mixture. Floating in a circular motion with a moistened sponge float creates a trail or groove where the larger sand aggregate rolls across or scars the surface.

12.3.3 *Dash finish or tunnel finish*—The dash finish can be applied by hand or machine. The hand-applied method is typically achieved by splattering the plaster onto the brown coat using a large stiff brush. The depth of texture is determined, in large part, by the consistency of plaster, the size of sand aggregate, and the distance from which the plaster technician slings the plaster onto the surface. The machine-applied dash finish can be applied directly onto the brown coat from the plastering gun. The tunnel finish or heavy-dash finish (Fig. 12.4) is machine-applied in a manner similar to a light-dash finish (Fig. 12.5), but the tunnel finish typically has greater depth of texture. Factors that determine depth of texture using the hand-trowel method also apply to the machine-applied method. An advantage of the machine-applied method is that the nozzle operator has the ability to fine-tune the spray pattern at the gun by adjusting the air pressure or by changing the size of the orifice at the plaster gun nozzle. Adjusting the pumping rate or plaster flow rate also alters the spray pattern and depth of texture. A disadvantage of the machine-applied method can be application speed. Only a skilled nozzle operator should apply dash finishes. The plaster should be sprayed in a manner that avoids over-texturing, undertexturing, and inconsistency of texture across the plaster coating. The knock-down dash finish (Fig. 12.6), also known as the brocade finish, is achieved by lightly troweling the dash finish surface to flatten the raised portions.

Fig. 12.7—Scraped finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA.).

Fig. 12.9—Arizona finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.11—Frieze finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.8—Light-lace finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.10—Heavy-lace finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.12—Spanish finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

12.3.4 *Scraped finish*—The scraped finish (Fig. 12.7) is achieved by drawing the edge of a sharp straight tool, held at right angles to the plaster plane, across the finish coat after the plaster has become slightly stiff. Initial placement is similar to the smooth surface finish, using either the hand-applied or machine-applied method. The finish coating is hand troweled to achieve uniform depth and continued past midset until trowel lines or other marks left from prior trowel passes are eliminated or smoothed into the surface. The edge of certain screeding tools, such as a darby tool, rod tool, or other sharp-edged long, straight tool can be used. Scraping or tearing of the surface should be done after midset and before final set. The type of tool used, timing of scraping, sand aggregate size, and force of scraping or tearing across the finish determines the depth of texture.

12.3.5 *Skip-trowel finishes*—Skip-trowel finishes can vary in texture, from fine texture light-lace finish (Fig. 12.8) and feathery texture Arizona finish (Fig. 12.9), to coarse texture heavy-lace finish (Fig. 12.10) and heavy knock-down texture frieze finish (Fig. 12.11) or Spanish finish (12.12). There are many variations of the skip-trowel finish. Skip-trowel finishes can also be trowel-flattened near final set to lessen depth of texture, such as the California finish (Fig. 12.13) and Monterey finish (Fig. 12.14).

Skip-trowel finishes are usually achieved by applying a full-coverage background-color coat, followed by a second color coat that creates the desired texture pattern. Background coats can be used to cover scratch coat or brown coat applications that have no color pigment. The background coat establishes the background color. The finish coat should follow quickly using the double-back method to ensure that the two coats closely match in color. A variation of the skip-trowel finish can be done using a machine-applied spray pattern. A similar aesthetic finish can be achieved by machine application as a dash finish, which is followed by trowel knock-down of the raised portions of the dash texture or spray pattern (Fig. 12.6). The majority of skip-trowel finishes are hand-applied.

The skip-trowel texture is created by lightly fanning a loaded trowel on edge across the undercoat. The fresh plaster is pulled from the edge of the trowel in a sporadic fashion and adheres to the surface of the undercoat, creating a lace pattern. The depth of the lace pattern is determined in part by the size of the sand aggregate and the consistency or slump

Fig. 12.13—California finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.15—Marblecrete finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.17—Web finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.14—Monterey finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

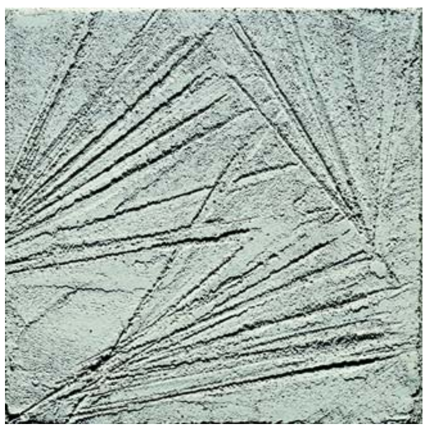


Fig. 12.16—Briar finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.18—Trowel-sweep finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

of plaster. Various skip-trowel textures can be created by varying the force applied to the trowel and by trowel-flattening the skip-trowel surface near final set.

12.3.6 *Marblecrete or exposed-aggregate finish*—The marblecrete finish (Fig. 12.15) or exposed-aggregate finish consists of a thick bedding coat into which aggregates are embedded. The bedding coat should be thick enough to hold the size of aggregate that is being placed, and should be allowed to set or stiffen enough so that the bedding can hold the aggregate in place without sagging. Aggregate can be applied into the bedding coat by hand or by blowing or shooting the aggregate into the bedding surface with a rock dash gun or similar machine-applied method. The aggregate should be tamped or otherwise forced into the surface of the bedding coat, creating a level embedment of aggregate, and ensuring the aggregate is properly keyed into the bedding.

Tamping or embedding of the aggregate should take place while the bedding coat is in a plastic (fresh) state and before midset, if possible. The aggregates, once introduced and tamped into the bedding coat, should not be moved or otherwise manipulated until the plaster reaches final set. Continued working of bedding or aggregate can result in failure of the aggregates to remain keyed into the plaster. The surface aggregate may be cleaned by wire brush, acid wash, or both, the following day.

12.3.7 *Web and briar finish*—The web and briar finishes are achieved using a hand-applied finish coat. The trowel is loaded with plaster and drop-placed or deposited, off the edge of the trowel, onto the brown coat in a single hit-and-release manner. The briar finish (Fig. 12.16) is either trowel-loaded in small amounts or is deposited in small amounts with each drop-placement. The web finish (Fig. 12.17) is heavily trowel-loaded, and deposits a large amount of plaster with each drop-placement. The plasterer determines the design by placement of each trowel-load or deposit of plaster. The size of sand determines the depth of texture. Many variations of this type of finish are possible.

12.3.8 *Trowel-sweep finish*—The trowel-sweep finish (Fig. 12.18) is achieved using a hand-applied finish coat. The trowel is loaded with plaster and placed on the brown coat in a fan-shaped or vertical stroke. Coarse sand should be used with this finish coating to gain depth of texture and lessen the potential for shrinkage cracking. Each stroke or trowel load of plaster should overlap the previous fan-shaped or vertical

Fig. 12.19—Brushed or sacked finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.20—Combed finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.21—Simulated stone finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

stroke to form high ridges off the toe of the trowel. Many variations of this type of texture are possible.

12.3.9 *Sacked or brushed finish*—The sacked or brushed texture should be applied in two coats. The two coats may consist of a brown coat and finish-texture coat, or a background color coat and finish-texture color coat applied onto a brown coat. The coats can be placed using the hand-applied or machine-applied method.

The double-back method should be used when the two-coat application is placed onto the brown coat. A thin coat should be forced into the brown coat and troweled to an even depth and a smooth surface, followed by a second thin coat. The second coat should be troweled in a random pattern while overlapping all previous strokes.

The sacked finish (Fig. 12.19) is created by rubbing the surface with a damp burlap or similar fabric or brushing the surface using a damp brush. The finish can be troweled to flatten any raised areas.

12.3.10 *Combed, marked-off, or carved-pattern finish*—The combed, marked-off, or carved patterns can be achieved using a combing tool or similar tool that creates desired markings in plaster. The finish coat can be hand applied or machine applied onto the brown coat. The finish coat surface is troweled smooth and screeded using a darby, rod, or similar straightedge tool near midset. The finish coat should be of even thickness so that the comb or carving tool pattern can be of a consistent depth. The final depth of the finish coat should be greater than the depth of the combing tool's teeth or carving tool's notches so that the undercoat is not exposed. A straightedge tool or other such template should be used as guide for the comb or notch tool when a straight vertical, straight horizontal, or repeating detail or design must conform to a given pattern. Figure 12.20 is an example of the combed finish.

12.3.11 *Simulated stone, brick, or wood pattern finish*—Simulated stone, brick, or wood pattern finishes are generally created using two different methods. One method uses the brown coat, exposed through the finish coat, to appear as the simulated joints between the simulated stone (Fig. 12.21), brick (Fig. 12.22), or wood pattern. The second method uses a thin background color coat that is applied to the brown coat to appear as the simulated joints between the simulated stone, brick, or wood pattern. Apart from this distinction, the remaining portions of the application are similar for both methods.

Tape templates are set into place on the hardened brown coat or hardened background color coat to which the texture finish is to be applied. When removed, the template tape exposes the undercoat that simulates the joints between the simulated stone, brick, or wood pattern. Joints can also be simulated by raking or scraping away the finish coating to expose the undercoat.

Coloration of simulated stone, brick, or wood patterns can be achieved by broadcasting dyes or pigments across the finish coat and troweling them into the plaster. The texture of simulated stone, brick, or wood can be achieved by using a broom finish, brush finish, brocade-type trowel technique, or other finishing technique. There are numerous color combinations, finishing materials, and techniques used to simulate a realistic look.

12.3.12 *English finish*—The English finish (Fig. 12.23) is achieved using a hand-applied finish coat applied in two parts. The first coat, or background color coat, is applied to the brown coat. The second coat, or texture coat, is applied to the background color coat between initial set and midset using a rounded trowel. The trowel, loaded with plaster, is placed on the background color coat using short strokes in varying directions, leaving a rough, irregular pattern. Coarse sand should be used with this finish coating to gain depth of texture and to lessen the potential for shrinkage cracking.

12.3.13 *Smooth finish*—Smooth-coat finishes (Fig. 12.24) should be applied in two coats using either the hand-applied or machine-applied method. The first coat should be scratched or forced into the brown coat. The second coat should be applied before the first coat reaches midset using the double-back method. Both coats should have a nominal 1/8 to 1/4 in. (3 to 6 mm) thickness. The second coat can be of greater thickness than the first coat. The second coat, or top coat, should be troweled in a uniform long-stroke pattern. Each trowel pass flattens ridges and other imperfections from

Fig. 12.22—Simulated brick finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.23—English finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

Fig. 12.24—Smooth finish (Photo courtesy of Technical Services Information Bureau, Fullerton, CA).

previous trowel passes. Overtroweling can result in plaster sagging. Walls and other vertical members should not be cross-troweled or troweled horizontally until the plaster nears final set.

Many plasterers prefer to sponge-float the top coat after the coating has sufficiently stiffened past midset. Floating the surface of the plaster opens the surface and redistributes the plaster near the surface, which in turn redistributes moisture. Floating allows the plaster to dry evenly at the surface and aids the plasterer in creating a smooth and even finish.

Some minor imperfections are unavoidable. A final random troweling just before final set, using lubricating water, can remove many minor imperfections. Smooth-troweled surfaces are discouraged because of their tendency to show cracks and imperfections, particularly over open wood-framed supports. Burnishing or hard troweling the surface to final set can discolor the finish. The hard-trowel finishing technique is considered the accepted method for creating the smooth finish. Special trowels are available that reduce discoloration of the plaster. Minor imperfections and slight waviness across the smooth-finish surface should be expected. The appearance of imperfections and waviness can be exaggerated, given the angle of the sun or other light source across the plaster surface. Every attempt should be made to manipulate the light source and, if possible, focus lighting vertically down onto the surface rather than horizontally across the finish.

CHAPTER 13—CURING

Portland cement-based plaster requires moisture to hydrate the portland cement. Plaster, like concrete, can lose moisture from the upper surface. A significant difference is that plaster has a minimal thickness that renders it incapable of storing moisture needed to continue hydration. As a result, rapid moisture loss from plaster can occur in certain environments. Concrete, because of its thickness, has a greater ability to store moisture and replenish vital moisture to the surface lost to evaporation or absorption. Plaster has little reserve of moisture to replenish lost surface moisture. Therefore, a method of curing plaster should be used that ensures continued hydration. Curing can be accomplished by supplementing moisture to the plaster through sprinkling, spraying, soaking, immersing, or otherwise maintaining moisture within the plaster.

The duration of curing required may be dependent on the rate of strength gain. The curing period is terminated when the plaster has attained the amount of strength necessary to adequately perform its intended function. The curing method should be determined before applying plaster. The curing regimen should include a method to combat known absorptive capabilities of the base substrate and prevailing weather conditions at time of placement. Certain plaster bases are capable of absorbing abnormally high amounts of moisture from fresh plaster. Highly absorptive solid substrates should be soaked before applying plaster. Presoaking the substrate reduces the amount and rate of moisture loss from fresh plaster due to absorption. Presoaking the substrate can also increase the time cure water is retained during the initial curing period. Presoaked substrates should be allowed to dry, then lightly wetted to initiate suction before application of plaster. The weather conditions at placement, such as high temperature, high winds, or low relative humidity, should be considered, and measures should be taken to ensure that proper hydration continues. When possible, plaster coatings that contain color pigment additions should not undergo curing with water. The scratch coat and brown coat under the color finish coats should be water cured and then allowed to dry for several days before applying the color coats. Water curing a plaster undercoat reduces the rate that water and water-soluble salts migrate through hardened plaster. Migrating water-soluble salts can adversely affect the coloration of plaster. Migrating salts or efflorescence discolorations are especially noticeable on colored plaster finishes.

Misting or fogging hardened plaster with water for a few days after application is common practice for most unpigmented or noncolored plaster. Plaster should be kept moist continuously and should not be allowed to dry to a point that hydration ceases during the curing period. The relative humidity within a plaster coating should remain above 70%. When the relative humidity of ambient air is above 70%, fogging may not be needed. Hot, dry, and windy conditions may require that additional moisture be supplemented to plaster and at greater frequency.

Plastic sheeting may be used to cover the plaster to retard evaporation. Plastic sheeting should be flat across the plaster with no wrinkles, creases, tears, or holes. No area should be left uncovered. If practicable, the plastic sheets should be raised off of the plaster surface, allowing air to circulate under the sheeting. This will prevent discolorations due to the plastic intermittently touching the plaster, known as the greenhouse effect (Section 12.2.3). Plastic sheeting placed too soon can cause damage to the plaster finish. Plastic sheeting placed too late can allow critical hydration moisture within plaster to escape.

A natural, unpigmented, or light-tone color finish coat may require moist curing in certain environments to prevent the portland cement-based plaster from abnormal shrinkage cracking or to prevent tensile cracking. The decision to cure using water to avoid abnormal shrinkage or meet critical tensile strength should always prevail over withholding water to avoid discoloration to colored plaster. The latter is an aesthetic concern; the former is an integrity concern (Section 15.3.1).

Membrane-forming curing compounds are generally not used on plaster, particularly when the surface is to be painted. Resin-based membrane-forming curing compounds may be used, however, only when compatible with the paint being applied. Painting should be delayed at least 2 weeks when a membrane-forming curing compound is used. Membrane-forming curing compounds are used during extreme weather conditions such as low humidity, high temperature, or high wind. Membrane-forming curing compounds are also used on certain color coats to reduce evaporation and lessen the likelihood of having to use a supplemental water curing procedure, which can cause discoloration.

A portland cement-based plaster that will be subjected to freezing temperatures should not be moist cured during the time when freezing temperatures are expected. It is not recommended to plaster below 40 °F (4 °C). Plaster that is placed before the ambient temperature is below 40 °F (4 °C) should be sheltered and heated to ensure that the plaster does not freeze and hydration of the cement continues. The placement environment of portland cement-based plaster can vary from region to region and from season to season; therefore, the appropriate building codes, project specifications, and local plastering trade recommendations should be followed. The type of curing regimen chosen and duration of curing should be a function of the physical and aesthetic attributes that are expected from the hardened plaster.

CHAPTER 14—TESTING

14.1—Introduction

A list of standards, specifications, and test methods for materials used in portland cement-based plaster can be found in ASTM C926. Proportions of materials are also found in ASTM C926 and most building codes. There are no physical requirements or standard test methods designed specifically to evaluate the structural performance of in-place plaster. This guide uses the term "structural" for plaster only when referencing the integrity of the plaster matrix or ability of plaster to perform the intended function of a coating. Portland cement-based plaster is not a structural element of building design and is not given consideration when determining structural capacity, except as provided by local code. The ability of plaster to properly function as a coating is directly related to the expertise and care in workmanship, and the quality and consistency of materials. This chapter provides guidance on evaluating the workmanship and materials of portland cement-based plaster.

14.2—Evaluating materials

There is no standard test method for evaluating all the materials of portland cement-based plaster; however, ASTM C780, which applies to masonry mortar, may be used for guidance. Test methods designed for cement paste (neat cement) or concrete can produce erroneous results when inappropriately used for portland cement-based plaster. When proprietary additives or admixtures are added to portland cement-based plaster, the manufacturer's recommendations and instructions should be followed. Individual components of portland cement-based plaster should comply with the following referenced standards or requirements:

- Portland cement: ASTM C150 Type I, Type II, Type III as specified, Type V as specified, or ASTM C1157 as specified;
- Sand: ASTM C897 or C144;
- Type S hydrated lime: ASTM C207;
- Plastic cement: ASTM C1328;
- Masonry cement: ASTM C91;
- Mortar cement: ASTM C1329;
- Pozzolans: ASTM C618;
- Slag cement: ASTM C989;
- Air-entrained cement: ASTM C150;
- Air-entrained blended cement: ASTM C595;
- Blended cement: ASTM C595 or C1157;
- Fibers: ASTM C1116/C1116M;
- Bonding agents: ASTM C631 or C932;
- Functional additions: ASTM C688; and
- Water: The water used in mixing, placing, finishing, and curing should be clean and free of such amounts of mineral or organic substances as would adversely affect the set of plaster, the durability of plaster, or the metal reinforcement within plaster.

14.3—Test methods for evaluating hardened plaster

Only specifications and standards that are written for hardened plaster should be used in the evaluation of hardened plaster. Test methods designed for concrete materials can be used well when tested by an experienced analyst who is familiar with local plastering materials and has successfully tested their methods against control samples of known composition. Failure to recognize and understand composition and application differences between portland cement-based plaster and other cementitious products can result in erroneous conclusions. Testing and evaluations should be based on the intended function of plaster. The plaster mixture proportioning, water-cement ratio, retempering of the plaster, and placement, finishing, and curing techniques are examples of variations from the standard-of-practice of concrete and other cementitious products.

14.3.1 *Evaluation of composition of hardened plaster*—Hardened plaster should be evaluated in accordance with ASTM C1324, which details the methods and procedures for chemical analysis and petrographic examination of hardened masonry mortar. This test method also includes the testing of hardened plaster. The components of hardened plaster, including portland cement, masonry cement, calcite, dolomite, aggregate, and air content can be evaluated by this method.

Data should be evaluated by an analyst with a good knowledge of plastering. Alternatively, an analyst and a plaster expert can evaluate the analytical data obtained by ASTM C1324 or other test methods.

Apparent determinations of content and type of cementitious material and aggregate present in plaster can be misleading. The presence of lime, fillers, and pozzolans within a typical plaster mixture can adversely affect laboratory testing procedures. The analyst should know which of these inorganic components are present in the plaster before attempting to quantify values of the plaster mixture components. The accuracy of proportion calculations in accordance with ASTM C1324 is dependent on assumed oxide analysis for typical portland cement. Additionally, when mortar or plaster containing masonry cement is analyzed, a typical portland cement content of the masonry cement is assumed. Assumptions of composition can introduce significant errors to proportion calculations dependent on the actual composition of the cementitious materials used in plaster. In particular, accurate proportional analysis of plaster containing pozzolans, slag, or supplementary cementitious materials might not be possible unless samples of each individual ingredient are also available for analysis. Reliability of proportion calculations using ASTM C1324 or other test methods is dependent on the analyst's knowledge of these inorganic components in hardened plaster.

14.3.2 *Evaluation of characteristics of hardened plaster*—The evaluation of hardened plaster should be evaluated in accordance with the petrographic techniques as described in ASTM C856 and C1324. Petrographic analysis can be used to describe, identify, and characterize plaster constituents, and to identify secondary reaction products and textural characteristics. Petrography can also be used to evaluate the thickness of individual plaster coats, overall coating thickness, adequacy of mixing, cement hydration and curing, adequacy of bond, strength properties and air-void characteristics, as well as describe and identify deleterious materials and secondary deposits. The results of an examination in accordance with ASTM C856 can yield information that is necessary to evaluate the following: aggressive environment deterioration, cracking, insufficient bonding, freezing-and-thawing failures, leaching deterioration, chemical sulfate attack, physical salt attack, alkali-aggregate reaction (AAR), corrosion of embedded metal, and unsound aggregate or cementitious materials.

14.4—Evaluating workmanship

The details of the plaster application should be in accordance with the project drawings and specifications, and with the federal, state, and local standards and specifications, and other agencies, such as OSHA, that may apply. The workmanship of the lathers, preparation crews, plasterers, and finishers should be examined. Items stipulated by contract or code can be evaluated as a means of quality assurance or compliance. Items can be inspected after the plastering application to evaluate workmanship or determine cause of a failure. The following items should be inspected by a knowledgeable individual when making a visual analysis of an in-place wall assembly, together with the standards or specifications that apply.

- Proper attachment and lapping of paper and lath: ASTM C1063; C926, Section 5;
- Coverage of the plaster and embedment of reinforcement: ASTM C926, Section 7;
- Regularity of scoring, floating, and texture patterns: ASTM C926, Appendix;
- Provisions for control joints and drainage: ASTM C1063; C926, Annexes;
- Integrity of planes, angles, corners, and lines: ASTM C926, Annexes;
- Thickness of coats, both individual and combined: ASTM C926, Tables 1, 3, and 4;
- Proper bond between base and successive coats: ASTM C631; C932; C926, Section 5; and
- Uniformity in the surface texture and color of the plaster finish—ASTM C926, Appendix.

This guide can also be used in conjunction with prevailing standards and specifications as an aid to the inspector, laboratory technician, and others who may need guidance in the fields of materials evaluation, inspections, and failure analyses.

CHAPTER 15—TROUBLESHOOTING AND REPAIR

15.1—Introduction

Portland cement-based plaster is a coating that can be proportioned to provide resistance to ultraviolet light, weather, moisture, fire, abrasion, or a combination of these. Portland cement-based plaster provides aesthetic appeal and serves as a barrier from the elements or a given environment. Portland cement-based plaster is not considered to be a structural element of construction; therefore, it is not intended to resist building movements, settlement of solid base structural members, or movements within wood-frame structural members. Defects and failures of a portland cement-based plaster can be attributed to inadequate materials, improper mixture proportions, improper placement or finishing techniques, improper curing regimen, aggressive service environment, structural movement forces, inadequate accommodation of volume changes, or a combination of these.

This section addresses common plaster defects and failures as well as complaints about plaster, and suggests remedies. To troubleshoot portland cement-based plaster, a professional in the field of portland cement-based plastering should perform an investigation. Initially, a visual condition survey of the plaster should be performed to identify and verify potential defects or failures. Knowing the sequential history and details of lath installation or plaster base preparation, plaster mixture proportions, mixing procedures, placement procedures, finishing techniques, and the curing regimen employed can be helpful in understanding the cause of many plaster defects or failures. Repair techniques should be considered and selected from a practical and an aesthetic viewpoint. Some of the repairs covered in this guide may not result in an acceptable appearance. The focus of a plaster repair, as described herein, is primarily to re-establish integrity of the plaster finish for its intended purpose, and secondarily to achieve an acceptable aesthetic appearance.

15.2—Cracking

15.2.1 *General*—Plaster cracks should be classified by type before determining a method of repair. Crack types include: shrinkage cracks, check cracks, plastic cracks, craze cracks, and structural movement cracks, such as tensile stress cracks.

15.2.2 *Shrinkage, check, and craze cracks*—Shrinkage, check, and craze cracks are created from volume changes that occur within the fresh plaster matrix due to hydration and moisture loss as a plaster sets and dries. Check cracks are typically only cosmetic problems and are often reversible as they can reseal themselves. These cracks tend to close or seal shut with cement hydration by-products, primarily calcium hydroxide, during the curing period. Check cracks, though closed, absorb water at a faster rate than the overall plaster matrix, allowing the crack to become temporarily visible until the plaster surface is saturated or dries again. Shrinkage, check, and craze cracks are more noticeable on smooth textures such as the hard-trowel finish. These cracks can appear open if, before their resealing, dust or dirt is trapped within the cracks. Generally, this does not affect the performance of the plaster and is not considered a failure of the plaster. Crazing and shrinkage cracks can also remain open.

Shrinkage, check, and craze cracks can be remedied by one of the following approaches:

1. Open shrinkage or craze cracks can be filled with caulk, sealant, or cement paste, with or without polymeric additives. Sand or fillers containing grit can inhibit the patch material from penetrating smaller cracks. The cement paste, caulk, or sealant should be of a consistency that allows for maximum penetration into the crack. The repair material should be forced into the crack. Excess should then be rubbed off by glove or fabric using a motion across, and not along, the crack;

2. Closed check cracks can be opened with a knife or similar tool and then treated with a cement paste, caulk, or sealant;

3. Numerous check cracks can be painted over. Shrinkage and craze cracks are small enough to be sealed by the brushing action or rolling action of a paint application. Best coverage is achieved by using a thick paint applied directly into, then across, the cracks. This treatment can then be followed by a second application of brushed, rolled, or sprayed paint across the entire panel or member; and

4. Check, hairline shrinkage, and craze cracks do not need to be repaired. Resealed cracks and hairline shrinkage and craze cracks generally affect only the upper portion of a plaster matrix and do not penetrate through a plaster coating.

15.2.3 *Plastic cracks*—Plastic cracks are created from a rapid volume change due to excessive water loss within plaster or near the surface during set or drying. Plastic cracks can be open cracks near the surface, as with typical shrinkage cracks, or they can penetrate through the thickness of a plaster coating. Large plastic cracks in a base coat can act as a fracture plane along which subsequent coatings can crack. Water loss from within the plaster matrix, due to excessive evaporation from adverse weather conditions or excessive absorption into a substrate, should be limited to avoid shrinkage and plastic cracks. Scratch coats and brown coats should be properly cured, and any large cracks should be filled before applying the finish coat(s). Possible contributors to plastic cracks are:

1. Lack of additional mixing water needed to offset water losses from the placement environment or prevailing weather conditions such as evaporation or expected absorption from a solid substrate;

2. Use of excessive mixing water (beyond that amount needed to maintain proper hydration and to allow for proper pumping, placement, tooling, and finishing of the plaster to final set);

3. Finishing the plaster too early in the set of the plaster, or not working the plaster after midset (the time when the tensile strength of the plaster can overcome the internal stress of the volume changes associated with water loss);

4. Use of a cement-rich mixture proportion that does not conform to ASTM C926;

5. Rapid absorption of moisture from within the fresh plaster coat, resulting from an undercoat or solid substrate that is too dry, improperly cured, or not sufficiently hydrated, before applying the subsequent plaster coating;

6. Excessive loss of moisture from fresh plaster due to high wind, high temperature, low humidity, or some combination of these;

7. Neglected, delayed, or improper curing regimen;

8. Overtempering the plaster finish beyond that amount of additional water needed to properly place, tool, and finish a plaster. (Tempering and retempering are accepted practices in the field of plastering, provided the intended function of the plaster is not compromised, while overtempering should be avoided); and

9. Improper sand gradation.

Smaller plastic cracks can be cleaned and filled with caulk, sealant, cement paste with or without polymeric additives, finish color plaster with extremely fine sand with or without polymeric additives, or other appropriate patching material. The repair material should be forced into the crack, and the excess material should then be rubbed off with a glove or fabric using a motion across, not along, the crack. Larger plastic cracks should be repaired in a similar manner except the crack patching material should include sand or filler material with grit. The surface can be fog coated, color coated, or painted if the plastic cracks are too numerous or if the patch repairs will not be visually acceptable.

15.2.4 *Structural movement or tensile stress cracks*—Structural movement or tensile stress cracks are significant cracks that either extend through the entire thickness of a plaster coating or through the delaminated or debonded portion of a plaster coating. Unlike shrinkage cracks, which are limited to a maximum width determined by the volume change a plaster undergoes during set, structural movement cracks can continue growing in length, width, or number until movement stops in the underlying structure or structural member. Structural movement and tensile stress cracks typically follow the stress pattern that the crack relieved. Structural movement cracks tend to be long and straight, and can extend across multiple panels or sections. Structural cracks are generally not found in great numbers. A single structural crack can relieve the stress of an area. Tensile stress cracks tend to originate at some point of stress, such as the corner of a window or door, and radiate outward across a panel or section.

Structural movement cracks and tensile stress cracks can be active cracks or inactive cracks. Active cracks are the result of ongoing structural movement or fluctuating tensile strain that continually opens, closes, slides, lifts, or lowers the plaster along the fracture. Inactive cracks do not exhibit further movement. Active and inactive structural movement cracks and tensile stress cracks can be repaired. Structural issues should be identified and properly repaired or addressed before attempting any plaster repairs. Some active cracks may require that the responsible structural element allowing movement or creating stress be stabilized or that pressure from the stress be relieved with control joints. Possible contributors to structural movement cracks or tensile stress cracks are:

1. Structural movement due to soil expansion, settlement, thermal changes, or improper structural design, allowing movement of one or more structural elements;
2. Failure to install control joints, improperly installing control joints, installing control joints too far apart, or otherwise allowing expected movement-related or stress-related cracks to occur in areas other than at intentional break lines;
3. Insufficient plaster thickness (as specified in ASTM C926) providing little to no tensile strength capacity to resist cracking;
4. Improper fastening of the lath, allowing movement across the plaster plane;
5. Improper preparation of the solid plaster base substrate, causing cracking due to poor adhesion of the plaster to the substrate;
6. Water intrusion into a wood-framed building, causing expansion to the structural member and stress to the plaster; and
7. Dissimilar plaster base substrates, such as masonry and wood, having different rates of expansion and contraction, causing movement at their juncture or joining.

Smaller inactive structural movement cracks and tensile stress cracks should be cleaned and filled with caulk, sealant, cement paste with or without polymeric additives, finish color plaster with extremely fine sand with or without a polymer additive, or other appropriate patching material. Wider inactive structural movement cracks and tensile stress cracks should be cleaned and filled with sanded caulk, sealant, finish color plaster with fine sand with or without polymeric additives, or other appropriate sanded patching material. The repair material should be forced into the crack, and the excess material should then be rubbed off with a glove or fabric using a motion across, and not along, the crack. The surface can be fog coated, color coated, or painted if the cracks are too noticeable or if the patch repairs are unacceptable. Active structural movement cracks or tensile cracks fixed in the aforementioned manner often reoccur. Active structural cracks should be treated with elastomeric caulking or sealant forced into the open or routed-out crack; however, the appearance may not always be acceptable.

15.3—Weak plaster

15.3.1 *General*—Weak or chalky plaster can result from inadequate materials, incompatible materials, improper proportioning, overtempering, troweling past final set, adverse placement conditions, or inadequate curing. The materials in portland cement-based plaster should conform to the specifications and standards referred to in Section 14.4. The handling, mixing, and placing of the plaster should conform to ASTM C926. Though finishing techniques and the curing procedures can vary, the methods used should be capable of creating durable plaster. ACI 308R, ASTM C926, and this guide can be used to aid in creating proper finishing techniques and curing regimens.

When standards, specifications, and guides for plaster materials, mixture proportions, mixing, plaster applications, and proper curing methods are not followed, or when adverse weather conditions are not adequately considered and accommodated, a weak or chalky plaster coating material can result. Possible contributors to the cause of a weak or chalky plaster are:

1. Excessive sand or a plaster having an insufficient cementing binder;
2. Excessive mixing water, causing the cement binder to be more porous;
3. Excessive lime, causing the plaster to be weakened and increasing laitance at the surface;
4. Excessive or improper use of certain admixtures;
5. Placement of plaster at or below 40 °F (4 °C), resulting in slowing or stopping hydration and setting;
6. Improper gradation of the sand; and
7. Impurities in the sand or water.

15.3.2 *Remedy*—A young plaster coating or just-hardened plaster coating that is weak or chalky can sometimes be moist-cured for several days to increase the plaster's strength and reduce surface dusting or chalking. Moist curing is less likely to provide significant improvement to plaster that is over 2 months old. Surface hardeners can be applied in the latter situation. Surface hardeners may help eliminate the dusting or chalking of the surface, and may sufficiently strengthen the plaster coating to a point that is considered acceptable. If a plaster coating or a portion of a plaster coating cannot be sufficiently improved using either of the aforementioned repairs, then that coating or portion should be removed down to a solid base and replaced. Replacement coatings should be applied in a similar manner and with the same number of coats to ensure an equal depth of finish to that of the existing plaster. The repaired section or member should be cured properly.

15.4—Debonding and delamination

15.4.1 *General*—Debonding and delamination are both separations. Plaster debonding is a separation that occurs between a single hardened coat of plaster and an undercoat, solid substrate, bond coat, or other coating or substrate material. Delamination is a separation that occurs within a single hardened coat of plaster and generally involves the nominal 1/8 in. (3 mm) outer layer of the plaster finish surface. A plaster coating that has achieved proper mechanical bond will generally maintain that bond throughout the service life of the plaster. A proper mechanical bond is created by forcing the plaster into the open, roughened, etched, or scratched surface of the substrate, thereby keying or interlocking the two surfaces.

Debonding of a plaster coat can be due to one or more of the following:

1. Surface carbonation on the undercoat or on a solid substrate;
2. Surface efflorescence or surface laitance on an undercoat or solid substrate;
3. An overly smooth or dense solid substrate surface or undercoat;
4. An overly dry solid substrate or undercoat with a high rate of absorption that results in rapid moisture loss from the fresh plaster and causes premature drying or stiffening before the fresh plaster can be absorbed or forced into the pores of the substrate or undercoat;
5. A solid substrate or undercoat that is saturated or overly wetted. Water occupies the open texture or pore spaces of a plaster base and restricts mechanical bond or absorption of plaster into the plaster base;
6. An overly thin coat of plaster with little to no tensile strength to resist shrinkage stress;
7. An overly thick coat of plaster that has pulled away from the lath network;
8. Certain contaminants on the substrate such as form-release agents, oil, dirt, or loose debris;
9. A scratch coat, brown coat, or other plaster coat that was not properly scratched, scored, notched, or otherwise prepared to receive a subsequent plaster coat; and
10. Improper usage or application of a bonding agent.

Delamination of a coat of plaster can be due to one of more of the following:

1. Overtroweling the surface of the plaster;
2. Troweling the surface of the hardened plaster after final set;
3. Blisters that have detached;
4. Contact with aggressive chemicals;
5. Alkali-silica reactions, sulfate attack, or salt attack; and
6. Freezing and thawing.

Buckles or large bulges on the surface of a plaster are delaminations or debonded areas that have not yet detached. Buckles are generally caused by the failure of a coat of plaster to bond to the undercoat or substrate. Blisters or small round bumps on the surface of a plaster are generally created by trapped air near the surface of a fresh plaster that causes a small delamination. The detachment of a blister results in a small piece of the thin upper surface layer of the plaster falling off.

15.4.2 *Remedy*—Isolated debonded areas should be removed. The surface that is to be patched should be clean and free of all loose materials or contaminants. A bonding agent should be used before, or in conjunction with, application of the repair coatings. The new coats should be applied in a similar manner and in the same number of coats as the existing plaster. The repair coating should be properly cured. The surface can be fog coated, color coated, or painted if the repairs are overly noticeable.

A plastered panel, ceiling, wall, or other member that has a large debonded area or a large number of smaller debonded areas may need to be completely redone. An alternative can be to repair the debonded or delaminated areas by patching to the level of the existing plaster, then giving the entire member a new texture, fog or color coat, or repainting.

15.5—Discoloration of plaster

15.5.1 *General*—Plaster discoloration can result from the normal ongoing process of hydration, differences in moisture content, or differences in thickness. Discoloration or mottling can be due to other causes such as staining, trowel burn, greenhouse effect, or rusting reinforcement. Slight color variations, which have the appearance of uniformly shaded, blotchy, or cloudy appearance across the surface, should be expected. Mottling discoloration can be abnormally severe and have a large amount of nonuniformity or exaggerated coloration.

Some discoloration or mottling can be expected, but should be somewhat uniform with slight color variations across the surface of a plaster. Some variation of moisture content and hydration do occur within the plaster coating. This discoloration is not considered to be a failure or defect, but a normal characteristic of many cementitious products not in need of remedy. Generally, discoloration of this type fades or becomes more uniform in color as plaster continues to hydrate and as moisture within young plaster is used in reaction or released. New and old plaster surfaces can be cleaned to improve their appearance and lessen discoloration.

Severe discoloration or areas of sporadic discoloration may be due to one or more of the following:

1. Contaminated sand or impurities in the plaster mixture ingredients (such as iron, which can cause rust-colored discolorations);
2. Color pigments that are not thoroughly mixed (that can appear as concentrated spots of color pigment or as lines and swirls of color pigment if a concentrated color pigment spot is troweled);
3. Varying the water content of the plaster finish coat from batch to batch;
4. Uneven rates of hydration resulting from variations in the moisture content within a plaster coat (due to the substrate or undercoat having varying moisture contents, varying rates of absorption, or both);

5. Localized areas within a solid substrate that release a constant flow of moisture, also called weepers (which may range in size from several inches to several feet in diameter and can also carry contaminants or minerals that affect the coloration of the plaster coat);

6. Rain or other water on the surface of a young plaster (such as water that splashes or wets only certain portions of a plaster finish, causing discoloration to those nonuniformly wetted areas, unlike a uniform water cure that is applied to a plaster finish in a uniform fashion across the entire plaster surface);

7. Trowel burning, overtroweling, or dry floating (causing severe mottling or severe dark-shaded or blotchy areas, often gray in appearance, that may come from the metal of the trowel being deposited onto the plaster surface and from troweling past final set; the discoloration can be found in a repeating pattern or in an arc pattern that follows the troweling motions made by the plaster technician);

8. Troweling a hard-trowel finish near final set without trowel-lubricating water being added either to the trowel or to the plaster surface;

9. Uneven thickness of the plaster coat (thicker areas of a plaster coating are generally darker in color and thinner areas are generally lighter in color because thicker plaster tends to retain moisture longer due to varying rates of hydration and moisture retention);

10. Corrosion of metal lath, wire support network, or reinforcement steel that is embedded in the plaster or within the solid substrate below (rusting metal stains can migrate through the plaster and appear as rust marks or stains on the surface, ranging in color from an orange-red to black);

11. Calcium chloride accelerator (can cause plaster to be darker in color and can cause mottling to be exaggerated); and

12. Polymeric additives that have not been thoroughly mixed.

Staining discoloration can be precipitated, rusted, leached, or absorbed onto the plaster surface, and can be caused by:

1. Spills, splashes, or other liquid materials;
2. Dirt, leaves, or other solid organic materials;
3. Oils, acids, polymers, or other synthetic materials;
4. Efflorescence, salt migration, or precipitation; and
5. Pollution, such as carbon dioxide levels in the air, or certain contaminants or chemicals in the water.

15.5.2 *Remedy*—Discoloration can be repaired by removal and patching of the affected area, then applying a light fog coat or color coat over the affected area in a manner that matches the unaffected portion of the plaster coating, or the entire member can be painted.

Staining can sometimes be removed from the surface by sanding, grinding, acid washing, bleaching, chemically treating, or otherwise cleaning the plaster surface. The surface can also be repaired as described previously for discoloration.

Surface repairs, such as sanding or grinding, can sometimes remove or lessen the degree of discoloration to an acceptable appearance with certain finishes. A small area of the plaster coat should be tested before treating the entire plaster coating to determine if the chemical or physical treatments are effective in removing the discoloration and if the treatment will be damaging to the plaster. Otherwise, the surface can be treated with a light fog coat or color coat of plaster applied over the entire member, or the entire member can be painted.

Rust or other contamination should be repaired by removing the rusting metal or contaminant and then patching the plaster. Covering this type of discoloration with paint, color coat, or fog coat, without removing the rusting metal or contaminant, will almost certainly result in the discoloration reappearing through the coating in the future.

15.6—Long-term deterioration

15.6.1 *General*—Service life of hardened plaster is determined largely by the environment in which the plaster is placed. Sections 15.6.2 through 15.6.8 describe the factors that influence or accelerate the deterioration of plaster. Additional information on long-term deterioration of cementitious materials can be found in ACI 201.2R.

15.6.2 *Chemical attack*—Plaster is susceptible to chemical attack from air, soil, water, substrate, and any other compound or material that can deteriorate plaster when in contact with it. Plaster is considered susceptible if water or moisture is present together with a given amount of salt, acid, or other chemical or ion, in strengths capable of deteriorating plaster. Water-soluble salts, acids, or ions, such as sulfates, chlorides, and carbonates, can be transported into plaster, leading to the deterioration of the plaster coating, such as spalling. Sulfates can react with cementitious materials, causing expansion that can crack plaster or delaminate the upper surface layer of plaster. Chlorides can accelerate the deterioration of embedded metal lath or wire mesh.

Plaster experiencing chemical attack typically exhibits some type of damage, such as salt crystallization, surface efflorescence, salt migration, cracking, scaling, flaking, or upper-layer surface delamination of the plaster coating.

15.6.3 *Unsound or reactive sand particles*—In the presence of moisture, certain unsound or reactive sands or aggregates can chemically react with sulfates or alkalies in cement, or from the placement environment, causing deterioration of plaster materials. Unlike concrete, which has larger aggregate in its composition, portland cement-based plaster typically consists of graded sand that ranges from very fine fractions to larger sand particles of a nominal 1/8 in. (3 mm) diameter. At this small size, unsound or reactive sand or aggregate does not generally cause enough expansion to be considered damaging to the service life or function of a plaster coating. The stress that is created from this expansive reaction would typically cause a small popout. Unsound or reactive aggregate or sand includes expansive clays, reactive or porous cherts, certain zeolites, certain shales, volcanic opaline materials, and minerals containing potassium or sodium.

15.6.4 *Freezing-and-thawing deterioration*—Freezing-and-thawing damage of plaster is rare. Portland cement-based plaster typically has sufficient air entrainment or porosity to resist freezing-and-thawing damage. Nevertheless, damage can occur to a dense or non-air-entrained plaster that is critically saturated. The components of plaster, the high *w/cm*, and the overall placement application, including mixing, pumping, and placing of the plaster, create porosity within the matrix that may increase resistance to freezing-and-thawing damage. Plaster is most susceptible to deterioration from freezing and thawing if the overall matrix of the plaster is dense (nonporous), has a hard-trowel finish, or if a nonbreathing sealant or waterproof coating is applied to the plaster surface.

15.6.5 *Carbonation*—Carbonation proceeds from the surface of a plaster, and progresses inward over time. It is normal for carbonation to penetrate the entire thickness of a plaster matrix. The rate of reaction and the depth of carbonation vary as a function of the permeability of a plaster coating. Carbonation takes place when a plaster coating reacts with carbon dioxide in air or with a carbonate or bicarbonate ions in water. Typically, carbonation is not considered deleterious or a threat to the service life of plaster. If certain conditions prevail, however, deterioration can take place.

Carbonation lowers the pH of plaster, which in turn allows embedded metal lath or wire mesh to be more susceptible to corrosion.

Carbonation involves reaction of the calcium compounds in cement and lime portions of plaster with carbon dioxide to form calcium carbonate. A carbonated plaster surface that is in a water environment or in the presence of moisture having a low carbonate alkalinity can have a deleterious secondary chemical reaction that converts calcium carbonate into water-soluble calcium bicarbonate.

Surface carbonation of a young plaster can inhibit cement hydration and exaggerate the discoloration or blotchy appearance of the finish. Surface carbonation on a fresh or young plaster can also inhibit surface check cracks from resealing. Check cracks are often advantageously filled with the calcium hydroxide compound liberated during hydration of cement. Carbonation of the plaster surface can slow or stop the migration of soluble calcium hydroxide by forming the near-insoluble and less-mobile compound of calcium carbonate. Additional information on the effects of carbonation can be found in the PCA EB049.

15.6.6 *Aggressive water deterioration*—Aggressive water is any water that has a chemical imbalance with the plaster materials, and that can remove, dissolve, or otherwise react with the plaster materials to cause deterioration. Water that has low calcium hardness content, low total dissolved-minerals content, low pH, low carbonate alkalinity, or high concentrations of harmful elements or ions can deteriorate the plaster coating.

15.6.7 *Leaching deterioration*—Leaching of soluble plaster materials can take place when water or moisture is allowed to percolate through a plaster coating. Leaching can also take place if water is able to continually or repeatedly absorb into, and evaporate out of, a plaster coating. Leaching deteriorates plaster by dissolving the plaster matrix. Leaching can weaken the surface; cause delamination, spalling, or flaking of the surface; or cause complete dissolution of the plaster surface over time. Soft water, deionized water, or water with low alkalinity can leach the lime portion of plaster and certain compounds from cement, especially calcium hydroxide.

15.6.8 *Remedy*—Remedies for repairing long-term deteriorated plaster are similar to those described in Sections 15.3.2 and 15.5.2. Lasting repairs should involve removal of unsound plaster materials. Patching or reapplication of the base and finish coats should match the remaining unaffected portion of the plaster member.

CHAPTER 16—REFERENCES

16.1—Referenced standards and reports

The standards and reports listed below were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

American Concrete Institute

201.2R	Guide to Durable Concrete
232.1R	Use of Raw or Processed Natural Pozzolans in Concrete
308R	Guide to Curing Concrete
515.1R	Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete
546R	Concrete Repair Guide

ASTM International

A641/A641M	Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
A653/A653M	Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
C35	Specification for Inorganic Aggregates for Use in Gypsum Plaster
C91	Specification for Masonry Cement
C144	Specification for Aggregate for Masonry Mortar
C150	Specification for Portland Cement
C206	Specification for Finishing Hydrated Lime
C207	Specification for Hydrated Lime for Masonry Purposes
C260	Specification for Air-Entraining Admixtures for Concrete
C270	Specification for Mortar for Unit Masonry
C494/C494M	Specification for Chemical Admixtures for Concrete
C595	Specification for Blended Hydraulic Cements
C618	Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C631	Specification for Bonding Compounds for Interior Gypsum Plastering
C688	Specification for Functional Additions for Use in Hydraulic Cements
C780	Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
C841	Specification for Installation of Interior Lathing and Furring
C847	Specification for Metal Lath
C856	Practice for Petrographic Examination of Hardened Concrete

C897 Specification for Aggregate for Job-Mixed Portland Cement-Based Plasters
C926 Specification for Application of Portland Cement-Based Plaster
C932 Specification for Surface-Applied Bonding Compounds for Exterior Plastering
C933 Specification for Welded Wire Lath
C979 Specification for Pigments for Integrally Colored Concrete
C989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
C1032 Specification for Woven Wire Plaster Base
C1059 Specification for Latex Agents for Bonding Fresh to Hardened Concrete
C1063 Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
C1116/C1116M Specification for Fiber-Reinforced Concrete and Shotcrete
C1157 Performance Specification for Hydraulic Cement
C1324 Test Method for Examination and Analysis of Hardened Masonry Mortar
C1328 Specification for Plastic (Stucco) Cement
C1329 Specification for Mortar Cement
D98 Specification for Calcium Chloride
D4258 Practice for Surface Cleaning Concrete for Coating
D4259 Practice for Abrading Concrete
D4261 Practice for Surface Cleaning Concrete Unit Masonry for Coating
D4262 Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
D4263 Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
E241 Guide for Limiting Water-Induced Damage to Buildings
E1857 Guide for Selection of Cleaning Techniques for Masonry, Concrete, and Stucco Surfaces
E2112 Practice for Installation of Exterior Windows, Doors and Skylights

Federal Specifications
UU-B-790a Building Paper, Vegetable Fiber: (Kraft, Water-Proofed Water Repellent and Fire Resistant)
UU-P-31 B/171 Tensile Breaking Strength (Dry)
UU-P-31 B/Gen. General Specifications and Methods of Testing

International Conference of Building Officials
UBC Uniform Building Code

Portland Cement Association
EB049 Portland Cement Plaster/Stucco Manual

The above publications may be obtained from the following organizations:

American Concrete Institute
P.O. Box 9094
Farmington Hills, MI 48333-9094
www.concrete.org

ASTM International
100 Barr Harbor Dr.
West Conshohocken, PA 19428
www.astm.org

Federal Specifications
Standardization Documents Order Desk
Bldg. 4, Section D
700 Robbins Ave.
Philadelphia, PA 19111-5094

International Conference of Building Officials
5360 South Workman Mill Rd.
Whittier, CA 90601
www.iccsafe.org

Portland Cement Association
5420 Old Orchard Rd.
Skokie, IL 60077-1083
www.cement.org

16.2—Cited references

Engineered Wood Association (APA), 2006, "Installation of Stucco Exterior Finish Over Wood Structural Panel Wall Sheathing," *Data File* Q370G, APA, apawood.org, Tacoma, WA, 6 pp. (available as pdf file only)

ICC Evaluation Service, Inc., 2006, "Acceptance Criteria for Cementitious Exterior Wall Coatings," AC11, ICC Evaluation Service, Whittier, CA, 8 pp.

National Plasterers Council, Inc., *Technical Manual*, sixth edition, National Plasterers Council, Inc., Port Charlotte, FL.

Robert, G. T., Jr., 1997, *Exterior Insulation and Finish System Design Handbook*, CMD Associates, Inc., Seattle, WA, 240 pp.

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