Portland Cement

Plaster / Stucco Manual

Portland Cement Association

EB049

Portland Cement Plaster/Stucco Manual

FIFTH EDITION

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An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.

FOREWORD

This manual serves as a guide to acceptable practices in designing, mixing, and applying portland cement plaster (stucco). It is intended as an authoritative reference manual for architects, specifiers, building officials, inspectors, contractors, plasterers, and apprentices. The newer materials, textures and finishes, and technology described provide ways to achieve attention-getting appearance and freedom of architectural form without sacrificing the utility and economy of plaster.

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WARNING: Contact with wet (unhardened) concrete, mortar, cement, or cement mixtures can cause SKIN IRRITATION, SEVERE CHEMICAL BURNS (THIRD-DEGREE), or SERIOUS EYE DAMAGE. Frequent exposure may be associated with irritant and/or allergic contact dermatitis. Wear waterproof gloves, a long-sleeved shirt, full-length trousers, and proper eye protection when working with these materials. If you have to stand in wet concrete, use waterproof boots that are high enough to keep concrete from flowing into them. Wash wet concrete, mortar, cement, or cement mixtures from your skin immediately. Flush eyes with clean water immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete, mortar, cement, or cement mixtures from clothing. Seek immediate medical attention if you have persistent or severe discomfort.

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The serviceability of portland cement plaster has been proof-tested through long use in extreme environments. With its proven history of durability, plaster will continue to be used in new and creative applications, limited only by the imagination of the designer.


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INTRODUCTION

Portland cement plaster is a versatile facing material that can be applied to any flat or curved surface either inside or outside any structure or building. Examples of the versatility of plaster include housing in developing countries, high-rise-building enclosures of prefabricated panels (built at ground level then elevated and fastened in their final positions), simulated mountains in amusement parks, rock grottos in zoos, and ferrocement boats and ships. The serviceability of portland cement plaster has been proof-tested through long use in extreme environments such as the cold temperatures of Alaska and Canada, the hot temperatures of the humid Gulf States, and the dry Southwestern States. With its proven history of durability, plaster will continue to be used in new and creative applications, limited only by the imagination of the designer.

Portland cement plaster is a combination of portland cement-based cementitious material(s) and aggregate, mixed with a suitable amount of water to form a plastic mass. The plaster will adhere to a surface and harden, preserving any form and texture imparted to it while plastic.

Portland cement plaster is usually applied in three coats over metal reinforcement with or without solid backing. Two-coat work may be used over solid masonry or concrete surfaces that are reasonably true planes and permit development of adequate bond. Some substrates serving as backing, such as smooth concrete, have level surfaces and uniform suction that make thin, single-coat plastering possible. The cementitious material in plaster may be either portland cement, air-entraining portland cement, masonry cement, blended cements, or plastic cement used singly; or it may be portland cement used in combination with masonry cement, plastic cement, or hydrated lime. Color can be obtained by using colored cements, adding pigments to the fresh mixture, or painting (or staining) the hardened plaster.

Plaster in the freshly mixed state is a plastic, workable material. It can be applied by hand or machine to conform to any shape, using two or three applications, or coats. The final appearance of the finish coat can be varied by changing the size and shape of the aggregate, adding color, changing the consistency of the finish mix, and the method or equipment used for plastering. Ultimately, it is the plasterer's skill in manipulating the fresh mix that determines the look of the finish coat.

Plaster in its hardened state is a desirable facing material: hard, strong, fire resistant, rot and fungus resistant, color retentive, and durable under wet-dry or freeze-thaw weather cycles. Plaster has proved to be a long lasting wall cover in all climates, from the very hot to the very cold. As a surface finish, its appeal lies in its utility, low first cost, and minimum need for maintenance. Design practices that limit moisture exposure—such as roof overhangs—will increase the plaster's durability by reducing wet/dry cycling. A plaster finish on brick or block walls improves resistance to rain penetration and contributes to a weather-tight enclosure.

This manual presents recommended procedures based on accepted practices that will produce high-quality portland cement plaster with the desired serviceability and beauty.

Portland cement plaster (sometimes called "traditional or conventional stucco") should not be confused with exterior insulation and finish systems (EIFS) or "synthetic stucco systems" that have become popular but have recently been the subject of controversy due to moisture infiltration problems resulting from improper installation or design. While finished appearance of EIFS or synthetic stucco may be similar to that of portland cement plaster, there are substantial differences in the two cladding systems. Synthetic stuccos are proprietary systems that consist of a polymer-based laminate that is wet-applied, usually in two coats, to rigid insulation board that is fastened to a wall with adhesive, mechanical fasteners, or both. Polymer based (PB) systems, sometimes known as thin coat, soft coat, or flexible finishes are most common. The base coat for PB systems is usually only $\frac{1}{16}$ in. (1.6 mm) thick, and finish-coat thickness is typically not thicker than the maximum sand particle size in the finish coat.

The focus of this publication is solely portland cement plaster. Information about EIFS must be obtained from other sources.

CODES, STANDARDS, AND GUIDES

Construction specifications setting forth the minimum requirements for plastering work must be closely followed, whether stated in industry-wide standards and guide specifications or in local building codes and ordinances (see Appendix A). These written specifications establish acceptance requirements for the quality of materials and workmanship. Compliance with construction specifications protects both the customer and contractor. All members of the design and construct team should be aware that design, materials, and construction affect the performance of each segment of a structure as well as the entire structure.

Though applicable codes vary throughout North America, they are always mandatory and should be strictly followed. In the past in the United States, local jurisdictions adopted one of three model building codes, the *BOCA National Building Code (BOCA),* the *Standard Building Code (SBC),* or the *Uniform Building Code (UBC)*. In Canada, specifying agencies typically follow the *National Building Code,* which contains stucco information in Section 9.28.

During the 1990s in the United States, the sponsoring organizations that produced the BOCA, SBC, and UBC formed the International Codes Council (ICC) and developed the *International Building Code (IBC)* for commercial construction and the *International Residential Code (IRC)* for dwellings. Working from the existing three model codes, building officials established a unified code for the country and beyond. Even with the new 2000 I-Codes barely in effect, a competing model building code from the National Fire Protection Agency, designated NFPA 5000, was completed in 2002. However, the portland cement plaster provisions of BOCA, SBC, IBC, IRC and NFPA 5000 reference ASTM C 926, the *Standard Specification for Application of Portland Cement-Based Plaster,* and ASTM C 1063, the *Standard Specification for Installation of Lathing and Furring for Portland Cement-Based Plaster*. The UBC does not reference these two ASTM Standards. UBC provisions for portland cement plaster are contained in Chapter 25 of that model code.

Project specifications typically contain additional references to national standards and industry and manufacturers' guides and recommendations. Current standards pertaining to portland cement plaster and plastering, approved by ASTM and the American Concrete Institute (ACI), should be reviewed and understood before commencing any phase of plastering. Manufacturers' guides and recommendations address plastering while concentrating on a specific material. As guides and recommendations, their contents are informative but not mandatory, unless required by the project specification.

This manual is a guide that conveys recommendations for the use of portland cement plaster, of which portland cement is the basic binding ingredient. Its purpose is to provide technical information on materials, design, and application to assure continued success of the portland cement plaster.

PORTLAND CEMENT PLASTERING

Portland cement plastering can be simple or sophisticated depending on the specific application (Figure 1). With experience gained over the years, certain (constituent) materials in specific geographical areas have demonstrated their superiority in producing a weather resistive (plaster) facing for buildings. Whether or not machinery will be used to convey plaster to the working face of the wall adds another consideration for materials selection and proportioning of plaster. The in-service exposure conditions of the plaster may lead to additional materials and proportioning considerations.

Figure 1. A plasterer trowels a wall face. Flat wall surfaces are some of the simplest and most common plaster applications. (30241-0)

Broadly stated, portland cement plaster may be any combination of cementitious material, fine aggregate, and water. Experience, however, has shown that the simplest effective combination consists of one part cement to approximately three or four parts fine aggregate by volume. Depending on the locale, the cement may be masonry cement, plastic cement, portland cement, blended cement, or a combination of portland cement or blended cement and hydrated lime. These materials, when properly proportioned, will provide necessary resistance to weather and cracking. When applied over frame construction, the two base coats of plaster should have a total thickness of approximately ¾ in. (19 mm) to produce a solid base for any decorative finish coat of plaster. This simple plaster formula and these plaster coat requirements will produce a serviceable portland cement plaster surface. Modifications to the plaster formula can ease application and promote greater longevity of the plastered surface.

Portland cement plastering can be as advanced as the craftsman's knowledge and experience with the material will allow. More sophisticated plaster systems are typically used to optimize uniformity, longevity, economy, and the use of local materials. A plasterer with a keen understanding of materials and application methods, applying a weather resistant facing on a high-rise building, promotes his craft and produces a surface requiring minimal maintenance. Successful plastering requires someone with a working knowledge of the materials in plaster, who not only knows how to properly combine the individual plaster components, but also knows how the hardened plaster will perform in its particular environment.

GLOSSARY OF PLASTERING TERMS

Many words, common throughout the product manufacturing and plastering trade, become specific in their definition and use. Such terms are contained in the Glossary – Appendix B. This manual uses many of the terms defined in the glossary. Others are included in the glossary so the reader can relate to terms or concepts used in this manual.

Some basic terms of interest that should be understood by the user of this manual are as follows:

The term "plaster" applies to the combined materials (cement, sand, water, and admixture, if applicable) during and after mixing and when applied and hardened, whether as an exterior or interior facing surface. "Plaster," as used throughout this manual, refers to plaster with portland cement–based products as the main cementitious constituent. Other available plaster systems are not addressed in this manual.

The word "plaster" refers to the mixture. "Plastering" is the application of plaster.

Portland cement stucco and portland cement plaster are the same material. The term "stucco" is widely used to describe the cement plaster used for coating exterior surfaces of buildings. In some geographical areas, "stucco" refers only to factory-prepared finish-coat mixtures.

The word "coat(s)" refers to individual thickness(es) of plaster applied to a wall surface. Basically, two or three coats are involved in all plastering. Numbered consecutively from the inner plaster surface to the outer plaster surface, they are first, second, and third coats. Preferably, and as used in this guide, the three coats are referred to as the scratch coat, the brown coat, and the finish coat. The combination of scratch and brown coats is referred to as the base-coat plaster. The last (second or third) coat is the finish coat.

TOOLS FOR PLASTERING

A wide array of common plastering tools and specialized tools are available to the craftsman and artisan completing the plaster application. A listing of tools is contained in Appendix C.

Discoloration and other imperfections of the plaster surface will occur if tools are not properly cleaned after each use. Tools should be washed to remove any adhering plaster, scoured with plasterer's sand, and wiped dry. Mixers should be thoroughly cleaned, especially if the mixer has been used for materials other than portland cement plaster. Sand is also recommended for scouring interior surfaces of the mixer.

Good quality and appropriate tools and equipment that are clean, free of warping, and without excessive wear are necessary to do a good plastering job. Improper tools may compromise the quality of the hardened plaster in spite of their ability to provide a visually acceptable finished surface.

DESIRABLE PROPERTIES OF PLASTER

Plaster must possess certain properties in both the fresh and hardened states to perform satisfactorily during plastering and while in service. The plaster, as discharged from the mixer, must have the properties necessary for either hand or machine application. During application, the plaster must provide adhesion to a (solid) base and cohesion for encapsulating metal lath. It must remain plastic after application to allow striking a smooth, plane surface for subsequent coats or for surface texturing. Fresh plaster must maintain its bond to the substrate, which may be the previous coat, and as it cures and hardens, increase its bond to that substrate. After curing, the plaster must provide hardness and strength, reasonable resistance to cracking, and resistance to weather.

Fresh Plaster

Fresh plaster, as discharged from the mixer, should have the following properties:

Adhesion. The capability to adhere to an identical or compatible material is developed in plaster by the portland cement paste, that is, the combination of cement, air, and water. Air-entrained portland cements, masonry cements, plastic cements and other types of cement that have been ground finer generally possess greater adhesion than do non-air-entrained, normal-fineness cement counterparts.

Cohesion. The capability of plaster to hold together or cling to itself is also developed by the portland cement paste. During plastering to metal-lath reinforcement, the cohesion of the plaster governs its ability to remain fixed in place after the plaster envelops the metal reinforcement. A cohesive plaster remains where it is placed. Air entrainment and fines in the mixture contribute to plaster cohesion.

Workability. The ease of placing and later rodding and floating plaster are measures of its workability. Workability involves adhesion and cohesion as well as unit weight and plastic deformation. In the field, the plasterer judges the degree of workability during application. In the laboratory, degree of workability is measured by various standardized tests, including tests for flow, slump, unit weight, and plastic deformation during penetration testing. To give plaster its best workability, aggregate having favorable shape and grading, cement, and optimum amounts of air, water, and plasticizers must be properly proportioned and combined during mixing. If the quantity of any of these ingredients is outside the range of optimum amounts, the workability of the plaster will be decreased. Plaster with less than optimum workability requires greater effort by the plasterer during application and can result in an appreciable reduction in the performance of the hardened plaster.

Hardened Plaster

The finished, hardened plaster should have the following performance characteristics:

Weather Resistance. The ability of plaster to withstand weathering includes: resistance to rain and snow; freeze-thaw durability; resistance to extreme thermal and moisture changes; and resistance to aggressive chemicals in the atmosphere, such as acid rain. Plaster that is properly proportioned, thoroughly mixed, applied over suitable substrates, and cured will exhibit good durability and resistance to the natural environment.

Resistance to rain penetration is obtained by using properly cured portland cement plaster that has been adequately densified during application. Freeze-thaw durability is achieved by using a plaster mixture that contains air-entrained cementitious materials or an air-entraining admixture introduced during batching. Use of optimum aggregate content in conjunction with proper application and curing provides resistance to excessive thermal and moisture volume changes.

The normal alkalinity of portland cement plaster provides resistance to mildly aggressive chemicals in the environment. Acid rain, which contains minor amounts of nitric oxides and sulfur oxides, is converted to a neutral base when it comes in contact with the calcium-rich plaster surface. However, sulfates, from sulfate laden soils that are allowed to either contact or supply liquid into portland cement plaster by absorption, will react with the portland cement and cause disruptive expansion. In these more aggressive sulfate environments, additional resistance may be achieved through the use of special cement or special types of cement. Types II and V portland cement are less susceptible to sulfate attack than normal Type I portland cement. Masonry cement and plastic cement plasters provide greater resistance to sulfate attack than that exhibited by cement-lime plasters.

Bond. The ability of plaster to bond with a base of identical or compatible material is especially important when the plaster is applied to a solid base. Bond is normally developed during the portland cement hydration process. As cement hydrates, the resulting new chemical compounds develop crystals within macroscopic and microscopic surface deformations at the interface between the applied plaster and the surface to which it is applied. The degree to which bond is obtained depends on the area of contact, surface texture, degree of suction, availability of water for cement hydration, and the hydration period. Wherever bond to the substrate cannot be obtained, metal reinforcement must be used to support the plaster through mechanical interlocking.

Freeze-Thaw Durability. The ability of plaster to resist the disruptive forces associated with the expansion of freezing water within saturated plaster is a measure of durability. Although plaster normally is used on a wall or ceiling, where the in-service water content of the hardened plaster is well below critical saturation levels, the use of air-entrained plaster is especially beneficial where snow, slush, and deicer chemicals may be splashed or sprayed against a wall surface.

Tensile Strength. The ability of plaster to resist tensile stresses, whether developed internally or externally, is closely related to the cracking characteristics of the plaster. Plaster densification by proper and timely floating during brown coat application increases tensile strength. Curing and hardening also increase the tensile strength of the plaster and its ability to resist cracking.

As plaster dries, it shrinks. Internal tensile stresses result from this shrinkage. These drying shrinkage stresses are related to the paste-to-aggregate ratio of the plaster after rodding and floating of the brown coat. Initially, the brown coat plaster has a high paste-to-aggregate ratio, because of the water content required for application. Absorption and evaporation cause a reduction in the plaster's initial water content, thereby reducing the paste-to-aggregate ratio. Floating of the brown coat further reduces the water content as reconsolidation of the plaster draws internal moisture to the surface, where it evaporates. The design of the particular plaster section determines the degree to which drying shrinkage is restrained or unrestrained. Since greater stresses result from the restraint of shrinkage, control joints are incorporated into the design to minimize restraint, and thus drying shrinkage stresses, in the plaster.

The tensile strength of plaster increases rapidly during early ages when moisture is available for curing. Tensile strength is required to resist shrinkage stresses and lessen cracking. Proper curing of well proportioned and densified plaster is compulsory to obtain maximum tensile strength.

Compressive Strength. While the ability of a plaster to carry its own weight plus added service and wind loads is a physical property of interest, high compressive strength in plaster is really not important. There are correlations, however, between compressive strength and other more important physical properties. Compressive strength is easy to measure, but the other properties are not. These correlations permit compressive strength testing to be used as an indicator that the other properties have been attained.

For example, compressive strength and tensile strength of plasters have been correlated. Therefore, compressive strength tests, which are more easily performed, can be used to estimate the tensile strength of plaster. Similarly, relationships exist between compressive strength and completeness of hydration, absorption, water permeability characteristics of plaster, and other properties. However, high compressive strength should not be interpreted as an indicator that one particular plaster mix is better than another. Compatibility of the collective physical characteristics of the fresh and hardened plaster with the requirements of the application being considered should be the guideline for selection of plaster mixes.

Laboratory measurements of compressive strength of plaster have resulted in the plaster-mixture recommendations set forth in this manual. However, compressive strength is not typically specified for qualification of mixes, as a quality control field test, or as a criterion for acceptance or rejection of the finished work. This is because test results must be cautiously interpreted, since water content, temperature effects, and test specimen geometry all influence the results. Uniformity of mixtures, batch to batch, can best be determined by inspection of the batching process or use of the aggregate ratio and water content tests. These tests are defined in ASTM Method C 780, and are generally preferred over compressive strength testing for quality control purposes, since each provides more timely information on batch-to-batch uniformity. When it is desirable to know the compressive strength of a plaster mixture, ASTM Method C 780 can be used to determine this value.

Unit Weight. Though not commonly specified as a criterion in new construction, the unit weight of installed plaster is sometimes an important piece of information. For instance, in retrofit applications, a designer may need to assess the effect of increased loading on a wall or its foundation as a result of adding a new stucco coating. Weight per wall area is a function of the density of plaster and plaster thickness. Fresh and hardened plaster is typically assumed to have a density of 142 lb/cu ft (2275 kg/m³).

Tables 2 and 3 of ASTM C 1063 provide guidelines for support member sizes and spacings for ceilings and walls that will receive portland cement plaster. This includes the minimum weight of metal plaster bases and recommended method of attaching them to the structure.

Table 1a. Weight of Plaster (U.S. customary)

Stucco thickness, in.	lb/sq ft
½	5.9
¾	8.9
1	11.8

Table 1b. Mass of Plaster (metric)

Stucco thickness, mm	kg/m²
13	30
19	43
25	56

MATERIALS

The skilled plasterer knows how important the selection and use of proper materials are to the performance of finished plaster. The choice of plastering materials is based on knowledge of the materials and their contribution to satisfactory appearance, serviceability, and durability. Proper materials are necessary to produce the desired results in both fresh and hardened plaster. All materials used in plaster should meet the appropriate product requirements stated in the specifications. The selection of good/desirable/appropriate materials is described in the section "Mixtures."

Cement

Cements used in plaster are "hydraulic cements," meaning that they react with water to harden and are capable of doing so when immersed in water. The various types of hydraulic cement listed below are not available in all geographic areas. Thus, it is beneficial to know which cements are readily available prior to selecting plaster type for a specific project.

The type of cement used should comply with current requirements of one of the following applicable product specifications:

Portland cement	ASTM Designation: C 150, Types I, II, and III, or their air-entrained equivalents, Types IA, IIA, and IIIA (Type V may be used for increased sulfate resistance). ASTM Designation: C 1157, Types GU, HE, MS, HS, and MH. CSA A5 Designation: Types 10, 20, 30.
White portland cement	ASTM Designation: C 150, Type I, II, and III, or their air-entrained counterparts, IA, IIA, and IIIA. CSA Designation A5, Type 10 White.
Blended hydraulic cement	ASTM Designation: C 595, Types IP, IP(M), IS and IS(M), or their air-entrained counterparts, IP-A, IP(M)-A, IS-A, IS(M)-A. ASTM Designation: C 1157, Types GU, HE, MS, HS, and MH.
Masonry cement	ASTM Designation: C 91, Types M, S, N, and White (M, S, or N). CSA A8 Designation: N, S, White (N or S).
Plastic cement	ASTM Designation: C 1328, Type M and S, or Uniform Building Code Standard: UBC 25-1.

As shown here, specifications used in Canada currently allow portland cement, white cement, and masonry cement for plaster mixtures. Blended hydraulic cements and plastic cements are not allowed.

Portland cement, ASTM C 150, serves as the basic active ingredient in plaster. It may be used singly, in combination with other hydraulic cements, as a component of other hydraulic cements, or in combination with a plasticizer. The product standard provides for differing types, some with an air-entrained counterpart. Those of special interest to the plasterer are:

- Type I, normal portland cement is a general-purpose cement recommended for most conditions for which the special properties of the other cement types are not required.
- Type II is a modified portland cement that has slower heat liberation during hydration and improved resistance to sulfate attack. The improved sulfate resistance may be significant for plaster used in certain geographical areas. Normally, availability in an area signals their desirability for use in plaster.
- Type III is a high-early-strength cement. Its chemical composition and somewhat greater fineness promote the development of high-early-age strength and greater heat liberation. These characteristics are especially beneficial when plastering during cold weather.
- Type V is a high-sulfate-resistant cement. Its chemical composition provides greater resistance to sulfate attack than that exhibited by other types of portland cement. Type V may not be available in many geographical regions and should only be considered for use where severe exposure to sulfate is anticipated.
- Type IA, IIA, and IIIA cements are similar to their Type I, II, and III counterparts but intentionally contain an air-entraining addition. These air-entraining cements produce minute, well distributed air bubbles throughout the plaster during mixing. The entrained air bubbles improve the plasticity of fresh plaster and increase the freeze-thaw durability of hardened plaster.

In Canada, portland cement conforming to CSA A5 lists very similar categories to ASTM C 150. These cements, like ASTM C 150 cements, may also be used singly, in combination with other hydraulic cements, as a component of other hydraulic cements, or in combination with a plasticizer. The product standard provides for differing types. Those of special interest to the plaster industry are:

- Type 10, normal portland cement is a general-purpose cement recommended for most conditions for which the special properties of the other cement types are not required.
- Type 20 is a moderate portland cement that has improved resistance to sulfate attack. The improved sulfate resistance may be significant for plaster placed in certain geographical areas. Normally, availability in an area signals desirability for use in plaster. CSA A5 also provides an option for Type 20 cements for slower heat liberation during hydration and gives the designation Type 20, moderate heat of hydration. This may be beneficial when placing plaster in warm temperatures.
- Type 30 is a high-early-strength cement. Its chemical composition and somewhat greater fineness promote the development of high-early-age strength and greater heat liberation. These characteristics are especially beneficial when plastering during cold weather.
- Type 50 is a high-sulfate-resistant cement. Its chemical composition provides greater resistance to sulfate attack than that exhibited by other types of portland cement. Type 50 may not be available in many geographical regions and should only be considered for use where severe exposure to sulfate is anticipated.

White portland cement is used to produce white or light colored finish-coat plasters. This cement should meet the requirements of ASTM C 150 for Type I and Type III, or one of their air-entrained counterparts. White portland cement is also available as a Type II or Type V portland cement, though less commonly so. In Canada, CSA A5 White Type 10 portland cement is available and its use in plaster is allowed.

In the U. S., blended hydraulic cement, ASTM C 595 or C 1157, is manufactured with two or more inorganic constituents, which singly or collectively contribute to the strength of the cement. Some five classes of blended cement, totaling sixteen individual types, are recognized in ASTM C 595. In ASTM C 1157, six types are recognized. The cement types listed above have been found satisfactory and desirable for plastering.

Masonry cement, ASTM C 91 or CSA A8, is manufactured to produce a cementitious material that will be workable, durable, and achieve moderate to high strengths. Specifically manufactured for the masonry and plaster industry, these products are fine-ground, air-entraining, and highly workable cements ideally suited for plaster. No additional air-entraining agent should be used with masonry cement. By definition, masonry cement is a hydraulic cement, primarily used in masonry and plastering construction, that consists of a mixture of portland or blended hydraulic cement and plasticizing materials (such as limestone, hydrated, or hydraulic lime) together with other materials introduced to enhance one or more properties such as setting time, workability, water retention, and durability. The various types of masonry cement (Types M, S, and N) yield different levels of compressive strengths. Type M and S are high-strength masonry cements that provide strengths comparable to those typically obtained by adding portland cement to Type N masonry cement at the mixer. Since these products are formulated at the point of manufacture to provide indicated strength levels, their use simplifies field batching and mixing procedures, improving control of proportioning. Canadian specifications do not include a designation for Type M masonry cement.

Plastic cement is a product manufactured expressly for the plaster industry and is most commonly available in the southwest and on the west coast. A plastic cement is a hydraulic cement, primarily used in portland cement–based plastering construction. It consists of a mixture of portland and blended hydraulic cement and plasticizing materials (such as limestone, hydrated, or hydraulic lime) together with other materials introduced to enhance one or more properties such as setting time, workability, water retention, and durability. ASTM C 1328 defines separate requirements for a Type M and a Type S plastic cement. UBC 25-1 does not classify plastic cement as different types, but defines one set of requirements that corresponds to those of an ASTM C 1328-Type M plastic cement. When plastic cement is used, no lime or other plasticizer may be added to the plaster at the time of mixing.

In the southeast, these specialized cements for plaster are known as "stucco cements" and are typically manufactured to meet the Type S requirements of ASTM C 1328. They are formulated to provide performance that is compatible with the aggregates, environment, and construction typical of that geographical region.

Plasticizers

The function of a plasticizer is to improve workability. Plasticizing materials added at the mixer should be used only in combination with portland cement or blended cement. They should not be added to mixtures containing plastic cement or masonry cement. Hydrated lime is commonly used as a plasticizer. It should meet the requirements of the following ASTM standards:

Special finishing hydrated lime — ASTM C 206, Type S

Hydrated lime for masonry purposes — ASTM C 207, Type S or SA

Water

Mixing water should be clean and fit to drink. It should also be free of harmful amounts of any mineral or organic substances that would discolor or affect the set of the plaster or cause corrosion of metal lath or accessories. Water from a domestic water supply usually is suitable. Unclean or questionable water should be tested to observe the effect of water purity on strength development (ASTM Method C 109) and time of setting (ASTM Method C 191). Laboratory tests of mortars (or cement pastes, as is applicable for time of setting test) containing questionable water should be compared with similar mortars (or pastes) containing clean, pure, distilled water. Any significant increase in setting time or any significant reduction in strength development, when the questionable sample is compared to the sample containing distilled water, justifies additional testing or the evaluation of water from another source. Significant changes are generally considered to be greater than a 10 % decrease in compressive strength, greater than a 30-minute increase in initial setting time, and greater than a 60-minute increase in final setting time.

Aggregate (Sand)

The amount and kind of aggregates used greatly affect the quality of a plaster, the skills and methods required to apply the plaster, and the performance of the plaster in service. Aggregates used in plaster should conform to ASTM C 897. They should be clean, free from organic impurities, loam, clay, and vegetable matter. These foreign materials can interfere with the setting and hardening (strength gain) of the cement paste and its adhesion to aggregate particles.

Aggregates used in plaster should be well graded. To emphasize the role of a well graded sand in plaster, consider that almost 1 cu ft (0.0283 m^3) of damp loose sand is needed to make 1 cu ft (0.0283 m^3) of plaster. The sand takes up nearly the entire volume, whereas cement paste (a combination of cement, air, and water) fills all the voids or spaces between the sand particles. Since the sand occupies such a large percentage of the volume, the importance of exacting requirements for aggregate cannot be overemphasized. Plaster properties, including workability, strength, and shrinkage are influenced by the shape and grading of the aggregates. Obtaining a clean, sound sand with the proper gradation of particles is a primary consideration.

Gradation requirements are established in consideration of the principle that large sand grains leave void spaces that are filled by smaller sand grains; voids between smaller sand grains are filled with still smaller sand grains. Since remaining voids must be filled with cement paste to provide a workable mix, optimum performance is achieved by minimizing aggregate void space. Stated differently, the optimum paste content of a plaster is a function of the volume of voids in the aggregate. This optimum paste content is the minimum amount of cement paste required such that sand particles are almost in contact with one another and void spaces are filled. After an optimum paste content is established by trial mixtures, the desired plaster strength can be obtained by selecting an appropriate cementitious material or combination of cementitious materials.

Paste is required to carry the aggregate and produce a workable mixture. Because the paste content affects characteristics of the hardened plaster, the proper quantity of cement to be combined with a volume of aggregate should be determined. Selection of the right combination of cement and aggregate involves evaluating combinations of ingredients for their workability, hardening, absorption, and shrinkage characteristics. Ideally, sample panels of plaster with varied proportions should be prepared and compared. Experience with local materials reduces the number of sample panels required.

The volume of void space within an aggregate batch can be measured in the laboratory by completely filling a unit measure of known volume with the aggregate and weighing it. A simple calculation using this unit weight along with the aggregate's relative density (specific gravity) provides the aggregate's void content. Various methods — shoveling, jigging, or rodding — can be used to fill the unit measure, and the void content resulting from each method will differ. The rodded unit weight value is considered a measure of the uniformity of sand-particle distribution and is sometimes termed "bulk volume." The bulk volume of sand is affected by its moisture content.

A given volume of sand will produce a slightly greater volume of plaster since cement paste envelops each aggregate particle, thereby separating them. The unit volume of freshly mixed plaster is sometimes termed "yield." During actual plastering, some of this additional volume is lost because of: (1) water lost by evaporation, (2) air content reduction during handling and application of the plaster, and (3) consolidation achieved by rodding and finishing.

A well graded sand that avoids the grading boundary limits of ASTM Specification C 897 is desirable. Many mortar sands can fall within the individual grading size and weight percentage limits, yet the resulting combined sizes may be difficult to use while plastering. Well graded aggregates are desirable because they produce plaster that is easy to apply.

Sands not meeting gradation limits may be used for plaster if modifications are made while proportioning and if hand, not machine, placement is used. Proof of any sand's acceptability is its service performance in the hardened plaster. The effects of proportioning, application, and consolidation are more significant to finished plaster quality than aggregate gradation.

Aggregates for finish coats need not meet the gradation requirements of the aggregate specification previously cited. Non-specification aggregates of varied sizes and shapes can be evaluated using sample panels to obtain special textures and finishes for the final surface. Constructing sample panels allows experimentation with mixtures and application procedures to achieve the desired surface textures before the start of construction. As a starting point, all aggregates for finish-coat plaster should be smaller than a No. 16 (1.18-mm) sieve size and evenly graded. Larger size particles can be added to obtain the desired final appearance of the surface.

Factory-Prepared Finish Coat

Many colors of factory-prepared finish-coat products (commonly known as stucco-coat or finish-coat mixes) are available in some localities. These factory-prepared, colored, finish-coat mixes contain all the necessary ingredients except water. Their use generally improves batch-to-batch consistency and color uniformity.

Use of any stucco-finish product should closely follow the manufacturer's recommendations, and its acceptability should be appraised after preparation of a sample panel.

Reinforcement

Metal lath or wire is used as a plaster base and reinforcement where plaster or stucco is applied to wood frame or steel stud walls, and surfaces that in themselves will not provide adequate mechanical keying or bond for the plaster. Examples of the latter are unsound, old stucco surfaces; painted surfaces; deteriorated or badly weathered clay brick and concrete masonry surfaces; and nonabsorbent concrete surfaces. Metal reinforcement for plaster is used primarily to mechanically anchor the plaster to a base and provide support for the scratch-coat plaster as it is applied.

In addition to providing anchorage and support for the scratch-coat plaster, the reinforcement should be sufficiently open and adequately spaced from solid surfaces to allow the plaster to penetrate openings, slump down over and around the metal strands, and embed the reinforcement. As the plaster hardens, reinforcement and plaster form an integral unit and provide a surface for the second (brown) coat of plaster. Full encasement of the reinforcement also protects the metal lath or mesh against corrosion. To assure adequate support of the fresh plaster and sufficient keys, openings in the reinforcement should not exceed 4 sq in. (250 mm^2).

Because plaster can be applied to vertical surfaces over solid bases, vertical surfaces on wood and metal framing with and without sheathing, and horizontal surfaces/ceilings (both in contact and suspended), plaster reinforcement varies in design and configuration. It is available in several different forms: expanded metal lath, woven wire lath, and welded wire lath. These products should comply with

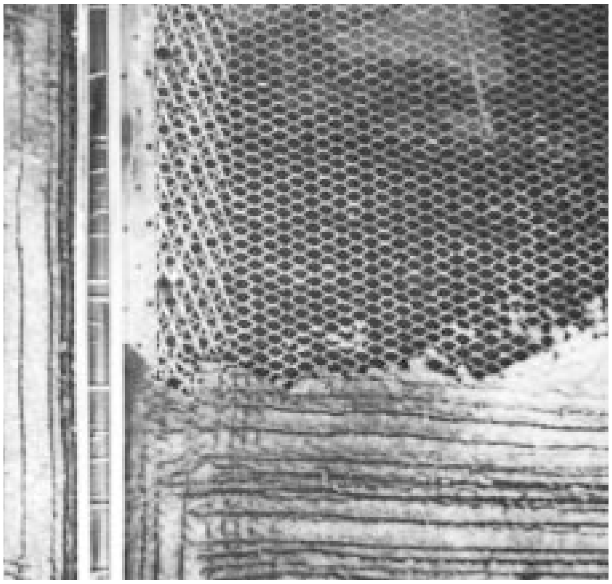


Figure 2. Expanded metal diamond-mesh lath. (66127)

ASTM Specifications C 847, C 933, or C 1032, as applicable. The installation of the reinforcement should be in accordance with ASTM C 1063. The weight and type of reinforcement used must be coordinated with spacing of supports and whether the application is a wall or ceiling. For example, ASTM C 1063 indicates that, when supported at a maximum spacing of 16 in. (406 mm) on center, diamond-mesh lath should weigh not less than 2.5 lb per sq yd (1.4 kg/m^2) for use on vertical surfaces (walls), and not less than 3.4 lb per sq yd (1.8 kg/m^2) for horizontal surfaces (ceilings). All lath must be lapped ½ in. (13 mm) on side laps and 1 in. (25 mm) on end laps, ensuring paper-to-paper and lath-to-lath configuration to prevent cracking.

Expanded Metal Lath. Diamond-mesh or rib lath should be fabricated from galvanized steel. Diamond-mesh lath is suitable for many interior and exterior applications including walls, ceilings, and ornamental work. It provides a large number of diamond-shaped openings over a given surface area for the plaster to encase. Diamond-mesh lath is available with paper backing and with self-furring dimples that offset the plane of the lath and maintain a space between the lath and solid substrates (Figure 2).

Rib lath is also an expanded metal lath. V-shaped ribs that run parallel to the length of the sheet provide stiffness to the lath. Rib lath is recommended for horizontal applications only. It is available as a ⅛-in. (3-mm) flat-rib and a ⅜-in. (10-mm) high-rib product. A ⅜-in. (10-mm) high-rib lath is not recommended in locations exposed to moisture or weather. The high-rib shape also forms a plane of weakness within the plaster and results in uneven plaster thickness, encouraging any plaster that is prone to excessive stress from drying shrinkage, climate changes, or building movements to crack over each V-rib. High-rib metal lath is an option for areas where additional stiffness is needed to span support spaced at greater than 16 in. (400 mm) on center. Locations such as soffits and ceiling areas protected from heavy rain and severe weather can be lathed with ⅜-in. (10-mm) high-rib lath weighing not less than 3.4 lb per sq yd (1.8 kg/m^2).

Woven Wire Mesh. Hexagonal woven wire lath (stucco netting) is available in rolls and sheets with 1½-in. (38-mm) openings of 17-gage galvanized wire or 1-in. (25-mm) hexagonal-mesh openings of 18-gage wire; some types include a paper backing and line wire (Figure 3). Woven wire lath should meet the requirements of ASTM C 1032 and ASTM C 1063. The user should follow the manufacturer's recommendations. Woven wire lath should be stretched tightly and securely fastened to supports to prevent sagging upon application of the scratch coat.

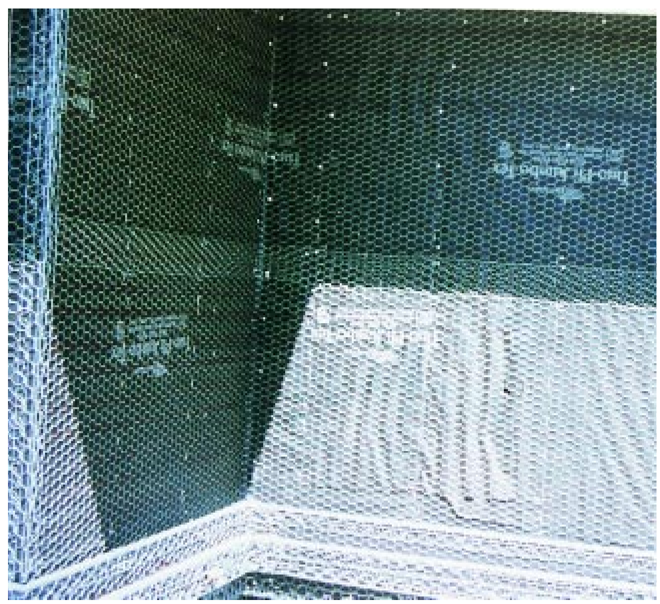


Figure 3. Woven wire lath installed to provide decorative offset. (66129)

Welded Wire Lath. Welded wire lath is a grid made of cold-drawn 16-gage (minimum) steel wires welded at their intersections or woven into squares or rectangles with openings not larger than 2 in. x 2 in. (50 mm x 50 mm) (Figure 4). The wire is galvanized. Welded wire lath is available with paper backing and furring crimps.

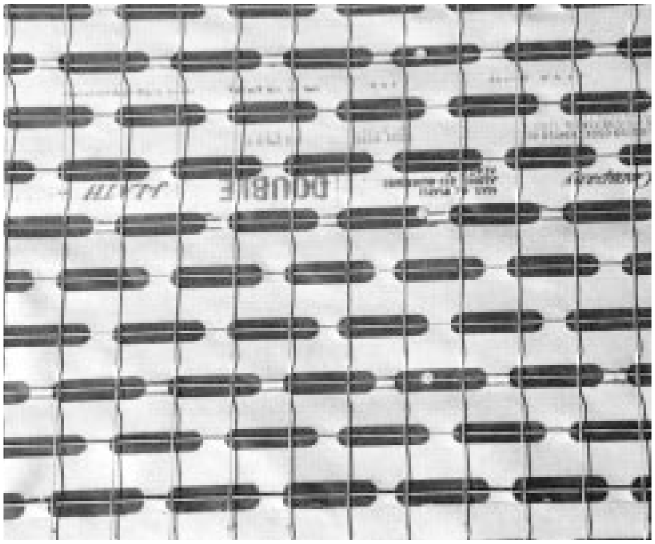


Figure 4. Welded wire lath with paper backing. (66128)

Accessories

A variety of lathing accessories are used with metal plaster bases to provide a finished edge to a plastered surface, to provide for stress relief, or to reinforce corners. Alternately, a rectangular strip lath measuring 3 in. x 12 in. (75 mm x 300 mm) can be placed diagonally across corners of openings (window, door, etc.) and wired to the lath to help control reentrant cracking. In any case, minor cracking at the corners of doors and windows and other stress points in not unreasonable and should be anticipated. Accessories are manufactured from zinc alloy, galvanized steel, anodized aluminum, and PVC. Requirements for accessories are given in ASTM C 1063. Consideration of the exposure and climatic conditions of the application must be taken into consideration when selecting accessory material. Examples of accessories are shown in Appendix D.

Building Paper and Weather Barrier Backing

The role of building paper is to provide the innermost surface to which plaster can be applied and allow for vapor transmission without water absorption or penetration. Building paper should comply with the current requirements of UU-B-790a, *Federal Specifications for Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellent, and Fire Resistant).* This specification differentiates weather resistive Kraft papers by types, grades, and styles. Type classifications are Type I (barrier paper), Type II (concrete curing paper), Type III (fire resistant paper), and Type IV (insulation tape paper). Grade classifications are made on the basis of water resistance and vapor permeability. Grade A is a high water-vapor resistant paper, Grade B is a moderate water-vapor resistant paper, Grade C is a water resistant paper, and Grade D a water-vapor permeable paper. Style classification is made on the basis of whether or not the paper is creped, reinforced with vegetable or inorganic fibers, and coated with rosin.

Type I building paper is typically used in plaster construction, although Type III may be required for special applications. In many types of construction and climates, it is desirable to allow for vapor transmission. Therefore, Grade D paper (water resistant, but vapor permeable paper) is often preferred to Grade A, Grade B, polyethylene fibrous fabric, and polyethylene film. The latter are vapor retarders and may trap water vapor within the wall system, particularly in cold climates. As an example, the Uniform Building Code and IBC 2000 require that two layers of Grade D paper be placed over plywood sheathing that is to receive lath and plaster. Grade D paper having a water resistance of 60 minutes or more is available and often preferred to Grade D paper having the minimum 10-minute water resistance required by UU-B-790a.

Most metal reinforcement is available with attached backing. Whether applied by the manufacturer or at the job site, a weather barrier equivalent to asphalt-saturated Kraft paper or felt should be installed behind the lath for all exterior plaster applied to a metal base. The weather resistive material should be free from holes and breaks.

Sheathing

Wood or other sheathing materials may be used over wood or metal studs to provide additional support to a wall system. If plywood sheathing is selected, the boards/panels should be positioned so their long axes are perpendicular to the studs. A ⅛-in. (3 mm) space should be provided between the edges of adjacent sheathing panels to allow for moisture expansion. Exterior-grade gypsum sheathing is also an option. As noted in the preceding section, sheathing should be covered with water resistant building material to reduce the possibility of water contacting the sheathing. All wood sheathing (and studs, too) should be the proper grade and moisture content (typically below 20%) for construction in order to prevent unnecessary cracks. Building suppliers can verify the moisture content of the wood as delivered to the job site, but it's up to the construction team to store materials so they remain dry. Once studs and sheathing are erected and covered, the building paper will protect them from moisture.

Alternately, it is possible to forgo sheathing and instead plaster directly over open-frame construction provided that line wires, waterproof building paper, and metal lath or wire lath are used as backup. However, sheathed frame construction generally results in more uniform plaster thickness than open frame construction.

Flashing

Flashing, a membrane to redirect water to building exteriors, should be properly placed and installed. Flashing is vital to the longevity of plaster and the prevention of water seepage into the building. Flashings must be designed and installed so that any water getting behind the plaster will be channeled downward and outward toward the exterior of the building. Retention of water within the wall can result in deterioration of the plaster as a result of rusting of the metal reinforcement, inserts, or attachments. Water collected within the wall may be responsible for disruptive expansion and subsequent deterioration of the plaster in a freeze-thaw environment. Only non-rusting flashings capable of directing water from the walls should be used. Common materials for flashing are sheet metals, composites, plastics, and rubber compounds (NCMA 2001).

Metal reinforcement is placed over flashing to support the plaster. ASTM C 1063 also requires installation of a foundation weep screed at the bottom of exterior walls, below the floor line, wherever the wall is supported by a floor or foundation. The foundation weep screed serves as a plaster stop and directs moisture to the wall exterior.

Effective moisture control measures for exterior plaster walls require cooperative efforts from designers and builders. The architect must design effective flashing details for all openings in exterior plastered walls. Flashing around door and window openings must be installed and adhered to the frames by the general contractor or glazing contractor. The lather must properly interface the building paper, accessories, and lath with the flashing membrane.

Admixtures

An admixture should be approved for use only after it has been laboratory tested under conditions that simulate those that will prevail during its intended use. Further, plaster containing the admixture should be evaluated at the project to establish that the results conform to what is expected. Admixtures should not be used indiscriminately. The use of soaps or detergents should not be condoned, since the uncontrolled air entrained with these materials is detrimental to plaster quality.

Plaster mixtures are very sensitive to admixtures. If plaster must be applied to an absorptive substrate or during extremely dry conditions, an admixture that retards cement hydration can increase and prolong the workability of the plaster. At the same time, however, this admixture can retard cement hydration. Even though the plaster contains an adequate amount of water, a low-strength plaster could result because evaporation and absorption can reduce the quantity of water available for cement hydration. On the other hand, an admixture that accelerates cement hydration can shorten the time period between application and floating, which may impose a difficult construction schedule. To gain maximum benefit of the admixture, proper curing of any plaster that contains admixtures is compulsory. As some admixtured plasters perform better when they receive an air cure, and others require water, it is necessary to know what conditions represent optimum curing for the type of admixture being used.

Laboratory testing for acceptance of an admixture for plaster should include a comparison of admixtured and non-admixtured plasters prepared under the temperature and humidity conditions anticipated. Testing should involve time of setting and compressive strength test methods. Time of setting changes should be in the direction intended (acceleration or retardation). Compressive strength results should show that the admixtured plaster is at least 90% of the non-admixtured plaster at both early and later ages. Compressive strength test specimens should be cured as the plaster is to be cured in the field, either stored in air or moist cured. Final acceptance of the admixtured plaster must be critically appraised during plastering and thereafter while the plaster is in service.

Air-Entraining Agents. Air-entraining portland cements, masonry cements, or plastic cements provide the benefit of entrained air without requiring that a separate chemical be added to the plaster mixture. Alternately, to create a system of well developed air voids, an air-entraining admixture meeting the requirements of ASTM C 260 may be introduced into the mixer during batching. Whether incorporated into the cement or batched as a separate ingredient, the air-entraining admixture improves both the workability of the fresh plaster and the freeze-thaw durability of the hardened plaster. The increased workability will be especially noticeable when using non-uniformly graded aggregates, or aggregates deficient in the finer 100 (150-µm) and 200 (75-µm) mesh sieve sizes.

During hand application, air entrainment improves workability, making the plaster easier to handle and spread. During machine application, air entrainment eases pumping and reduces segregation, although too much air can cause pump stoppages. The air content of plaster after spray application to the surface is lower than that of plaster from the mixer, because excess air will be dissipated during the spraying operation.

The manufacturer's recommendations regarding dosages of air-entraining admixtures should be closely followed.

Accelerators. Admixtures capable of increasing the rate of strength development may be beneficial under certain circumstances. Accelerators for plaster shorten the time delay between plaster rodding and floating. Thus, the accelerator shortens the time required between application and completion of the finishing operation. Calcium chloride is one accelerator capable of reducing the time between these operations. Calcium chloride also increases the rate of strength development. However, its use in plaster is not recommended, because it contributes to corrosion of metal reinforcement.

As an alternative to an accelerator, Type III portland cement can be used as part or all of the cementitious material. Heating the water and sand will also increase the rate of early strength development.

Antifreeze Compounds. Products marketed as antifreeze agents are not recommended for use in portland cement plaster. Calcium chloride, alcohol, and ethylene glycol have been considered for this purpose, but are not adequate as antifreeze in plaster. At recommended safe dosages they produce only a slight lowering of the freezing temperature of the plaster. The use of Type III cement, heated water and sand, enclosures, heated construction, or a combination thereof, will provide more satisfactory results.

Water Repellents. Products are available to reduce the water permeability of plaster. These formulations include water repellents, hydrophobic solids and liquids, and inert fillers. Quality plaster that is properly cured does not need water repellent admixtures. Laboratory tests that measure time of setting and water permeability of plaster show that water repellent compounds may actually retard portland cement hydration and increase permeability.

Color Pigments. A wide range of color pigments is available for obtaining integrally colored finish coats, though manufactured finish coats (premixed) generally provide more consistent results. The pigments should conform to ASTM C 979. Ideally, the pigment should produce good dispersion and suspension in the plastic mix and color permanence in the hardened state. The amount of pigment required depends on the color of the cement, the color of the sand (especially the fines), the color intensity desired, the water content of the plaster, and the curing. Once the pigment dosage has been determined, sufficient coloring should be preweighed for individual plaster mixes to ensure color uniformity from batch to batch.

The effect of adding color pigments to the plaster should be evaluated, using time of setting and strength test methods. The primary concern is that dispersing additions to the coloring compound may interfere with and retard portland cement hydration. Generally, lighter colors are more popular on plaster surfaces, so only small amounts of pigment will be necessary. In Canada, the *National Building Code* sets a limit of no more than 6% pigment (by mass of cement) for use in plaster mixtures.

Similar to the premixed finish-coat formulations, colored masonry cements that contain both pigment and cementitious material are available. Again the effects of sand and water will require selection of the necessary amount of pigment in the preblended, colored cement.

Color uniformity is dependent on batching uniformity and the use of consistent techniques in the application, finishing, and curing of the finish coat (see section on "Color Variation").

Bonding Agents

Products that increase the adhesion of plaster to substrate or plaster to plaster are called bonding agents, and are either surface applied to a substrate or integrally mixed into the plaster. Surface-applied bonding agents should conform to the requirements of ASTM C 932. Integral bonding agents should be used only after review of the manufacturer's documentation of testing and past performance.

These organic compounds are generally polyvinyl acetates or alcohols, cellulose derivatives, acrylic resins, or styrene butadienes. The polyvinyl alcohols and cellulose derivatives do increase the adhesion of plaster to substrate and are generally compatible with portland cement mixtures. Polyvinyl acetates and alcohols require air curing and are less effective in moist environments. The acrylic resin compounds also need air curing; when added to portland cement mixtures, acrylic resins play a significant role as a main cementing compound. Bonding agents can be beneficial admixtures where conventional plaster cannot be adequately moist cured. Conversely, their use in a moist environment is neither required nor desirable, especially if they are reemulsifiable. Bonding admixtures generally increase the potential for shrinkage of plaster because they contribute to a more elastic binder than cement paste.

Fibers

Small amounts of ½-in. (13-mm) long fibers of alkali resistant composition such as polypropylene, nylon, alkali resistant glass, or other similar materials are sometimes added to base-coat plaster mixtures. Fibers are added to these mixtures to increase cohesiveness, tensile strength, impact resistance, and to reduce shrinkage; ultimately, the main purpose of these combined properties is to reduce cracking. The fibers' effectiveness in contributing to improved performance in these areas is dependent on the composition, physical characteristics, and dosage of the fibers selected. Fibers used in plaster should conform to the requirements of ASTM C 1116 for fibers used in fiber reinforced concrete and shotcrete. They should be added to the mix in accordance with manufacturer's recommendations. Comprehensive information on the characteristics of specific fibers is contained the PCA publication *Fiber Reinforced Concrete, SP039*.

BASES

Portland cement plaster is applied to an array of bases, as can be seen in Table 2. The successful application of plaster to a base depends on the compatibility of the plaster and the base material, the soundness of the base, and the application procedure. Plaster is very compatible with concrete masonry and new concrete. Plaster may be compatible

Table 2. Bases for Portland Cement Plaster (Stucco)

Base suction	Base material
Low	Glazed tile, hard burnt brick, hard stone (pavers), plain and reinforced concrete, very dense and hard concrete block, hollow and unscored clay block
Medium	Concrete block, face or medium hard brick, medium-hard clay partition tile, good grade common brick, soft stone
High	Soft common brick, soft clay partition tile, aerated concrete, some lightweight concrete, lightweight concrete block
	Frame bases
Not applicable	Wood stud, metal stud

with old concrete or masonry, depending on the degree to which the surface is contaminated. Where plaster is not compatible with a particular base, the quality of the base must be upgraded to gain adequate bond, or metal reinforcement must be mechanically attached to the surface.

All bases should be sufficiently rigid to allow application of the plaster without any movement of the base. Plaster is applied by hand or machine to the wall surface then forced against the substrate by the troweling action. A solid base, such as old or new concrete or masonry, requires no special attention to rigidity during application.

Metal reinforcement over open framing may require additional bracing during plaster application. Metal lath studless partitions are another special case where additional bracing is required at the onset of plastering. This additional bracing should be removed immediately after scratch-coat plaster application to eliminate or reduce restraint during the subsequent drying period, when the plaster is undergoing its greatest volume change.

Solid bases, such as concrete or masonry, that are to receive plaster directly on their surface should be clean of any surface contamination that may prevent good suction and should have a sufficiently rough or scored texture to enhance good bond.

The absorptive characteristic of the surface of a base is an indicator of the bond that will be developed at the base-plaster interface. A normally absorptive surface will have good attraction between the wet plaster and the base and develop good bond. During application, the fresh plaster "wets-out" the substrate surface and promotes complete coverage of the substrate, thus producing a complete and receptive interface for bond to occur. A low or non-absorptive surface will reduce bond; bond does occur, but the interface is less resistant to shearing while the plaster shrinks.

Under normal to extreme drying conditions, highly absorptive surfaces must be premoistened to reduce the absorption characteristics of the base. Premoistening prevents rapid loss of water from the plaster to the base and allows for a continued hydration period as water from the base migrates to the applied plaster. Highly absorptive surfaces should be moistened as heavily as possible *without leaving a film of water on the surface when plastering starts.* Prewetting may be unnecessary when a plastering machine is to be used for spray application since machine-applied plaster is mixed to a wetter consistency than hand-applied plaster. If absorptive surfaces become wet or heavily moistened during humid weather, more time will be needed between plaster application and final floating. The plasterer has the option to either moisten the wall or adjust his work methods to compensate for wall moisture content and absorption characteristics.

To establish the ability of any surface to absorb water, water can be dashed or sprinkled onto the surface. If the water forms beads and runs off the surface, a poor bond can be anticipated. If the water is rapidly absorbed, then a good bond can be expected.

High-gloss surfaces, or those with low absorption, can be made more receptive to plaster application by first applying a dash or bond coat (Figure 5). Dash-coat plasters are slurry mixtures rich in cement. These plasters are literally dashed against the base surface by hand with a brush, trowel or paddle, or by machine. Enough plaster should be dash-applied to cover most of the surface. The dash coat remains unfinished—that is, it is not rodded, floated, or troweled—and should be allowed to set "as is" before application of the scratch-coat plaster. Alternatively, there are a number of special bonding materials that develop good bonding characteristics between plaster and low-suction bases. For example, products containing polyvinyl acetates or alcohols or acrylics will improve bond.

Figure 5. A dash-bond coat can be applied to enhance bond between a solid base and plaster. (40630)

Cast-in-Place Concrete

Cast-in-place concrete that is to receive plaster should be straight, true to line and plane, and have a lightly scored or pitted rough surface texture. During forming, the concrete contractor should avoid misalignment of forms, using too much form-release agent, using the wrong type of form-release agent, and using plastic-coated-plywood or metal forms. Close attention to these factors will reduce the amount of preplastering preparation needed to make the surface receptive to plaster.

Misalignment of walls can be corrected with a plaster coating; however, the variable thickness of the plaster coat required to restore a true plane can result in differential shrinkage and subsequent cracking. Excessively misaligned walls will require that furring, metal framing, and metal reinforcement be attached to the concrete surface. Plaster may conceal the misalignment, but extreme caution is recommended when attempting a solution. Avoid different plaster thicknesses within a single panel.

Dense, smooth surfaces and those retaining an excessive amount of form-release agent on or absorbed into the concrete can cause delamination of the plaster from the concrete base. Preventive action for either situation can be taken by mechanically attaching metal or wire lath to the concrete.

Newly placed concrete generally requires no special surface preparation, or at most a light sandblasting with hot water and fine silica sand. Form oil will affect the concrete surface, so washing to remove the oil should be required and completed.

Older concrete surfaces should be inspected to determine their alignment, surface texture, absorption characteristics, and surface contamination. Any painted or coated surface should have all traces of the paint or coating removed. High-pressure-water spray, with or without fine silica sand, will effectively remove paint; a light-to-heavy sandblasting may be required to remove coatings. The absorption characteristics of the cleaned surface will indicate whether the base is satisfactory for direct application or if metal reinforcement is needed.

A bonding agent painted on or spray-applied to the surface of the base will improve adhesion between the plaster coat and the base. Bonding agents should be applied according to manufacturers' recommendations. Under no condition should a surface treatment, other than a bonding agent, be applied to a concrete or concrete masonry surface prior to plastering.

Masonry

Masonry walls to be plastered may involve a wide variety of building materials ranging from high-absorption concrete masonry or brick units to low or nonabsorptive hard burnt brick and glass block. Plaster can be applied to all these surfaces. Where poor or no bond is anticipated, the use of metal reinforcement anchored to the surface is necessary.

Masonry walls should be inspected for misalignment, surface contamination, unfavorable surface conditions, and deterioration. The deviation from true alignment of the wall will govern the plaster thickness needed to restore a plane surface. If misalignment is excessive, furring and lathing prior to plaster application are recommended. The surface should be examined for contamination. Surface contamination, such as airborne soot, efflorescence, oils, paints, coatings, sealers, and mortar droppings, must be removed. If the surface shows satisfactory absorption after cleaning, plaster may be applied directly to the masonry. Where surfaces exhibit improper suction or contamination remains after cleaning, the use of metal reinforcement is recommended.

Before applying plaster to any masonry wall, assess the effectiveness of dampproofing provisions, flashings, and roof-wall accessories. All are intended to direct moisture away from the interior of a wall toward the outside as rapidly as possible. Make any necessary corrections to prevent water from entering the top of the wall, through either side of parapets, at sills, and at jamb seats before plastering.

Concrete Masonry. Concrete masonry provides an excellent base for plaster (Figure 6). When constructing concrete masonry walls that are to be plastered, use open-textured concrete masonry units to promote a mechanical key between the plaster and the base wall. Joints should be cut flush rather than tooled or sponge floated (Figure 7). The open texture on the surface of the block and a flush joint promotes good bond. In contrast, mortar floated over the surface of a masonry wall with a sponge seals the surface and leaves a weak high water-to-cement ratio dust on the surface that weakens bond. Because the portland cement in

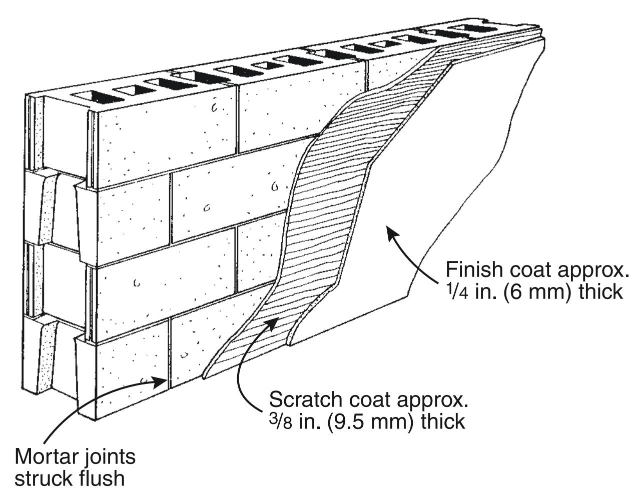


Figure 6. Plaster can be applied directly to concrete masonry. This system works well because the materials are similar, and thus, very compatible.

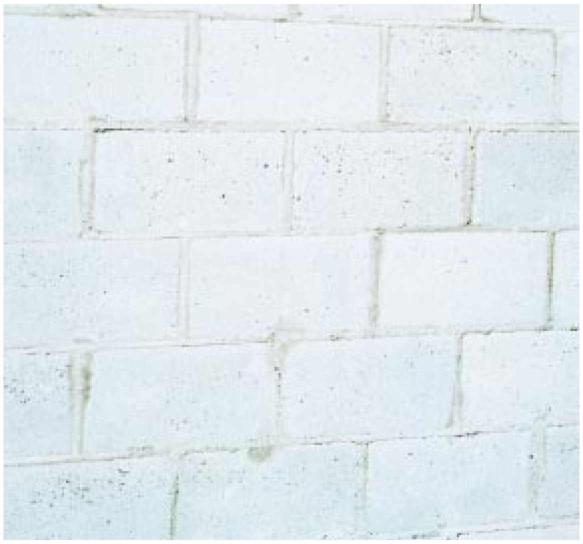


Figure 7. Joints on concrete masonry to receive plaster are struck flush. (66130)

the block is the same cementitious material as that in the plaster, the two have a great affinity. Because plaster and concrete masonry undergo similar volume changes in situ, control joints in the plaster should be limited to control joints where needed for the masonry.

Differential suction between the concrete masonry units and the mortar joints may cause "ghosting" of joint patterns in two-coat applications if mortar joints are tooled or the scratch coat is too thin. This is most likely to occur if the walls are built using blocks that had become very wet in storage and if walls are plastered soon after being built. This emphasizes the value of storing blocks under cover until used in the masonry segment and of plastering walls that are not saturated by rain. Premoistening the surface of concrete masonry walls prior to plastering should be common practice.

New concrete masonry walls to be plastered should be properly aligned and free of surface contamination. Mortar droppings should be scraped off before plaster is applied. *The concrete masonry wall should be properly cured and be carrying almost all of its design dead load before plaster is applied.*

Old concrete masonry walls should be inspected for alignment and surface condition prior to plastering. Old walls coated or moisture-sealed with a product other than portland cement paint should be restored to their original condition by sandblasting the surface.

Clay Masonry. When applying plaster to clay masonry walls, precautions should be taken similar to those for concrete masonry. Surfaces of hard and medium clay tile or unglazed clay brick usually are scored, have proper suction, and have textures rough enough to provide good bond. On old brick masonry where the mortar has become friable, the joints should be raked out and the entire surface cleaned before plastering. With old, disintegrating brick masonry, metal lathing should be used to provide a mechanical support for the plaster.

Metal Lath

Metal lath reinforcement should be used wherever plaster is applied over one of the following:

- Open-frame construction
- Sheathed frame construction
- Solid bases having surfaces that provide unsatisfactory bond

Since ASTM C 1063 is referenced by BOCA, SBC, and now the International Building Code (IBC) and NFPA 5000, it is a primary reference for design and installation criteria for metal reinforcement to receive plaster. ASTM C 1063 includes requirements for metal plaster bases, accessories, and attachments. It also contains criteria for the installation of metal plaster base ceilings and walls. Both the designer and the installer should be conversant with the requirements of that specification.

Metal reinforcement should be positioned and attached securely to the supporting structure. When applied to solid concrete or masonry bases, the metal lath should be anchored directly to the base with hardened concrete nails and power- or powder-actuated fasteners. A bond breaker, consisting of either paper or paper-backed lath, is recommended between reinforced plaster and a solid concrete or masonry base. Otherwise partial bonding

Figure 8. Metal studs should be properly spaced and securely fastened to structural steel. (30570-J)

of the plaster to the solid base can occur, resulting in differential movement and cracking.

The location of control joints in the metal reinforcement should match those in the supporting wall and as shown on the drawings (see section on "Control Joints"). Where open-wood-frame or sheathed construction is encountered, the metal reinforcement must be firmly nailed to the wood frame system. In steel frame construction, studding or furring for steel channels, steel channels, steel reinforcing rods, or metal studs should be properly spaced and securely fastened to the structural steel frame using clips, bolts, screws, or welds (Figure 8). If welded, they should be separated into smaller panels and the individual panels tied together with wire. This allows for movement and prevents excessive stresses within the portland cement plaster. If walls are rigidly fixed and restrain building movements, some deformation will occur, creating stresses in the plaster that can cause cracking. Therefore, control joints should be installed in large-area surfaces to prevent excessive stresses that cause cracking. The smaller panel areas isolated by control joints can accommodate shrinkage stresses better than a large area without control joints (see section on "Control Joints").

In metal-stud and runner-track wall systems, the reinforcement may be secured either to the studs or to the structure to provide rigid panels. In suspended-ceiling application, the metal reinforcement should be secured to the runner and furring system in a manner that will produce free-floating panels. The floating-panel approach lessens shrinkage and settlement cracking within the plaster panels. When securing the metal reinforcement to the supporting frame, the metal reinforcement should be held out from the base or frame approximately ¼ in. (6 mm). The reinforcement must be stretched between supports to reduce the slack. Nails, wires, or other devices for attaching the reinforcement to the supports should be spaced closely to provide rigid support. Generally, nails and attachments should be spaced every 6 in. (150 mm). Tightly attached reinforcement encourages an even plaster thickness. Otherwise, non-uniform thickness can result, and the thicker plaster between supports is stronger than the thinner plaster over the support stud, inducing cracking at stud locations. Sheathed construction generally results in more uniform plaster thickness than open-frame construction.

Metal reinforcement must form a continuous network of metal over the entire surface. Laps at ends and sides of wire lath must be one full mesh. For expanded metal lath, side laps (long dimension) should be ½ in. (13 mm) or the edge ribs should be nested. Expanded metal lath end laps should be 1 in. (25 mm). Laps should be wired securely and end laps should be staggered. To prevent cracking, wire ties holding the lath together should be spaced no more than 7 in. (175 mm) apart. In open-frame construction, joints and laps should be made at supports.

Paper-backed metal reinforcement should be lapped in the same way, being careful to maintain a shingle fashion paper-to-paper, metal-to-metal sequence for lap joints. A metal-to-paper sequence leads to reduced plaster thicknesses, improper embedment of reinforcement, and cracking at each lapped area.

Metal corner beads with solid metal noses are susceptible to corrosion when used in exposed exterior applications. It is difficult or impossible to get sufficient plaster behind these beads to completely encase them and prevent corrosion. Expanded metal mesh corner reinforcement or wire mesh corner reinforcement built up with a couple of layers of woven wire mesh are preferred in high-exposure applications as long as the spacing of the mesh permits complete encasement of the metal.

Open Frame. Metal reinforcement must be applied on all open-frame structures—whether of wood or metal frame—that will be plastered. The frame should be complete and carry the entire dead load of the structure prior to plaster application. Interior finishing may begin after exterior stucco work is complete, but vibrations or impacts against the exterior wall from the inside should be avoided.

In open-wood-frame construction, the structural frame should be properly braced and rigid. Where wire mesh lath is used, a soft, annealed steel wire, No. 18 gage or heavier (often called line wire), is first stretched horizontally across the face of the studs about 6 in. (150 mm) apart. The wire is stretched by nailing or stapling it to every fourth stud. It is tightened by raising or lowering it and securing it to the center stud.

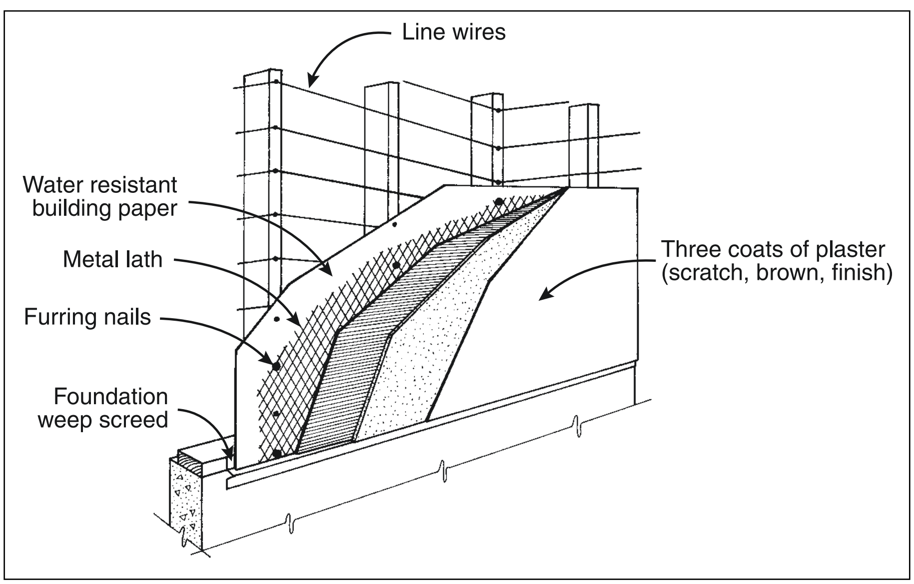


Figure 9. Plaster on open-wood-frame construction.

Next, the wall surface is covered by a waterproof building paper or felt that is nailed over the wire strands. The paper or felt should be lapped shingle fashion at least 2 in. (50 mm). The line wire provides a back support to minimize bulging of the paper or felt between the studs when plaster is applied and to help ensure a uniformly thick scratch coat.

Hexagonal wire mesh (stucco netting) is applied over the waterproof building paper or felt, using furring nails that hold the mesh out ¼ to ⅜ in. (6 to 9 mm) from the framing or self-furred lath with attachments made at furring point. As the plaster is applied, it is forced through the mesh openings and against the backing, completely embedding the metal lath in plaster (Figure 9).

In open-wood-frame construction, junctions or laps should be avoided when installing metal lath at reentrant or external corners. The lath should be started at least one full stud space away from the corner and bent to conform to the corner.

Paper-backed diamond mesh and paper-backed welded wire mesh lath can also be used in open-frame construction. These types of lath can be applied directly over the studs.

Sheathed Frame. The use of sheathing over wood or metal frame eliminates the necessity for wrapping the horizontal strands of annealed line wire around the structure. Sheathing materials include exterior gypsum board, insulation board, expanded or extruded polystyrene, wood, or plywood. Wood sheathing should be applied horizontally and securely fastened to each stud. Whenever plywood sheets or insulating boards are used as sheathing, allow a ⅛-in. (3-mm) space between adjoining plywood sheets or insulating board sheets to accommodate possible expansion of these materials.

Waterproof building paper or felt should always be placed over the sheathing followed by the accessories and then the metal reinforcement. Then the surface is ready for plastering (Figure 10). The lath and paper are lapped at the ends and sides for uninterrupted coverage of the surface. Metal reinforcement should be installed with its long dimension at right angles to the wood or metal stud supports.

Metal reinforcement must be attached to supports rather than the sheathing. In wood frame construction, metal reinforcement is fastened to the studs with galvanized or corrosion resistant furring nails or staples. Aluminum nails should not be used where they will be in direct contact with wet plaster in service. Portland cement reacts chemically with the aluminum, causing corrosion and cracking. Wire ties, metal clips, or other means of attachment that afford equivalent carrying strength and corrosion resistance are used to attach metal reinforcement to metal supports.

FRESH PLASTER MIXTURES

Proportioning

Portland cement plaster can be proportioned using a variety of cementitious materials and available aggregates to produce a hard surface that is resistant to abrasion and unaffected by dampness. Proportions should be adjusted to suit the use and climatic conditions that will prevail at the job site. The merits of each cementitious material and the benefits of selecting aggregate on the basis of void content and grading are explained in the section "Materials." The following paragraphs explain how the proper proportioning of individual materials will affect a mixture's performance in the fresh and hardened state.

A properly proportioned plaster mixture is characterized by good workability, ease of troweling, adhesion to bases, and resistance to sagging. Batch-to-batch uniformity in scratch-, brown-, and finish-coat mixtures will help assure uniform suction, color, and serviceability.

Plaster discharged from the mixer should contain as much water as can be tolerated for either hand or machine application. There is a good reason for this. Following finishing operations, the water content of a plaster coat will be lower than it was as the plaster was discharged from the mixer.

Base Coat. Successful performance has been achieved by the combinations of cementitious materials and aggregates shown in Table 3. These proportions are recommended for the scratch- and brown-coat applications. Note that the volume of aggregate listed in the table is given on the basis of the "sum of separate volumes of cementitious materials." For example, if a Type CM mix is selected as a scratch

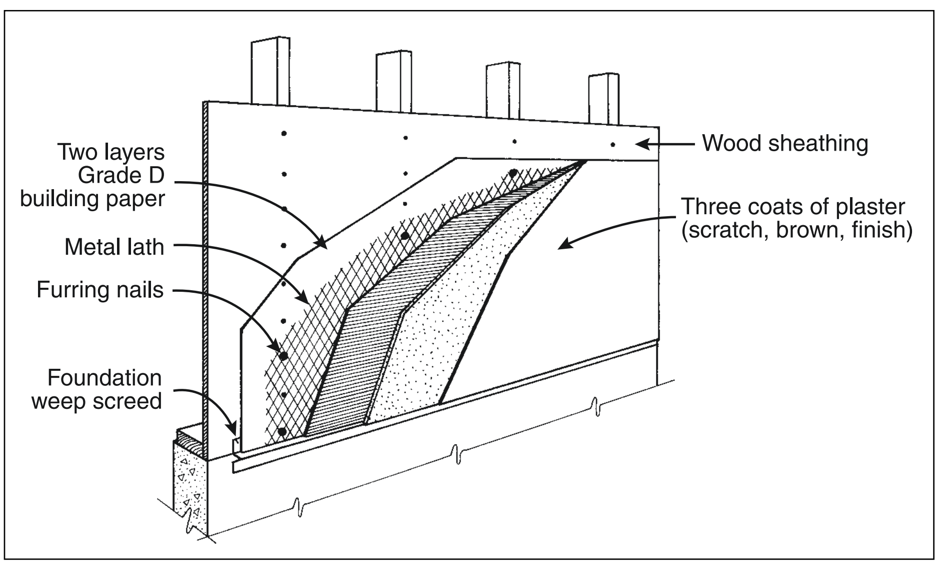


Figure 10. Plaster over sheathed frame construction.

Table 3. Base-Coat Plasters[1]

Plaster mix symbols	Parts by volume[2]						
	Cementitious materials					Volume of aggregate per sum of separate volumes of cementitious materials	
	Portland cement or blended cement	Plastic cement	Masonry cement		Lime		
			N	M or S		1st coat	2nd[3] coat
C	1	—	—	—	0 – ¾	2½ – 4	3 – 5
CL	1	—	—	—	¾ – 1½	2½ – 4	3 – 5
M	—	—	1	—	—	2½ – 4	3 – 5
CM	1	—	1	—	—	2½ – 4	3 – 5
MS	—	—	—	1	—	2½ – 4	3 – 5
P	—	1	—	—	—	2½ – 4	3 – 5
CP	1	1	—	—	—	2½ – 4	3 – 5

[1] Adapted from ASTM C 926.
[2] A range of sand contents allows for adjustment of each mix to optimize plaster properties using local materials.
[3] The same or greater sand proportion shall be used in the second coat than is used in the first coat.

coat with an aggregate ratio of 4, then 1 cu ft (0.0283 m^3) of portland cement (one bag) and 1 cu ft (0.0283 m^3) of Type N masonry cement (one bag) are combined with 8 cu ft (0.226 m^3) of damp, loose sand. For the purpose of proportioning in Table 3, lime is considered to be a cementitious material, and the following masses per unit volume are assumed for plaster materials:

Volume proportions of sand are made on the assumption that sand is in a damp, loose condition and that 1 cu ft (0.0283 m^3) of damp, loose sand will contain 80 lb (36 kg) of dry sand.

When selecting the plaster mix, basic considerations include: suction of the base, its surface irregularities, climate extremes, extent of surface exposure, type of base, and method of application. Tables 3 and 4 can help in the selection of plaster type and the recommended mixtures for the type selected.

These plaster mixtures can be prepared choosing among combinations of cementitious material and local sands. The sand content of the plaster is given as a range to allow the specifier to select high-strength, dense plaster where needed. A good rule is to select a mixture with the largest aggregate-to-cement ratio to reduce shrinkage and cracking. The use of an air-entrained plaster is recommended for geographical areas with freeze-thaw temperature cycles and for all locations where a deicer salt solution may be splashed against the plaster. For the brown-coat plaster that is applied over the scratch coat, the specifier should select the same plaster type (Table 4) with equal or larger aggregate-to-cement ratios. This design practice places the lower strength mixtures with corresponding lower shrinkage characteristics toward the exterior.

The plaster types recommended for specific bases (Table 4) reflect the combinations considered satisfactory for bases with differing absorption characteristics and for application over metal lath. A designer can choose to specify any or all of the mixture types to allow the contractor the widest range of options for finding locally available materials. Table 3 provides the proportions for the various plaster base coats.

Table 4. Recommended Base-Coat Plaster Types for Specific Bases[1]

Plaster base	Recommended plaster mixes	
	1st coat	2nd coat
Low absorption base, such as glazed and hard-burned brick or concrete	C CM or MS P	C, CL, M, or CM CM, MS, or M P
High absorption base, such as concrete masonry, absorptive brick, or tile	CL M CM or MS P	CL M CM, MS, or M P
Metal reinforcement	C CL CM or MS M CP P	C, CL, M, CM, or MS CL CM, M, or MS M CP or P P

[1] Adapted from ASTM C 926.

Lime or other plasticizers should not be added to the mixture where masonry cement or plastic cement are used, since these cements already contain plasticizers.

Finish Coat. For the finish coat, a factory-prepared finish-coat mixture should be considered, if locally available. The manufacturer's instructions should be closely followed for factory-prepared finish-coat plaster mixtures. Alternatively, the finish coat may be proportioned and mixed on site. If the finish-coat plaster is mixed on site, truer color and a more pleasing appearance can be obtained by using a white portland cement with a fine-graded, light-colored, washed sand. If coloring compounds are added during mixing, preweighed quantities should be introduced in the same sequence while charging the mixer. Close control of all quantities of mix ingredients is required to achieve consistent color.

Finish-coat plaster to be prepared on site should be selected from Table 5. In general, stronger finish coats are preferred for thrown finishes (for example, dry dash) and weaker finish coats work better for finishes that will be troweled to smooth, textured, or patterned finishes (BRE 1994). The aggregate used for the finish-coat plaster need not comply with the grading requirements for base-coat plasters. Unless otherwise specified, all of the aggregate should pass the No. 16 (1.18-mm) sieve and should be uniformly graded from coarse to fine. The sand should be selected for its ability to produce the desired surface texture and color.

Proportioning of plaster mixtures for texture and appearance is more an art than a science. Designers and specifiers should explore the many special surface finishes available, or develop new ones, for the third or finish coat. Sample panels prepared prior to construction are an effective way to develop procedures, provide a reference for acceptance of work on the structure, and establish performance characteristics. A sample panel should represent the acceptable finished work in the structure and be at least 4 ft × 8 ft (1.2 m × 2.4 m).

Mixing

Successful plastering depends on proper batching and mixing of the individual and combined materials. The plaster should possess both proper consistency and body to be spread either by hand or machine. Although batching by shovel is still the most common procedure, proportions should be checked daily with volume measures. Full bag quantities of cement (and lime, if applicable) should be used if proportioning allows. When a batch is properly proportioned, the volume of plaster in the mixer should be noted. Water additions should also be batched by volume with calibrated measures (containers of known volume), a quick-fill tank, or a water meter.

Mixing should produce a uniform blend of all materials. The accepted procedure is to:

1. Add the majority of the mix water and start mixer.
2. Add approximately one-half of the sand.
3. Add cement (when lime is used it is typically added to the mix just prior to adding the cement) and then any admixture, if approved.
4. Add remainder of sand.
5. Add water required to reach desired consistency, and continue mixing for 3 to 5 minutes or until the batch is uniform. Machine applications may reduce the total required mixing time. See Figures 11 through 14.

Ideally, mixing should be completed in a paddle-type mixer within 3 to 5 minutes after all ingredients are in the mixer. Where machine application is used, this mixing period may slow the plastering operation, so the mixer speed (rpm) should be adjusted to allow for shorter mixing periods. The proof of adequate mixing is the uniformity of the plaster as received and judged by the plasterer.

Table 5. Job-Mixed Finish-Coat Plaster[1]

Plaster mix symbols[2]	Proportion parts by volume					
	Cementitious materials					Volume of aggregate per sum of separate volumes of cementitious materials
	Portland cement or blended cement	Plastic cement	Masonry cement		Lime	
			N	M or S		
F	1	—	—	—	¾ – 1½	1½ – 3
FL	1	—	—	—	1½ – 2	1½ – 3
FM	—	—	1	—	—	1½ – 3
FCM	1	—	1	—	—	1½ – 3
FMS	—	—	—	1	—	1½ – 3
FP	—	1	—	—	—	1½ – 3

[1] Adapted from ASTM C 926.
[2] For finish surfaces subject to abrasive action, specify mix F, FP, FCM, or FMS.

The water content of the plaster should be determined by the plasterer. The plasterer can best judge the correct water content by observing its ease of application and the degree of bonding to the substrate. Bonding to the substrate can easily be assessed by removing some of the applied plaster and observing the degree of wetting of the substrate. Water is the only plaster ingredient that should be reduced or increased during on-site adjustment of the approved mix.

APPLYING PLASTER

Whether plaster is placed by hand or machine, it must be applied with sufficient force to develop full and intimate contact between the plaster and the substrate and to put in place sufficient material to obtain the specified thickness of the coat. The applied plaster must be brought to the desired thickness in accordance with Table 6, the walls made plumb, and the ceilings made level. The thickness of the coat of plaster is set by the use of screeds and grounds. When the area between the screeds and grounds is filled with mortar, a rod is used to even the surface. The rod can bear on the screeds or contact the grounds and be moved over the surface, cutting off high spots and showing up the hollow places, which must be filled and rodded again. Additional manipulation of the surface is then required to prepare it for the next coat. A plaster scratch coat is scored/scratched to promote mechanical bond between it and the brown coat, which is applied later. Brown-coat plasters are applied and floated to even the surface and bring it to proper plane, to provide a uniform suction throughout the base-coat plaster, and to provide a desirable surface for the finish coat. Brown-coat surfaces are floated

Figure 11. Step 1) Place water in mixer first. (66131)

Figure 12. Step 2) Then, add 50% of sand. (66132)

Figure 13. Step 3) Next, add cement. (66133)

Figure 14. Step 4) Last, add the balance of the sand and water required to achieve desired consistency. Mix from 3 to 5 minutes. (66134)

with a wood float to densify the plaster and to provide a surface that will improve bond with the final surface finish.

The scratch-coat plaster applied to metal reinforcement should completely encase the metal reinforcement. After applying plaster to an entire area, the surface should be rodded and scratched to promote mechanical keying (bond) with a brown coat. Scratching is normally done horizontally on a vertical surface. Horizontal scratches act as water dams and promote curing. Scratching vertically promotes cracking at studs where scratches or score marks are directly over studs, especially if they are too deep. Vertical scratching can contribute to erosion of the plaster during moist curing.

Following application and rodding, the brown-coat plaster needs special attention. The plasterer should pause before starting to float the surface. This time delay is related to cement hydration and loss of mix water through absorption and evaporation. In order for the desired reconsolidation (densification) of the plaster to be obtained, floating must be done with a wood float when the plaster is at the proper moisture content. The correct time to begin floating can be determined by placing the wood float against the plaster surface. The float should not adhere to the fresh plaster. Unless this condition (of the float not sticking to the plaster) exists during the floating operation, the plaster cannot be properly densified.

During application of the scratch-coat plaster to a solid base or application of all brown-coat plaster to scratch-coat plaster, the plasterer can determine the suitability of a plaster mix for developing intimate bond in the following way. Once the brown coat has been applied using the pressure required to develop good contact and when the plaster has the required thickness, the plasterer removes a small section of the freshly applied plaster down to the previous coat or base. This is easily done with the square end of a margin trowel. If the underlying coat has not been completely wetted by the coat just removed, the plasterer must either apply more pressure during plaster application or increase the water content of the plaster. The same test can be used to assess the suitability of machine-applied plasters.

As demonstrated by the examples shown in Appendix F, various textures and colors can be achieved in the finish-coat plaster. Each texture requires special tools and techniques. The uniform appearance and texture of the finish-coat plaster will be influenced by the care taken during application of the scratch and brown coats. Often color variations in the finish coat are traceable to base-coat variations (see "Color Variation" on page 29). These color variations can be minimized by prewetting the base coat prior to applying the finish coat. During sample panel preparation, any special finishing procedures and their correct timing and sequence should be documented for later use during actual construction.

Table 6. Nominal Plaster Thickness for Two- and Three-Coat Work[1,2,3], in. (mm)

	Vertical				Horizontal			
Base	**1st Coat**	**2nd Coat**	**3rd Coat[4]**	**Total**	**1st Coat**	**2nd Coat**	**3rd Coat**	**Total**
Interior and Exterior								
Three-coat work[5]								
Metal plaster base	⅜ (9.5)	⅜ (9.5)	⅛ (3)	⅞ (22)	¼ (6)	¼ (6)	⅛ (3)	⅝ (16)
Solid plaster base[6,7]								
Unit masonry	¼ (6)	¼ (6)	⅛ (3)	⅝ (16)		use two-coat work		
Cast-in-place or pre-cast concrete	¼ (6)	¼ (6)	⅛ (3)	⅝ (16)				⅜ (9.5) max.
Metal plaster base over solid base	½ (12.5)	¼ (6)	⅛ (3)	⅞ (22)	½ (12.5)	¼ (6)	⅛ (3)	⅞ (22)
Two-coat work[8]								
Solid plaster base								
Unit masonry[6,7]	⅜ (9.5)	⅛ (3)		½ (12.5)				⅜ (9.5) max.
Cast-in-place or pre-cast concrete	¼ (6)	⅛ (3)		⅜ (9.5)				⅜ (9.5) max.

1 Adapted from ASTM C 926.
2 Where a fire rating is required, plaster thickness shall conform to the applicable building code or to an approved test assembly. See section "Fire Resistance."
3 Exclusive of texture.
4 Additional coats shall be applied to meet finished thickness specified for solid plaster partitions.
5 For exposed aggregate finishes, the second (brown) coat shall become the "bedding" coat and shall be of sufficient thickness to receive and hold the aggregate. The total thickness shown in Table 6 shall be achieved.
6 Dash or brush coat of plaster materials shall not be accepted as a required coat.
7 Where masonry and concrete surfaces vary in plane, plaster thickness required to produce level surfaces shall not be required to be uniform.
8 Table 6 shows only the first and finish coats for vertical surfaces and only the total thickness on horizontal surfaces for two-coat work.

Both hand and machine application of plaster are common throughout the industry. Taking into consideration things like size of the project and ease of accessibility, plaster pumps and wheelbarrows can each be effective means of transporting fresh plaster to a wall surface (Figures 15 and 16). Although procedures, tools, and equipment may differ, the method of application produces essentially the same plaster. For hand-applied plaster, the water content is slightly less than for its machine-applied counterpart. For machine-applied plasters, the resulting air content is slightly less than for its hand-applied counterpart, because entrained air is dissipated as the plaster impacts the surface. Differences in the plaster associated with different application procedures are further reduced during rodding and floating. In place, plaster performance is considered to be equal for the two application procedures. However, machine-applied plaster develops more intimate contact (bond) with a substrate.

As shown in Table 6, plaster can be applied in two or three coats on various substrates. The *National Building Code* in Canada has slightly different requirements. It suggests at least two base coats and one finish coat for a total thickness of not less than 15 mm, measured from the face of the lath or the face of the masonry where no lath is used. The first coat must fully embed the lath. Both the first and second coats must be at least 6 mm thick. The finish coat is required to be at least 3 mm thick.

Figure 16. On this job, plaster was distributed by wheelbarrow to mortarboards. (IMG12627)

Hand Application

The operation of hand applying plaster begins when the fresh mixture for the scratch coat is placed on a mortarboard. Proper mixing is assessed by kneading the plaster on the board. The plasterer then transfers plaster from the board to the hawk and begins plastering the base surface (Figure 17). For vertical surfaces, plastering can be done from the bottom to the top of the work area, or from top to bottom. The direction depends on the type of work being done and local practice.

The plasterer lays plaster on the surface by applying enough pressure to obtain good contact between materials.

Figure 15. Plaster pump is placed adjacent to the mortar mixer to deliver the plaster to the work area. (30570-K)

Figure 17. The plasterer takes plaster from the board, puts it on his hawk, and begins to plaster the surface. (IMG12629)

This procedure continues until the entire surface is covered to the desired thickness. Enough plaster must be applied to cover all lath with sufficient material to permit a light scratch without revealing any lath. Excessive troweling or movement of the scratch-coat plaster must be avoided as it is being applied, because too much surface action will break the bond created between the plaster and the base, whether concrete or masonry or metal lath.

The scratch coat should be uniformly scored in a horizontal direction on vertical surfaces (Figure 18) and in one direction on ceilings; shallow scratching is adequate.

The brown-coat plaster is applied next in sufficient thickness, usually ¼ in. to ⅜ in. (6 mm to 10 mm), to bring the surface to the proper plane (Figure 19). A few minutes after the plaster has been applied, the surface is rodded to the desired plane with a darby (Figure 20). The plaster thickness is properly gauged with plaster screeds or wood slats of proper thickness as the guides. Following rodding and after the plaster achieves proper stiffness, the plasterer floats the surface to give it the correct texture. The brown coat should not be scored.

Floating of the brown coat is an extremely important part of plastering. Floating must be done only after the plaster has lost sufficient moisture so that the surface sheen has disappeared, but before the plaster has become so rigid that it cannot be moved under the float. This interval is critical, since the degree of consolidation that occurs during floating influences the shrinkage-cracking characteristics of the plaster.

The finish coat is applied to a predamped, but still absorptive, base coat to a thickness of about ⅛ in. (3 mm). For vertical surfaces, the finish coat is applied from the top down, and the whole surface must be covered without joinings (laps or interruptions). The finishing technique of the finish coat depends on the desired surface texture (Figure 21).

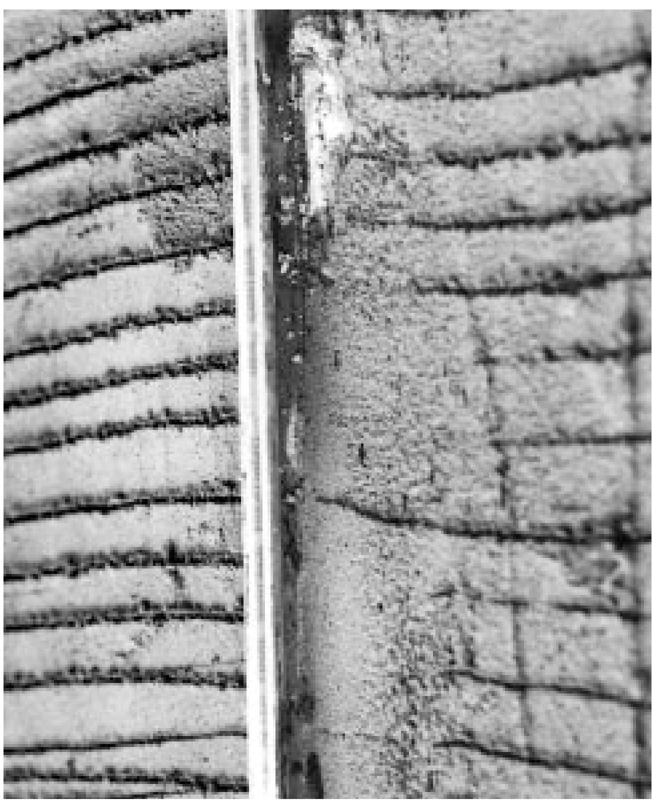


Figure 18. The first (scratch) coat is applied with enough pressure to obtain good contact between plaster and base surface. The scratch coat is scored horizontally. (30241-L)

Figure 19. The second (brown) coat is applied in a thickness to bring the surface to the proper plane. (30241-D)

Figure 20. A few minutes after the brown coat is applied, the surface is rodded to the desired plane. (70208)

Figure 21. Finally, the finish coat is applied to a predamped, but still absorptive, brown coat and floated and textured to the desired finish. (30241-J)

Machine Application

Applying plaster by machine requires preplanning so the operation will go smoothly. The plaster pump should be placed adjacent to the mixer and have sufficient hose attached to the pump to allow quick, easy pumping of plaster from the mixer to the surfaces to be plastered. Hose lengths should be relatively straight and no longer than necessary. Normally, rigid pipe is used to accommodate the high pressures near the pump. Rigid pipe also offers less friction than rubber hose. Reducing friction and subsequent pressure in the line helps reduce sand packing. Note that aluminum pipe or fittings should not be used to convey plaster. The pipe is coupled to a flexible rubber hose attached to the discharge nozzle. To ease the work effort demanded of the nozzleman, a light, flexible whip-line hose is used between the flexible rubber hose and the nozzle. The nozzle unit at the end of the pump line contains valves that give the operator remote control of the pressurized air and pump.

Before pumping plaster, the hose should be prewetted and lubricated to ensure unimpeded flow of plaster through the hose. Enough water is added to the pump holding tank to partially fill it. The pump is started and begins to move this water through the hose. The pump is stopped, the hose is disconnected at the pump, and a wet sponge is inserted in the hose. Safety considerations dictate that the whip line and nozzle not be connected to the hose at this time. The hose is reattached and the pump is started again. Water under pressure forces the wet sponge through the hose. A neat cement slurry (cement and water without sand) then is poured into the nearly drained pump holding tank. As pumping continues, the neat cement paste is forced through the hose, lubricating all hose surfaces. When the sponge emerges from the hose at the discharge end, the nozzleman stops the pump, attaches the whip line and nozzle, and sprays the remaining water and neat cement paste into a waste container. Since the neat cement paste is intended as lubrication for the hose, the operations involving line changes and nozzle additions should be completed as quickly as possible so the paste does not dry out or harden. The plaster mix is placed in the pump holding tank, pumped through the hose, and detected at the nozzle by the presence of sand. When the mixture is uniform in appearance, it is applied to the surface to be plastered.

During pumping applications, the nozzleman holds the nozzle approximately 12 in. (0.30 m) from the surface. Plaster is applied to the desired, or slightly greater, thickness. The nozzleman can vary the spray pattern and pattern size by adjusting the air pressure, changing the nozzle orifice size, varying the distance between the end of the air stem and the orifice, increasing or decreasing pump speed, or calling for a change in water content to adjust the consistency of the plaster mix. Through proper selection of

Figure 22. One worker applies portland cement plaster to an amusement park structure while another (background) floats the plaster and embeds the mesh. (30570-M)

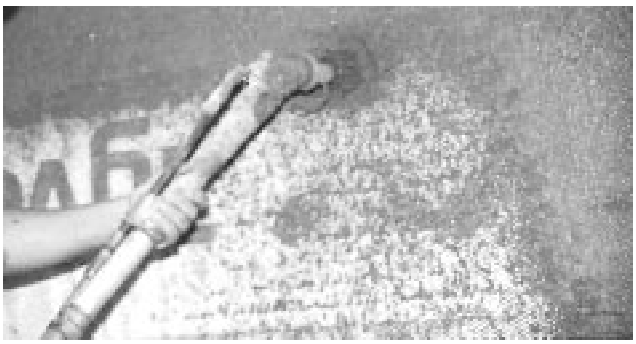


Figure 23. Machine application of portland cement plaster is an efficient method of placing material on a wall. (66135)

these options, the nozzleman can control the plaster application. An experienced nozzleman can make jobs run much smoother.

Machine application eliminates lap and joint marks, produces a more uniform appearance in color and texture, and produces, in colored finish coats, deeper, darker, and more uniform colors than can be obtained by hand application.

For scratch and brown coats, the nozzle should be moved with a steady, even stroke, laying on the proper thickness with one pass and overlapping successive strokes (Figures 22 and 23). The angle of the nozzle to the surface should be uniform. Around door bucks and window frames, the nozzle should be moved closer, to within a few inches (centimeters) of the surface.

The same rodding, floating, and finishing procedures used after hand application are used after machine application.

Good pumping practices require preconditioning, proper maintenance before and during pumping, and good cleanup and preventive maintenance of the hose upon completion of the work. Hose stoppages may occur during work due to poor mixtures or leakage at quick couplers located between pump and pipe, pipe and hose, and hose and nozzle. A stoppage requires immediate removal of the obstruction and, if necessary, repair or replacement of equipment. Excessive line pressure will activate the pump's safety valve or possibly rupture a hose. Regular preventive maintenance of the pump should be an established procedure. When pumping is completed, the pump and hoses should be immediately cleaned. Water used to clean the mixer is discharged into the pump hopper, and the nozzle is removed from the hose. Water is then added to the hopper while it is cleaned. The fresh water is then pumped through the hose until the hopper is emptied. A sponge is inserted at the pump end of the hose, clean water is added to the pump hopper, and both sponge and water are pumped through the hose to complete the cleaning operation. The U.S. Environmental Protection Agency and state agencies forbid discharging into the nation's waterways untreated wash water from pump and mixer washout operations.

Manufacturers of plastering machines publish instructions regarding their use, care, and maintenance. These instructions should be carefully followed.

Delay Between Successive Coats

Within the past 30 years, the time delay before applying the brown-coat plaster has been reduced from seven days to one day or less. The application of a coat of plaster should not be interrupted within a panel, and the full thickness of the base coats should be applied as rapidly as the two coats can be put in place. The brown-coat plaster should be applied as soon as the scratch-coat plaster is sufficiently rigid to resist, without cracking, the pressures of brown-coat application. Under certain conditions, application of both scratch and brown coats is possible on the same day. The short delay between the scratch and brown coats promotes more intimate contact between coats and more complete curing of the base coat.

Temperature Considerations

Temperature affects the speed of plastering by extending or reducing the time between consecutive operations. Cold weather lengthens the time between rodding and floating; hot weather shortens it. Dry weather has the same effect as hot weather. Dry or hot weather produces dry substrates and causes more rapid water loss from the plaster through both absorption and evaporation. Moderate changes in temperature and relative humidity can be overcome by heating materials during cool or cold weather and by prewetting during hot or dry weather to reduce the absorption of the base. The more extreme the temperature variation, the greater the required adjustments. Heated materials and enclosures are required during cold weather. Regardless of climatic conditions, when floating is completed at the proper time, the base-coat plaster will perform satisfactorily. Specific recommendations regarding the proper procedures to be followed in adverse temperature conditions are provided later in the section identified as "Hot and Cold Weather Considerations."

Control Joints and Panel Dimensions

Cracks develop in plaster from a number of causes:

- drying shrinkage stresses
- building movement
- foundation settlement
- restraints from lighting and plumbing fixtures that penetrate the plaster
- intersecting walls, ceilings, pilasters, and corners
- weakened sections in a wall or ceiling from a reduction in surface areas or cross sections because of fenestration
- severe thermal changes
- construction joints

Control joints are used to provide relief of stresses, thus controlling cracking (Figure 24). The location of control joints should be determined by the designer, not the applicator. Their placement should be strategically selected to correspond with lines of weakened structural planes as related to anticipated potential building movement including: corners of openings in the plaster skin such as vents, windows, and doors; structural plate lines or concentrations of large structural elements; where columns or beams join with walls or ceilings; over junctures of dissimilar bases (Figure 25); and over existing construction, expansion, or control joints.

Where plaster is applied to a concrete or masonry base with or without metal reinforcement, control joints in the plaster coat should be installed directly over and aligned with any control joints in the base. Normally, cracking will not occur in plaster applied to uncracked concrete or masonry bases if the plaster bonds tightly to the base structure. If excessive cracking does occur, the bond or mechanical anchorage is inadequate for the structural movement.

Where plaster is applied over metal reinforcement, the metal reinforcement should be fabricated and attached in a way that allows free movement of the panel area between the control joints. Failure to allow free movement will result in cracking at the thinnest portion of the panel. While designing the size of a free-moving panel, the total surface area should be divided into panels that preferably form a square. ASTM C 1063 requires that control joints be installed in walls to create panels of not more than 144 sq ft (13.4 m^2) in area and not more than 100 sq ft (9.3 m^2) for all ceilings, curves, or angular plaster surfaces. ASTM C 1063 indicates that the distance between control joints shall not exceed 18 ft (5.5 m) in either direction or a length-to-width ratio of 2½ to 1.

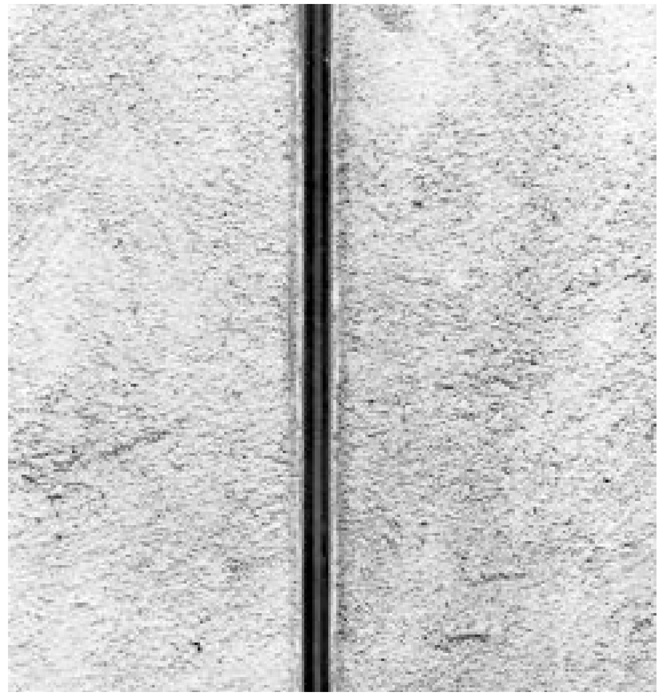


Figure 24. Control joints provide relief of stresses. (30241-G)

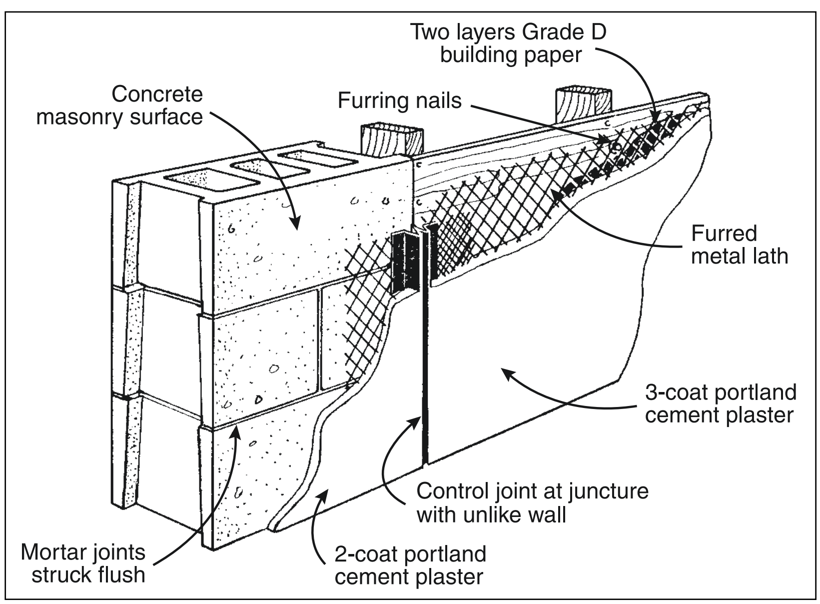


Figure 25. Control joints should be placed at the juncture of different types of construction.

A common error is to violate the ratio of panel dimensions, resulting in cracking of long, slender panels. These joint spacings represent industry recommendations based on typical plaster applications. Additional factors such as structural considerations previously noted or even surface texture of the finish coat (cracks are more apparent on smooth textured finishes than coarse textured finishes) may dictate more conservative placement of control joints.

Control joints can be installed with an array of plaster trim accessories. Examples of control joint accessories are illustrated in Appendix D. ASTM C 1063 requires that control joints be formed from a single prefabricated member or from back-to-back casing beads with a flexible barrier membrane behind the beads. A minimum separation of ⅛ in. (3.2 mm) is required, but the optimal specified and constructed gap may be greater depending on the thermal exposure range. The lath must be attached to the control joint (as well as the support studs), in the same manner that laps in the lath are wired together. However, it is very important that metal reinforcement stop at each side of the joint and never continue through the control joint. A ½-in. (13-mm) gap is desirable, and a weather resistant barrier should continue unbroken behind the control joint. All joints, intersections, and terminations of control joints should be embedded and weather sealed.

The simple notched or ground control joint is effective where plaster is of uniform thickness.

The accordion-pleat control joint seals out weather and is inserted to isolate adjacent free-moving plaster panels. Each leg of this joint must be attached to adjacent but isolated panels. If such a joint is used in open-frame construction, the control joint can be affixed to adjacent studs (double studs).

The control joint diaphragm should be installed in a closed, not open, position. Portland cement plaster shrinks as it hardens and dries, and the joint will open. As the weather changes from day to day, the joint will open further when the surface is cooling or drying and close partially when warming or being moistened.

Curing

To obtain the best result from the cementitious materials in portland cement plaster, some moisture must be maintained in the plaster for the first few days after application. Moist curing, under present plastering practice, usually is applied only to the base coat and continued until the application of the finish coat. Generally, fogging the surface with water at the start and again at the end of the workday will suffice. If the relative humidity is high (more than 70%), the frequency of moistening the surface may be reduced. If it is hot, dry, and windy, the plaster surface should be moistened and covered with a single sheet of polyethylene plastic (weighted or taped down) to prevent water loss through evaporation.

Immediately before finish-coat application, the base coat should be moistened. This moisture along with the water in the fresh plaster provides the total curing of the finish-coat plaster. As noted in the section on color, applying water to colored finish-coat plaster before hardening is a common cause of color variations, and should be avoided until after the surface has hardened.

Testing and Inspection

Because portland cement plaster is primarily a weather resistant facing on the exterior of a structure, the plaster section is non-structural. However, local building codes may still require inspections (and testing). If so, the requirements of the code should be followed. The quality assurance provisions for a project should be defined in the project specifications. For simple applications, such provisions may require only letters of certification on the products used and approval of plaster mixes, color, and texture. Quality assurance requirements for more complex applications may range from routine inspection of mixing procedure, materials storage and handling, and plastering application (especially floating of the brown coat), to inspection plus construction site testing.

While testing of plaster at the construction site is not typically required, such testing in accordance with ASTM C 780 can provide assurance that the materials are performing as expected and that proper control is being exercised during plaster preparation. The consistency retention test (ASTM C 780, Annex A2) can be used to establish the setting characteristics of the plaster mixture; the mortar aggregate ratio test method (ASTM C 780, Annex A4) and the mortar water content (ASTM C 780, Annex A5) can be used to assess the care and consistency with which batches of plaster are prepared. When ASTM C 780 is incorporated into a quality assurance program, preconstruction tests of plaster materials should be conducted to establish baseline values for measured properties and confirm the capabilities of the testing agency. Such preconstruction tests of plaster mixtures can effectively be accomplished during preparation of the plaster sample panel. Quality control tests should be completed according to the frequency indicated by the project specifications. Increased testing frequency should be required when inspections indicate a relaxing of those procedures that were used during test panel preparation, when variations are observed in plaster appearance, or when test results differ significantly from the baseline values.

Hot and Cold Weather Considerations

Although portland cement plaster can be applied during cold weather at temperatures below 40°F (4°C), better results can usually be achieved when plastering is done at temperatures above 40°F (4°C). At freezing temperatures, the water content of plaster is sufficiently high such that the plaster will undergo disruptive expansion as the water within it freezes. A heated enclosure and use of heated materials are recommended when the daytime temperature is 40°F (4°C) and falling. The enclosure should be maintained above 40°F (4°C) for at least 24 hours after plastering, and preferably longer. In Canada, specifications require that the base coat for plaster be maintained above freezing and that the fresh mix be maintained at or above 10°C during application and for not less than 48 hours afterwards.

When plaster materials are heated as further protection from cold temperatures, the mixing water is logically the first material to be heated. Water heated to 130°–140°F (54°–60°C) and combined with cold but unfrozen sand will produce plaster in the 70°–100°F (21°–38°C) temperature range. Heating water to raise the mortar temperature has the effect of accelerating the plaster set, which protects against early freezing. Avoid heating materials such that plaster temperature exceeds 120°F (49°C), since at temperatures exceeding 120°F (49°C) flash set of the plaster is imminent. At the early stages of design, the selection of an air-entrained material, such as masonry cement, will allow using a lower water content plaster with better early-age resistance to freeze-thaw damage. Where the plaster moisture content has been lowered by natural evaporation and reaction with portland cement (hydration), the plaster can withstand lower ambient temperatures.

Interior portland cement plaster work should be maintained at or above 50°F (10°C) until the structure is occupied. Interior plaster such as is used in freezers or cold-storage rooms should be allowed to set, cure, and dry and should then be gradually brought down to the subfreezing service temperature.

During hot ambient temperatures, a common concern for plaster is early drying. Provisions should be made to keep fresh plaster moist, whether by covering with a plastic sheet or by fogging with water. Wind and sun shades can prevent excessive drying or heating conditions. In extreme cases, it may be necessary to cool mix water or aggregates.

Color Variation

Color variation in finish-coat plaster can usually be traced to one or more causes, including the following:

- Failure to maintain established proportions of aggregate to cementitious materials
- Failure to maintain uniform working consistency between batches
- Cold joints in the brown coat
- Overfloating the brown coat
- Non-uniform predampening of the brown coat prior to applying the finish coat
- Water additions to plaster surface during finish-coat texturing

Color variation in exterior finish-coat stucco can be corrected by application of a fog coat or brush coat. For brush coating, a factory-prepared brush coat mixture is mixed with water to produce a milky consistency. The wall is dampened lightly and evenly before the brush coat is applied. A fog coat should be applied to a dry surface, using as fine a spray as possible. Curing of these coats is necessary under hot, dry, or windy conditions by applying a light fog spray of water the following day.

SPECIAL APPLICATIONS

Fire Resistant Construction

Portland cement plaster has been used for many years where fire resistance rated construction is required by building codes or is desired by the building owner. It can be used as a protective covering for steel columns and beams, and as a protective finish for walls and ceilings of floor and roof assemblies. Wherever these assemblies are required to be fire resistance rated and will be exposed directly to the rain or to the effects of moisture laden air, portland cement–based plaster should be considered due to its excellent performance in these types of environmental conditions.

Building codes in the U.S. generally require that the fire endurance of a material or assembly of materials be determined by a fire test conducted in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*. Over the years, many assemblies incorporating portland cement–based plaster have been tested and their fire endurance periods recorded. Until recently, locating documented results of these fire tests has been difficult.

Now a publication, *Single Source Document: Fire-Related Portland Cement–Based Plaster Assemblies,* contains descriptions of plaster assemblies with fire resistance ratings up to 4 hours. Most of the wall assemblies are of either wood or steel framing members; however, several masonry walls are included. The publication also has several floor and roof assemblies that utilize plaster as the exposed ceiling finish. Numerous methods of protecting steel columns and beams are shown.

Other sources of information include:

- *Fire Resistance Directory, Volume I,* Underwriters Laboratories, Inc., 2002
- *Uniform Building Code 1997, Volume 1,* (Chapter 7, Tables 7-A, 7-B, and 7-C), International Conference of Building Officials
- *International Building Code 2000,* (Chapter 7, Tables 719-1a, 719-1b, and 719-1c), International Code Council
- *Guidelines for Determining Fire Resistance Ratings of Building Elements (Appendix A),* Building Officials and Code Administrators International, Inc., 2001

Most, if not all, assemblies in these documents are contained in the *Single Source Document*.

In many cases plaster is applied to concrete or masonry walls, either at the time of construction or many years later. Regardless of when applied, plaster on one or both sides of a wall increases its fire resistance. Thus plaster is an excellent choice as a finish material addition to walls when buildings are undergoing repair or renovation to comply with current building codes.

Most building codes, including the *International Building Code* (IBC 2000) and the National Fire Protection Association's *Building Construction and Fire Safety Code* (NFPA 5000), permit fire resistance ratings to be calculated. The following resource documents or codes contain procedures for calculating the fire resistance rating of a concrete or masonry wall to which portland cement plaster has been applied.

- *Standard Building Code/1999,* Southern Building Code Congress International, Inc.
- *Guidelines for Determining Fire Resistance Ratings of Building Elements,* (Chapters 2–4), Building Officials and Code Administrators International, Inc., 2001
- *National Building Code of Canada 1995*, (Appendix D), National Research Council of Canada
- *International Building Code 2000,* (Chapter 7, Section 720.2.1.4, Table 720.2.1.4(2)), International Code Council
- *Standard Methods for Determining Fire Resistance of Concrete and Masonry Construction Assemblies,* (Chapter 5), ACI 216.1-97/TMS 0216.1-97, American Concrete Institute and The Masonry Society, 1997
- *Standard Calculation Methods for Structural Fire Protection*, (Chapters 2 and 4), ASCE/SFPE 29-99, American Society of Civil Engineers, 1998
- *Methods for Calculating Fire Resistance of Steel, Concrete, Wood, Concrete Masonry and Clay Masonry Construction,* (Section 7.713.3), Uniform Building Code Standard 7-7, Uniform Building Code, Volume 3, International Conference of Building Officials, 1997

When reviewing resource documents for assemblies employing portland cement–based plaster, assemblies with gypsum plaster, gypsum-perlite plaster, or gypsum-vermiculite plaster will generally be encountered. Due to differences in thermal properties of the various types of plaster, a comparable thickness of portland cement–based plaster should not be substituted for plaster of another type.

Ceramic Tile Installation

In areas subject to high humidity, especially where ceramic tile is selected for the final surface, portland cement plaster makes an ideal base. The materials and construction procedures are covered by a national standard, ANSI A108.1, and industry guides such as the *Handbook for Ceramic Tile Installation*.

The advantage of portland cement plaster for this application is that it is very water resistant. Water penetrating the tile grout is absorbed by the plaster and then lost through evaporation. The plaster can be applied over studs, with or without sheathing, and is either hand- or machine-applied in two coats. The resulting surface should be capable of bonding with the portland cement paste bond coat. The bond coat may contain a bonding agent to improve the adhesion between the tile and the plaster.

Surface Bonded Masonry

A recent innovation in the plastering industry is the use of glass fibers as reinforcement in neat cement paste and mortar. These glass-reinforced cements and mortars are applied to the faces of dry-stacked masonry (with no masonry mortar in the joints between units) to provide wall stability and strength. Application is possible by hand or machine. The surface bonding material is applied in a ⅛-in. (3-mm) minimum thickness with plastering tools. Rodding and floating operations are unnecessary with this thin, single coat plaster system.

Commercial products are available with standard (E-glass) glass fibers, or alkali resistant (AR-glass) glass fibers. Some of the mixtures include a fine 30-mesh (600-µm) silica sand. The mixtures generally contain glass fibers that are approximately ½ in. (13 mm) in length. Each fiber is a bundle of individual filaments held together and enveloped in a sizing material.

When the glass-reinforced cement and mortar products became available, concern about an alkali-glass reaction was common. Alkali resistant glass has been developed to significantly reduce the concern about undesirable alkali-glass reactions. The present specification for surface bonding mortars, ASTM C 887, acknowledges this concern about unfavorable reactions and requires that the producer demonstrate that the glass composition, cement matrix, or both have been modified to significantly reduce or eliminate such reactions.

The structural capabilities of the glass-reinforced mixtures also are being incorporated into pleasing architectural and structural components.

Coolers and Walk-in Freezers

One of the successful uses of portland cement plaster with a hard, steel-trowel finish is on the interior surfaces of refrigeration or cooling rooms. In this construction, a steel structure typically carries the roof load, and concrete masonry units form the building's exterior walls. A vapor barrier is placed over the masonry and under two layers of insulation board, which then receive a portland cement plaster hard-finish surface. Sometimes, particularly in remodeling work, it may be necessary first to plaster the rough masonry surface in order to provide a smooth plane on which to apply the insulation. This construction involves plastering over insulation board with or without metal reinforcement.

Portland cement plaster bonds tenaciously to most insulation, such as polyurethane, polystyrene, and cork. Each of these materials, although basically water resistant, possesses sufficient surface irregularities to allow mechanical keying of the plaster to the insulation material. Some materials, however, are too soft or too smooth to allow proper mechanical keying between plaster and insulation. Scoring the surface of the insulation may be sufficient, modification of the plaster using admixtures to promote bonding may be helpful, or it may be necessary to cover the surface of these materials with metal lath. A problem arises with any insulation because the applied plaster can lose water only by evaporation from the exposed inner surface. Early freezing of any excess water in the plaster could cause delamination between the insulation and plaster.

Plastering is done in two coats. For the scratch coat, the plaster is applied with sufficient pressure to promote intimate contact with the insulation. After rodding the plaster to a true surface, it must be floated and refloated to promote water loss throughout its entire thickness before troweling the surface. These precautions are necessary because the plaster upon cooling and drying will undergo differential volume changes, that is, greater shrinkage at the surface than at the plaster and insulation interface. The warping effect can coincide with shrinkage cracking and will be most pronounced at the intersection of shrinkage cracks. Warping will curl the plaster away from the insulation. Consequently, after the surface has been troweled, it must be cut into small square panels to prevent or reduce the severity of warping. A groover is used to score control joints into the plaster at short intervals, approximately 2 ft (0.6 m) apart on centers. Inserting sealants into the control joints after shrinkage occurs will render the joints resistant to air and moisture penetration.

Swimming Pools

The finish coat of a swimming pool is generally a white portland cement plaster that has been given a smooth, steel-trowel finish (Figure 26). Properly applied, this material provides a smooth, watertight finish surface. The plaster usually is from ⅜ in. to ¾ in. (9.5 mm to 19 mm) thick, applied to the surface of a prepared base of cast-in-place concrete, concrete masonry, or shotcrete. Whatever substrate material is chosen, it should be clean, sound, free of debris, and be rough, coarse, and porous to ensure good mechanical bond. The base can be roughened to enhance bond with the plaster. A bonding agent of the type recommended for swimming pools may be necessary if the substrate surface is too smooth.

Figure 26. White portland cement plaster is an attractive and durable interior finish for swimming pools. (52983)

The National Plaster Council recommends using no less than 1 part cement (or cementitious materials) to 2 parts sand along with sufficient water to achieve a trowelable consistency and ensure that the coating does not dry out before it starts to set.

Plaster should be mixed in a power mixer. Factory premixed finishes are available. Trowels used for pool work should be of stainless material with rounded ends to prevent trowel burns.

Before applying the plaster, the base should be sprayed with clean water to reduce suction. The mix should be applied quickly to the walls in a thin coat, beginning at the deepest part of the pool. The plasterer then should double back with the brown coat to produce a total thickness of approximately ⅜ in. (10 mm). When the brown-coat plaster has stiffened sufficiently, troweling should begin and continue until all catfaces (see Appendix B) are eliminated and the surface properly compacted. Before troweling is completed, the trowel should literally ring as it is moved across the surface.

After the pool wall has been completely plastered, it must be cured immediately by filling the pool with water as rapidly as possible without causing any erosion of the paste from the surface of the plaster. Making arrangements with the local water department to use a convenient fire hydrant will ensure rapid filling if the pool is large. Small pools can be filled by a garden hose with a towel wrapped around the discharge end to prevent damage to the fresh plaster. The hose should be positioned at the deep end of the pool.

When the pool is in use, the owner must maintain a balance between alkaline and acid water conditions. An alkaline condition will promote the growth of crystals on the plaster surface, resulting in cuts and abrasions to swimmers. Conversely, an acid water condition will cause deterioration of the alkaline cement plaster and shorten the serviceability of the pool finish coat.

To protect against frost damage in cold weather, the pool owner can drain the pool and risk the need for replastering the following spring; keep the pool filled with warm water and use an insulating cover to maintain the water temperature above freezing; or place items (such as logs) in the pool to relieve expansive forces when the water freezes. Preventive maintenance considerations and economics may dictate completely enclosing the pool.

Old plaster pools in need of restoration can be repaired by first removing all unsound plaster and replastering these areas back to the original plane or contours. Unsound plaster, or plaster that has lost its bond to the base, can easily be detected by tapping the surface with a wooden mallet or metal rod. A dull, hollow sound indicates delamination or loss of bond; a sharp, solid sound indicates good adhesion between plaster and base. After cleaning the old plaster surface with a high pressure-velocity water-jet spray, the new plaster can be applied.

New plaster applied over existing plaster can be as thin as ⅛ in. (3 mm) if the plasterer can obtain sufficient bond with the mixture.

Discoloration of swimming pool plaster may be caused by deleterious substances in aggregates, over-troweling or burning the surface, contaminated mixing water, and improper use and maintenance. Deleterious substances include blast-furnace-slag contaminants (causing yellow, brown, green, blue, or purple spots) or graphite (causing gray specks), all of which can only be removed by coring discolored areas and replacing plaster. Burns from over-troweling can be removed by rubbing the affected area with an abrasive or by acid etching the entire area. Discoloration due to contaminated water sources can be remedied only by establishing the discoloration compound and either reducing or oxidizing the materials. Perhaps the most common cause of discoloration is aggressive pool water chemistry resulting from improper use and maintenance. Abuse in use of the pool may vary from improper chemical (acid) additions to the water, to sun protection lotion, or to improper chemical balance. A white streak from pool top to the bottom drain indicates acids were added to the pool in concentrated form. Rings around the pool surface indicate sun protection lotions. An acid water condition in the pool may be indicated by bluish-white deposits leading from the water-filter return to the pool drain, a condition not uncommon when copper tubing has been used in pool construction. The *NPC Technical Manual* contains a thorough section on troubleshooting and repair of cracks, soft plaster, debonding and delamination, discoloration, and general deterioration. (NPC 2003) The manual can also be used for failure analysis, in addition to serving as a guide for inspection and writing specifications for the proper application of pool plaster.

Further information on swimming pools can be found in the book titled *Swimming Pools* (Perkins 1988).

Courts – Handball, Squash, Racquetball

The popularity of handball, squash, and racquetball as recreation is providing the plastering industry with a challenging application for smooth-trowel-finish surfaces on building interiors. Many court walls are constructed of concrete masonry, which serves as an excellent solid base for portland cement plaster. Because of the frequent, high impact of the ball on the plaster, metal reinforcement is sometimes specified on the front wall surface of handball and squash courts. Metal lath is also sometimes used on the playing and side walls of racquetball courts.

Handball court construction requires that masonry walls be built to conventional masonry specifications and tolerances. Joints should be struck flush with the face of the masonry and not tooled or sponge floated. Although some courts have a vapor retarder at the interior concrete masonry surface, this practice is not recommended as it prevents the bonding of plaster to the walls.

Where metal reinforcement is used on the front, high-impact wall surfaces, an open-mesh reinforcement should be selected. The metal reinforcement should be furred out ¼ in. (6 mm) from the wall using furring nails or self-furring metal lath. The lath should be affixed securely with nails to the concrete masonry wall; nails should be spaced approximately 16 in. (400 mm) apart.

Construction details must be planned carefully. The plaster should be separated from the finished flooring with casing beads installed ¼ in. (6 mm) above the finished floor, with the flooring underneath the base bead but not touching the basic wall construction. In the application procedure that follows, plaster can be placed on concrete masonry walls without control joints.

Plaster mixes "C," "CM," "MS," "P," or "CP" as defined in Table 3 may be used for the scratch-coat plaster. An aggregate ratio of 3 to 3¾ parts of sand by volume, per sum of the volume(s) of cement(s) is recommended. If a "C" mix is used, it should be proportioned to contain 1 part of portland cement, 0 to ¼ part of hydrated lime, and 3 to 3¾ parts of sand by volume per sum of volumes of cement and lime. Immediately prior to plastering, the dry concrete masonry wall should be thoroughly moistened to reduce its absorption. Ideally, the plaster should be machine applied to obtain intimate contact and strong bond between the base and the plaster. Hand application of the scratch-coat plaster must be done with sufficient pressure to force the plaster through the metal lath and tightly against the base surface. After sufficient material has been applied, the surface should be scored horizontally.

The brown-coat plaster should be applied either immediately after the scratch-coat plaster has become sufficiently rigid to allow application or the following day. This plaster should be proportioned using the same plaster mix as used in the scratch coat, except an aggregate ratio of 4 to 4½ parts of sand, by volume, per sum of volumes of cement(s) or cement and lime is recommended. The plaster should be applied with enough pressure to obtain tight contact with the scratch coat. It should be built up to the required thickness and rodded to plumb the surface and bring it to a smooth plane. After rodding the soft plaster, the plasterer should wait a few minutes for the plaster to harden before the surface is floated (reconsolidated) and brought to a good straight surface with sufficient roughness to develop mechanical bond with the finish-coat plaster. On succeeding days, the plaster should be moist cured to develop full strength and hardness.

The finish-coat plaster should be applied approximately seven days after completing the base coat. Finish-coat plaster mixes "FCM," "FMS," or "FP" as defined in Table 5 may be used. Aggregate should consist of 3 parts of minus 30-mesh (600-µm) white silica sand by volume per sum of the volume(s) of cement(s). If portland cement-lime finish-coat mix is used, it should contain 1 part of white portland cement, ½ to 1 part hydrated lime, and 4 parts of minus 30-mesh (600-µm) white silica sand by volume per sum of the volumes of cement and lime. The finish-coat plaster should be applied on the predampened base-coat plaster to a thickness of ⅛ in. (3 mm) and steel troweled to obtain a smooth surface.

Throughout this construction sequence, the curing of plaster coats and precautions required in adverse climatic conditions, as recommended in this publication, should be followed.

CARE AND MAINTENANCE OF PLASTER

Preventive maintenance of plaster in service will prolong its useful life. The preventive maintenance program should involve periodic and scheduled inspection of the plaster. Remedial corrective measures should be established and implemented as the need arises. Temporary repairs should be discouraged. The preventive maintenance procedures should alert anyone attempting repairs that the corrective measures should return the plaster to its original condition.

Washing of the plaster surfaces will keep the surface clean and the color bright. Washing plaster walls is completed as follows:

1. Prewet the entire wall surface, saturating it with clean water. Water should be applied starting at the bottom and continuing to the top.
2. Use a garden hose to direct a high-pressure stream of water against the wall to loosen the dirt. Start at the top and wash the dirt down the wall to the bottom.
3. Flush remaining dirt off the wall with a follow-up application of water.

Prewetting overcomes absorption by the plaster and prevents dirty wash water from being absorbed at a lower elevation, thereby dulling the finish. The use of high-pressure spraying equipment and detergents may be necessary to remove accumulated surface contaminant. To test, select a small section of the plaster and apply low pressure with an appropriate detergent. When difficult stains are encountered, increasing the pressure will allow removal of more surface contamination. Keep the stream of water moving over the surface to prevent erosion of the plaster and never use abrasives when high-pressure water spraying. Use a fan nozzle to produce a flat spray and angle spray to avoid hitting the surface of the plaster with a perpendicular stream of water.

Plaster Repair

Cracks that appear within the first 30 days after installation and are wider than 1⁄16 in. (1.5 mm) can be filled or repaired with the same color coat material. If a crack is visible from more than 10 ft (3 m) away or is a source of leaking, it should be patched.

Chipped corners and small holes in the plaster can be patched. The patch area should be prewet before patching plaster is applied. Patching plaster should be made from essentially the same materials used throughout the plaster field. Apply patching materials in thin consecutive layers, troweling each layer until firm, and continue applying thin layers until the base-coat plaster has been replaced (Figure 27). The finish-coat plaster then can be applied and textured to match the surrounding plaster.

Additional information on plaster repair, including surface preparation, is available in another PCA publication, *Repair of Portland Cement Plaster (Stucco),* IS526.

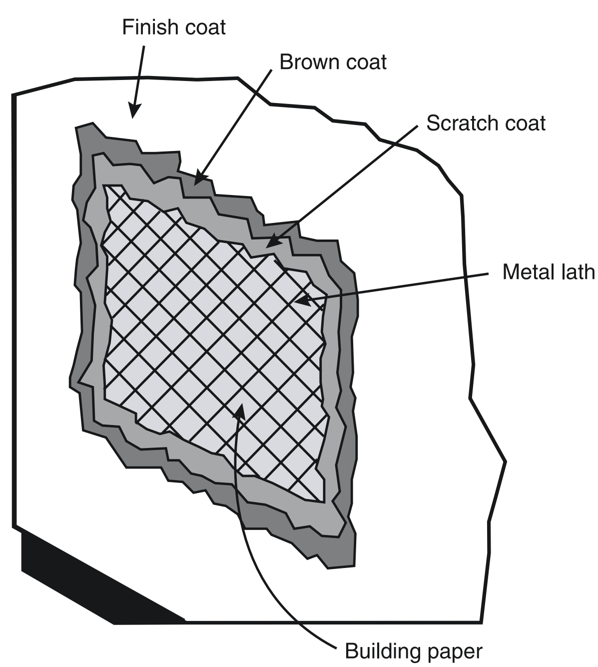


Figure 27. When patching plaster, each succeeding coat is cut back farther than the preceding coat, the base coat being the smallest area and the finish coat being the largest area to be patched.

Historic stucco repair may be more involved. Until the late 1800s, plasters were primarily lime based. Around that time, portland cement became more widely available. Including it as an ingredient in plaster created a harder, more durable product, and it soon eclipsed the popularity of the softer lime materials, which were more susceptible to water damage. Since construction date alone is not an indication of whether or not plaster or lime was used as a binder, a visual assessment, and perhaps, testing, may be needed to ascertain the plaster make-up. It is always suggested to replace like with like, but in the case of very old buildings, adding some portland cement to the repair formulation may provide added durability without impairing performance. A professional should be consulted.

Painting

With the ability to tint finish coats using integral color pigments, the necessity of painting new plaster to achieve a colored finish is diminished. However, if it is desired to paint new stucco surfaces, many products are available for this purpose, including cement-based paints, elastomeric acrylic or silicon coatings, or thin latex paints. For best results, use paints that are specifically manufactured for use on portland cement plaster and consult with the paint manufacturer for recommendations on application and how long plaster should be cured prior to painting.

Painting of exterior plaster with a portland cement-based paint can restore or improve the original appearance of the plaster. To prepare, dampen the surface before application. Available products are mixed with water to brushable consistency and heavily applied so any minor cracks or holes are sealed. Following painting, moist cure the entire surface using a fine mist spray of water, being careful to prevent surface erosion. The appearance created by surface treatments, such as paints and coatings, should be thoroughly evaluated before the work is done. Once the treatment is applied, it is difficult or impossible to return to the original surface.

PROBLEMS – THEIR CAUSES AND REMEDIES

Observation	Cause	Remedy
1. Cement floats on water during batching.	Cement is hydrophobic.	Mix normally. Cement will disperse when sand is added. Mix for longer time to insure dispersion.
2. Bagged materials contain lumps.	Materials stored in moist place.	Keep bagged materials high and dry. If lumps can be easily broken, use and mix with sand until abraded. If lumps are hard, discard.
3. Plaster froth in mixer.	Too much water, water too cold, or prolonged mixing.	Reduce air-entraining admixture, water, and mixing time. Add warm water.
4. Pump jams, no leaks in hose.	Equipment malfunction. Plaster air content is too high.	Repair equipment and check batching and mixing procedures.
5. Pump jams, hose coupling leaks, sand at leaking coupling.	Coupling malfunction.	Repair or replace coupling.
6. Pump jams, nozzle plugged, sand and cement at nozzle.	Materials improperly mixed.	Adjust mix procedure, replace screen on pump cement hopper.
7. Plaster stiffens immediately after application on concrete masonry base.	Base too dry.	Moisten base prior to plaster application.
8. Hard applied plaster falls off metal reinforcement when applied.	Metal lath upside down. Plaster cohesion low. Water content too high.	Position lath properly. Adjust mix to include an air-entraining material or admixture. Reduce water content.
9. Scratch-coat plaster is cracked over each stud.	Non-uniform plaster thickness.	Correct lathing procedure. Apply brown coat.
10. Efflorescence on scratch coat after seven days exposure.	Cold weather. Too long delay between coats.	Wash down wall with water. Apply brown coat. Heat water and sand if weather is cold.
11. Finish-coat blistering.	Mix overly rich. Surface over-troweled.	Adjust mix and change finishing procedure.
12. Finish-coat color not uniform.	Water dashed on surface during finishing.	Moisten base-coat plaster prior to finish-coat application. Apply fog coat to plaster surface.
13. Poor bond to concrete or concrete masonry substrate.	Base too dry. Lack of hydration.	Moisten base. Moist cure plaster.
14. Poor bond to concrete or smooth concrete masonry substrate.	Surface too smooth or dense.	Select concrete masonry units with open surface texture. Use dash bond coat, bonding agent, or attach metal reinforcement.
15. Poor bond to concrete or masonry.	Surface covered with dirt or other contaminant.	Avoid contamination of surfaces during construction. Brush clean, sandblast, or attach metal reinforcement.
16. Plaster cracks in craze pattern and is convex.	Brown coat harder than scratch coat or finish coat harder than base coat.	Increase sand content of brown-coat plaster as compared to scratch coat. Use lower strength finish coat.
17. Horizontal and vertical cracks at metal lath laps.	Improper laps using backed metal lath.	Lap back metal lath with paper to paper and metal over metal.
18. Cracking	Poor consolidation.	Correct rodding and floating procedures.
19. Cracking	Inadequate control joints.	Strategically place and properly install control joints.
20. Cracking	Early moisture loss.	Moist cure.
21. Color spots in white-coat swimming pool plaster.	Aggregate contaminated slag containing sulfite.	Use clean aggregate free of contaminants or impurities.
22. Streaks in white-coat swimming pool plaster.	Improper use of acidic chemicals in treatment of pool.	Properly dilute chemicals added to pool and disperse liquid throughout pool.

APPENDIX A

GENERAL AND CITED REFERENCES

Applicable codes and guides that the reader may be governed by include:

ACI Committee 524, *Guide to Portland Cement Plastering,* ACI 524R-93, ACI Committee 524 Report, American Concrete Institute, Farmington Hills, Michigan, 1993, 28 pages.

ANSI, *Specifications for Installation of Ceramic Tile in the Wet Set Method with Portland Cement Mortar,* ANSI A108.1, American National Standards Institute, New York, New York, 1992.

BOCA, *The BOCA National Building Code/1999,* "Chapter 25, Gypsum Board and Plaster," Building Officials and Code Administrators International, Inc., Country Club Hills, Illinois, 1999.

BRE, "Choosing External Rendering," *BRE Good Building Guide* (Series) GBG 18, Building Research Establishment, Garston, Watford, WD27JR UK/England, June 1994, 6 pages.

FWCI, *Single Source Document: Fire-Related Portland Cement–Based Plaster Assemblies,* The Foundation of the Wall & Ceiling Industry, Falls Church, Virginia, 1991.

ICBO, *Uniform Building Code/1997,* "Chapter 25, Gypsum Board and Plaster," International Conference of Building Officials, Whittier, California, 1997.

ICC, *International Building Code 2000,* International Code Council, Falls Church, Virginia, 2000, 756 pages.

Maylon, Gary J., *The Metal Lath Handbook,* Metal Lath Consulting Co., LLC, Trussville, Alabama, 2002, 244 pages.

NCMA, *Flashing Strategies for Concrete Masonry Walls,* TEK 19-4A, National Concrete Masonry Association, Herndon, Virginia, 2001.

NPC, *National Plasterer's Council Technical Manual,* National Plasterer's Council, Nuero, California, 2002.

Perkins, Philip H., *Swimming Pools,* Elsevier Applied Science, Wexham, 1988. (Available through International Thomson Publishing, Florence, Kentucky.)

SBCCI, *Standard Building Code,* "Chapter 25, Gypsum Board and Plaster," Southern Building Code Congress International, Inc., Birmingham, Alabama, 1999.

TCA, *Handbook for Ceramic Tile Installation,* Tile Council of America, Clemson, South Carolina, 1995.

UL, *Fire Resistance Directory, Volume I,* Underwriters Laboratories, Inc., Northbrook, Illinois, 2002.

REFERENCE DOCUMENTS

References to Portland Cement Plastering include:

ASTM STANDARDS – These standards are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania, 19428-2959, phone 610.832.9500 or via the Internet at www.astm.org.

A 641-98	Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
A 653-02	Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
C 33-02	Specification for Concrete Aggregates
C 35-01	Specification for Inorganic Aggregates for Use in Gypsum Plaster
C 91-01	Specification for Masonry Cement
C 109-02	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)

C 144-02	Specification for Aggregate for Masonry Mortar
C 150-02	Specification for Portland Cement
C 191-01a	Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
C 206-84 (97)	Specification for Finishing Hydrated Lime
C 207-91 (97)	Specification for Hydrated Lime for Masonry Purposes
C 226-02	Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement
C 233-01	Test Method for Air-Entraining Admixtures for Concrete
C 260-01	Specification for Air-Entraining Admixtures for Concrete
C 270-02	Specification for Mortar for Unit Masonry
C 494-99ae1	Specification for Chemical Admixtures for Concrete
C 595-02	Specification for Blended Hydraulic Cement
C 618-01	Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
C 631-95a	Specification for Bonding Compounds for Interior Gypsum Plastering
C 688-00	Specification for Functional Additions for Use in Hydraulic Cements
C 780-02	Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
C 841-99	Specification for Installation of Interior Lathing and Furring
C 847-95 (00)	Specification for Metal Lath
C 856-02	Practice for Petrographic Examination of Hardened Concrete
C 887-79a(2001)	Specification for Packaged, Dry, Combined Materials for Surface Bonding Mortar
C 897-00	Specification for Aggregates for Job-Mixed Portland Cement–Based Plasters
C 926-98a	Specification for Application of Portland Cement–Based Plaster
C 932-98a	Specification for Surface-Applied Bonding Agents for Exterior Plastering
C 933-96a(01)	Specification for Welded Wire Lath
C 946-91(01)	Standard Practice for Construction of Dry-Stacked, Surface-Bonded Walls
C 979-99	Specification for Pigments for Integrally Colored Concrete
C 989-99	Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
C1002-01	Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
C1007-00	Standard Specification for Installation of Load Bearing (Transverse and Axial) Steel Studs and Related Accessories
C 1032-96	Specification for Woven Wire Plaster Base
C 1042-99	Test Method for Bond Strength of Latex Systems Used with Concrete by Slant Shear
C 1059-99	Specification for Latex Agents for Bonding Fresh to Hardened Concrete
C 1063-99	Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement–Based Plaster

C 1116-02	Specification for Fiber-Reinforced Concrete and Shotcrete
C 1141-01	Specification for Admixtures for Shotcrete
C 1157-02	Performance Specification for Hydraulic Cement
C 1324-02a	Test Method for Examination and Analysis of Hardened Masonry Mortar
C 1328-00	Specification for Plastic (Stucco) Cement
D 98-98	Specification for Calcium Chloride
D 4258-83(99)	Practice for Surface Cleaning Concrete for Coating
D 4259-88(99)	Practice for Abrading Concrete
D 4262-83(99)	Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
D 4263-83(99)	Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
E 119-00a	Standard Test Methods for Fire Tests of Building Construction and Materials

CSA STANDARDS - These standards are available from the Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Ontario, M9W 1R3, Canada, phone 416.747.4044 or via the Internet at: sales@csa.ca.

A5	Portland Cement
A8	Masonry Cement
A23.5	Supplementary Cementing Materials

APPENDIX B

GLOSSARY OF PLASTERING TERMS

Accelerator. An admixture that speeds the rate of hydration of hydraulic cement, shortens the normal time of setting, or increases the rate of hardening, of strength development, or both, of portland cement plaster.

Addition. A substance that is interground or blended in limited amounts into a hydraulic cement during manufacture—not at the job site—either as a processing addition to aid in manufacturing and handling the cement or as a functional addition to modify the useful properties of the cement. Improperly called additive.

Admixture. A material, other than water, aggregates, and hydraulic cement, used as an ingredient of plaster and added to the batch immediately before or during mixing.

Aggregate. A granular material such as natural sand, manufactured sand, vermiculite, or perlite.

Air-entraining capacity. The capability of a material or process to develop a system of minute bubbles of air in cement paste, mortar, or plaster during mixing.

Air-entraining agent. An addition for hydraulic cement or an admixture for plaster that will cause air to be incorporated in the form of minute bubbles in the plaster during mixing, usually to increase its workability and its frost resistance.

Air-entraining hydraulic cement. Hydraulic cement containing an air-entraining addition in an amount that will cause the cement to entrain air in plaster within specified limits.

Air entrainment. The intentional introduction of air in the form of minute, disconnected bubbles (generally smaller than 1 mm) during mixing of portland cement plaster to improve cohesion and workability or to impart other desired characteristics to the plaster.

Back plastering. Applying a backup coat (or coats) of plaster to the back side of a solid plaster partition after the scratch coat has been applied and has set on the lathed side.

Base coat. The total of all plaster coats applied prior to application of the finish coat. The combined scratch and brown coats are the base coat.

Batching. Weighing or volumetrically measuring and introducing into the mixer the ingredients for a batch of plaster.

Binders. Cementing materials, either hydrated cements or products of cement or lime and reactive siliceous materials; cement type and curing conditions govern the binder formed.

Bleeding. The accumulation of mixing water on the surface of plaster caused by compression of the solid materials within the mass. Bleed water occurs on the surface of a mass of plaster in a container or hopper, commonly influenced by vibration. (Also called water gain.)

Blended hydraulic cement. A binder produced by intimately and uniformly intergrinding or blending two or more types of fine materials, such as portland cement, ground granulated blast-furnace slag, fly ash, silica fume, calcined clay, other pozzolans, and hydrated lime.

Blistering. Protuberances on a coat of plaster during or soon after the finishing operation; also bulging of the finish plaster coat where it separates and expands away from the base coat.

Block. A concrete masonry unit, usually containing hollow cores.

Bond. Adhesion of plaster to other surfaces against which it is applied; adhesion of cement paste to aggregate; adhesion between plaster coats or between plaster and a substrate. (See "Chemical Bond" and "Mechanical Bond.")

Bondbreaker. A material used to prevent adhesion of newly placed plaster to a section of the substrate.

Bond strength. The adhesion developed between plaster and a substrate; the resistance to separation of plaster from other materials in contact with it.

Bonding agent. A compound applied as a coating to a suitable substrate to enhance a bond between it and a succeeding layer, as between a subsurface and a succeeding plaster application; also a compound used as an admixture to increase adhesion at the mortar-substrate interface and increase cohesion of the plaster.

Brown coat. The second coat of three-coat plastering.

Brown out. To complete application of a base coat.

Carbonation. Reaction between carbon dioxide and a hydroxide to form a carbonate, especially in cement paste or plaster; the reaction with calcium compounds that produces calcium carbonate.

Catface. Blemishes or rough depressions in finish plaster comparable to pockmarks.

Cement, hydraulic. Any cement, such as portland cement, that will set and harden by chemical interaction with water and that is capable of doing so underwater.

Cement paste. A mixture of hydraulic cement and water, both before and after setting and hardening.

Checking. Development of shallow cracks at closely spaced but irregular intervals in the plaster surface. (Also known as alligator cracking or craze cracks.)

Chemical bond. Adhesion between dissimilar materials or between one plaster coat and another that is the result of a chemical reaction.

Coat. A layer or film, as a thickness of plaster or of paint, applied in a single operation.

Cohesion. The ability of a material to cling to itself.

Consistency. The relative mobility or ability of freshly mixed plaster to flow.

Contact ceiling. A ceiling with metal lath attached in direct contact with the construction above without use of runner channels or furring.

Control joint (Contraction-expansion joint). A designated separation in the plaster system that allows for movement caused by expansion or contraction of the system. The construction of the separation is accomplished by installation of manufactured devices for this application, or by fabrication procedures in the field using suitable materials.

Corner reinforcement. Metal reinforcement for plaster used at corners to provide continuity between two intersecting plaster planes.

Corrosion. Disintegration or deterioration of metal reinforcement due to electrolysis or chemical attack.

Craze cracks. Fine, random cracks or fissures that may appear in a plaster surface, caused by shrinkage. (See “Checking.”)

Cross scratching. Scratching of the first coat in two directions to provide a mechanical bond between coats. Not recommended for portland cement plaster scratch coat.

Curing. Keeping freshly applied plaster moist and at a favorable temperature for a suitable period following application. Curing assures satisfactory hydration and carbonation of the cementitious materials and proper hardening of the plaster.

Curling. The distortion or warping of an essentially planar surface into a curved shape, due to several factors such as temperature and moisture differences within the plaster coat.

Dampproofing. Treatment of plaster to retard the passage or absorption of water, or water vapor, either by application of a suitable surface treatment on exposed surfaces or by use of a suitable admixture or treated cement.

Darby. A flat wooden or magnesium-alloy tool with handles used to dress or float brown-coat plaster.

Dash-bond coat. A thick slurry of portland cement and fine sand plus sufficient water that is dashed by hand or machine onto concrete, masonry, or older plaster surfaces to provide a mechanical bond for succeeding plaster.

Dash texture. A finish coat of thick plaster hand-dashed or machine applied onto a well prepared, uniformly plane surface of brown-coat plaster. (Also called spatter-dash.)

Discoloration. Change in color from the normal or desired.

Double-back. Application of second coat of plaster to scratch-coat plaster immediately after the scratch coat has attained sufficient rigidity to receive it. (Also called double-up.)

Durability. The ability of portland cement plaster to resist weathering action, chemical attack, abrasion, and other potentially harmful service conditions.

Earth pigments. The class of pigments produced by physical processing of materials mined directly from the earth; also frequently called natural or mineral pigments or colors.

Efflorescence. A deposit of salts or bases, usually white, formed on a surface. Water soluble substances emerge in solution from within the plaster and are deposited during evaporation.

Expanded metal lath. Sheets of metal that are slit and pulled out to form diamond-shaped openings; used as metal reinforcement for plaster.

Featheredge. A wood or metal tool with a beveled edge and varying in length; used to straighten reentrant angles in finish-coat plaster. Also used to plane the surface of the brown coat and dry rod or dry rake it to better control color in the finish coat.

Fine aggregate. Natural or manufactured sand that passes the No. 4 (4.75-mm) sieve.

Finish coat. The final coat of plaster, the decorative surface, usually colored and textured.

Float. A rectangular tool consisting of a handle attached to a base pad of molded rubber, foam plastic, cork, wood, or felt tacked to wood and used to impart a relatively even but still open texture to a plaster surface.

Gradation. The size distribution of aggregate particles, determined by separation with standard screen sieves.

Hairline cracks. Very fine cracks in either random or essentially straight line patterns that are just visible to the naked eye. (See “Checking.”)

Harsh mixture. A mixture that lacks desired consistency and workability due to a deficiency of cement paste, aggregate fines, sufficient water, or a combination thereof.

Hawk. A tool to hold and carry plaster from the board to the working face during hand-applied plastering.

Hydrated lime. The product manufactured by heating limestone until carbon dioxide is removed, thus forming quicklime (calcium and magnesium oxides), subsequently hydrated using water additions. Hydrated lime processing involves pressure hydration, atmospheric hydration, or slaking.

Hydraulic cement. See "Cement, hydraulic."

Map cracking. See "Craze cracks."

Mechanical bond. The physical keying of one plaster coat to a substrate or another coat; or plaster keying to metal lath; or interlock between adjacent plaster coats created by surface irregularities, such as scratching.

Metal lath. Metal lath is slit and expanded or stamp-punched from plain or galvanized steel coils or sheets. It is of two types: diamond mesh lath, which may be flat or self-furred with impressed indentations, and rib lath. Metal lath is coated with a rust-inhibiting paint after fabrication or is galvanized.

Moisture movement. The migration of moisture within and from a porous medium, caused by an imbalance as surface moisture is lost through evaporation.

Mortar. A mixture of hydraulic cement, water, fine aggregate, and possibly plasticizers.

Nozzle. Attachment at discharge end of delivery hose used for machine application of plaster. The nozzle allows adjustment of the spray pattern.

Nozzleman. Person who manipulates the nozzle and controls plaster placement.

Plaster thickness. See "Thickness, plaster."

Plasticity. A complex property of plaster involving flow of the plaster associated with an applied force; that property of freshly mixed plaster that determines its resistance to deformation or its ease of molding.

Plasticizer. An additive that increases the plasticity of a portland cement plaster. Plasticizing agents include hydrated lime or lime putty, air-entraining agents, organic additions and fine ground or processed inorganic substances.

Retardation. Slowing down the rate of hardening or setting of plaster to increase the plaster setting and hardening times.

Retempering. After initial mixing, adding water and remixing plaster that has started to stiffen and become harsh.

Rod. A straightedge used to straighten the face of walls and ceilings by cutting off excess plaster to a plane established by forms, ground wires, or screeds.

Sand. See "Fine aggregate."

Scarifier. A tool with flexible steel tines used to scratch or rake the unset surface of a first (scratch) coat of plaster.

Scoring. Grooving by scratching or scoring, usually horizontal, of the scratch coat to provide mechanical keys with the brown coat.

Scratch coat. First coat of plaster applied to a surface in two- or three-coat plastering work.

Self-furring. Metal lath or wire lath formed during manufacture to include raised portions of the lath, ribs, or dimples that hold the lath away from the supporting surface and position it for embedment with plaster.

Set. The change in plaster from a plastic, workable state to a solid, rigid state. Set is modified by the terms "initial" and "final," both arbitrary appraisals of degree of hardening.

Spatterdash. See "Dash texture."

Suction. The absorptive capacity of a substrate or plaster surface immediately after being subjected to application of water or plaster.

Thickness, plaster. Plaster thickness is measured from the back plane of metal reinforcement or from the face of solid backing or support to the specified plaster surface, either scratch, base, or finish.

Trowel. A flat, broad-blade steel hand tool used to apply, spread, shape, and smooth finish-coat plaster.

Warping. A deviation of a wall surface from its original shape, usually caused by temperature or moisture differentials within the plaster. Also caused by an excessively rich (high-strength) finish-coat plaster or by hard troweling to produce a smooth finish-coat surface. (See also "Curling.")

Wire mesh lath. Plaster reinforcement available in two types, woven wire and welded wire. Woven wire is made of galvanized wire woven or twisted to form either squares or hexagons. Welded wire is zinc coated and electrically welded at all intersections. Both types may be paper backed.

Workability. The property of freshly mixed plaster that determines its working characteristics, i.e., the ease with which it can be mixed, placed, and finished.

APPENDIX C

TOOLS FOR PLASTERING

Basic hand tools

Hawk IMG12612

Trowels: common, margin, pointing IMG12615, IMG12614, IMG12613

Angle float, angle paddle

Brushes: browning, finishing, tool IMG12618

Scarifier or scratcher IMG12619, IMG12620

Floats: cork, rubber, sponge rubber, foam plaster, carpet IMG12621

Half hatchet

Hand tools for advanced work

Elastic knife

Steel square

Six-foot folding rule

Spring-loaded (push-pull) steel tape measure

Handsaw

Chalkline, plumb bob, level

Tin snips

Nippers

Angle plane IMG12616

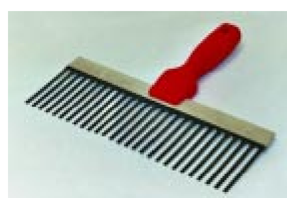
IMG12612

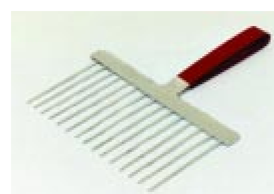
IMG12614

IMG12615

IMG12613

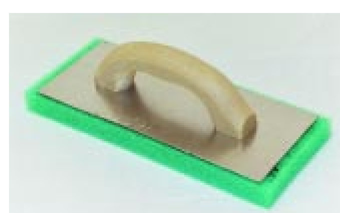
IMG12618





IMG12619 IMG12620

IMG12621



IMG12616

Specialized hand tools

Pool trowel

Midget trowel

Pipe trowel

Inside- and outside-corner trowel

Angle plow

Lathing hatchet

Steel tape

Cement-stucco dash brush IMG12617

Texture brushes; rice or stippling, wire texture

Rubber sponge IMG12623 (turtle-back sponges)

IMG12617

IMG12623

Ornamentation tools

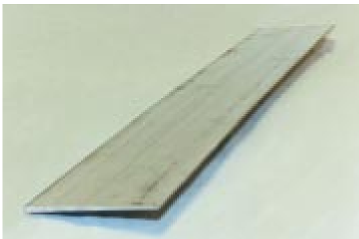
Trowel and square

Leaf and square

Miter rod or joint rod

Rubber gloves

Bevel square



IMG12624

Larger tools

Rod

Featheredge

Darby IMG12624 (wedge-shaped darby)

Slicker or shingle IMG12625 (magnesium slicker)

Scaffold

Water level

Stilts

IMG12625

Machine equipment

Plaster-mortar mixer

Plastering machine or plaster gun

Glitter gun, aggregate gun

Texturing machines

APPENDIX D

ACCESSORIES

Plaster accessories include beads, screeds, corner reinforcement, and control joint accessories.

Casing beads (plaster stops) are used to provide a finished edge around the perimeter of plaster (Fig. D-1).

Drip or weep screeds and vent screeds provide for moisture control or ventilation and help establish proper plaster thickness (Figs. D-2, D-3, and D-4). Some are available only in vinyl.

Corner reinforcement accessories are used to make straight corners (Fig. D-5) and may also provide a plaster ground (Figs. D-6 and D-7). Some of these are available in vinyl.

Control joint accessories are designed to permit movement between adjacent segments of plaster, thus relieving stress concentration and minimizing cracking. Sometimes termed "expansion joint," "control joint," or "expansion control joints" in manufacturers' literature, these accessories generally consist of expanded metal flanges with a double J-cross section or V- or M-shape bend in the middle (Figs. D-8, D-9, and D-10). In addition to one-piece control joint accessories, a two-piece accessory, a slip-joint expansion joint, is available that allows for two-dimensional movement across the joint (Fig. D-11). It is often used to join different types of construction.

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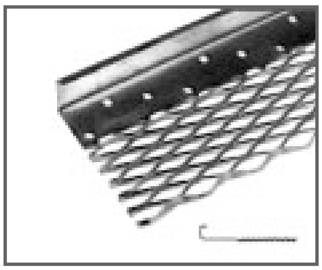
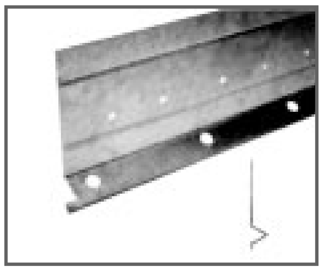
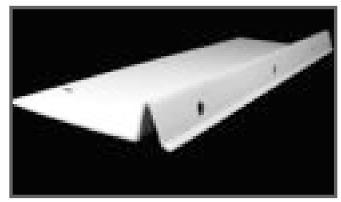


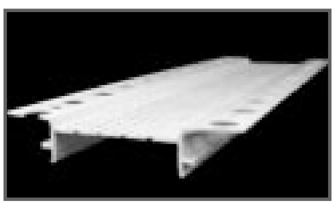
D-1 Casing Bead or Plaster Stop



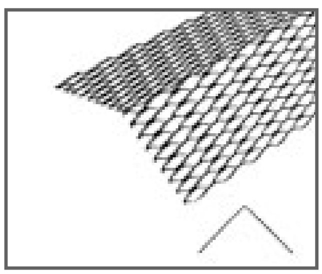
D-2 Foundation Weep Screed



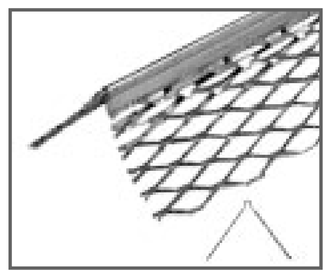
D-3 Foundation Weep Screed Vinyl



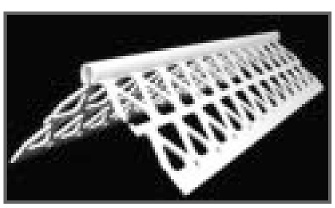
D-4 Soffit Screed (vinyl only)



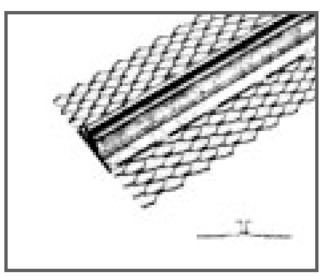
D-5 Corner Lath



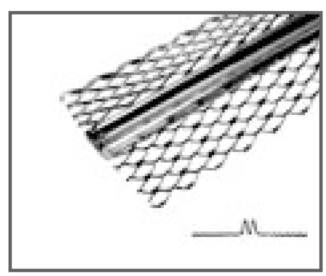
D-6 Corner Bead



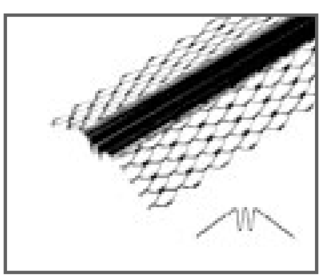
D-7 Corner Bead Vinyl



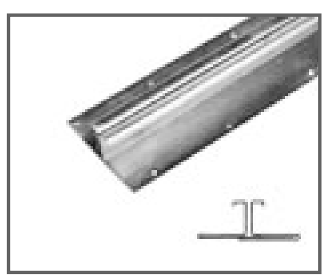
D-8 Expansion Control Joint "J"



D-9 Expansion Control Joint "M" or "VV"



D-10 Inside Corner Expansion



D-11 2-Piece Expansion Joint Slip Joint

APPENDIX E

Guide Specification

SECTION 09220

CEMENT PLASTER

PART 1 – GENERAL

1.01 RELATED SECTIONS

A. Section 03300 – Concrete

B. Section 04220 – Concrete Unit Masonry

C. Section 06110 – Wood Framing

D. Section 09205 – Metal Lath

1.02 REFERENCES

A. Building Code:

B. ASTM C 91-__ [19__ UBC Standard 21-11] - Masonry Cement

C. ASTM C 150-___ [19___ UBC Standard 19-1] - Portland Cement

D. ASTM C 206-___ - Finishing Hydrated Lime

E. ASTM C 207-___ [19___ UBC Standard 21-13] - Hydrated Lime for Masonry Mortar

F. ASTM C 595-___ [19___ UBC Standard 19-1] - Blended Hydraulic Cements

G. ASTM C 780-___ - Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

H. ASTM C 897-___ - Aggregates for Job Mixed Portland Cement-Based Plaster

I. ASTM C 926-___ - Application of Portland Cement-Based Plaster

J. ASTM C 932-___ - Surface-Applied Bonding Agents for Exterior Plastering

K. ASTM C 979-___ - Pigments for Integrally Colored Concrete

L. ASTM C 1116-___ - Fiber-Reinforced Concrete and Shotcrete

M. ASTM C 1157-___ - Performance Specification for Hydraulic Cement

N. ASTM C 1328-___ [19___ UBC Standard 25-1] - Plastic Cement

Notes to Specifier

This guide specification serves as a basis for the development of an office master specification or the preparation of a specification for a particular project. This document should be edited to remove provisions considered non-germane to the specific project.

1.01 Coordinate section numbers and titles with remainder of project specifications.

1.01.B Check that open textured units and cut flush mortar joints are specified in Section 04220 where concrete masonry surfaces are intended to receive plaster.

1.01.C Check that a 1/8-in. (3-mm) space is specified between the edges of adjacent plywood sheathing.

1.01.D Check that appropriate metal plaster base, building paper, and accessories are specified in accordance with ASTM C 1063 and applicable building codes.

1.02.A Specify applicable building code by name and date.

1.02.B - 1.02.M The applicable date for each reference should be given here or in Section 01090-REFERENCE STANDARDS. Alternate standards are given for specifications written for Uniform Building Code regions. Delete or add references as needed to be consistent with remainder of 09220.

1.03 SUBMITTALS

A. Certification of compliance of materials with product specifications.

B. Manufacturer's written specifications, proportion mixes, and installation instructions for factory-prepared finish materials.

C. Evidence of applicator's experience including project identification with names of Owner and Architect/Engineer.

1.03.C Delete if project size does not require such qualifications.

D. Samples of colored finish-coat plaster containing coloring compound and specific aggregate to be used during plastering.

1.03.D Delete if factory-prepared finish-coat plaster mixes will be used.

E. Preconstruction test results.

1.03.E Delete unless testing is required. If testing is required, select paragraph E to correspond with testing requirements given in 1.04.D and 3.05.B.

OR

E. Preconstruction and construction test results.

1.04 QUALITY ASSURANCE

A. Fire resistance ratings: __________.

1.04.A Indicate requirements for fire resistance rating for type of construction in hours if applicable.

B. Applicator Qualifications: Application of cement plaster on at least three projects equal in scope to this Work.

1.04.B Delete when project size does not require such qualifications.

C. Sample Panel

1. Size: 4 ft × 8 ft (1.2 m × 2.4 m).
2. Construct panel using subbase, base, lathing & furring, accessories, plaster coats, color, and finish texture representative of that required on the project.
3. Panel will be reviewed for proper construction, color, texture, and workmanship.
4. Do not proceed with work until sample plaster panel is approved by Owner and Architect/Engineer.
5. Maintain sample panel on site for duration of project for comparison purposes.
6. Remove sample panel from site when directed by Architect/Engineer.

D. Preconstruction Testing

1.04.D Delete if testing is not required.

1. Perform tests on plaster mix in accordance with ASTM C 780 for __________.

1.04.D.1 Indicate property to be evaluated. Coordinate with 1.03.E and 3.05.B.

2. Admixtures: Test laboratory-prepared plaster combinations containing admixtures and non-admixtured counterparts for __________.

1.04.D.2 Discourage use of admixtures unless plaster demonstrates improved properties when laboratory tested and during application. Define the properties to be evaluated.

3. Preconstruction testing will be used as basis for comparison with construction testing.

1.04.D.3 Delete if construction testing is not required.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver manufactured materials in original unopened packages or containers, fully identified with manufacturer's label intact and legible.

B. Keep cement and lime dry, stored above ground, under cover and away from damp surfaces.

C. Remove wet or deteriorated materials from project site.

1.06 JOB CONDITIONS

A. Cold Weather Requirements

1. Exterior plaster work: Do not apply cement plaster when ambient temperature is less than 40°F (4°C).

1.06.A.1 Delete if no exterior work.

OR

1. Exterior plaster work: When ambient temperature is less than 40°F (4°C), heat sand and mixing water to minimum of 70°F (21°C) and provide temporary protection and heat in plastered area for 24 hours.

1.06.A.1 Method of temporary protection and heat is option of Contractor.

2. Interior plaster work: Do not apply cement plaster unless minimum temperature of 50°F (10°C) has been and continues to be maintained in building for minimum 48 hours prior to plaster application, during setting and hardening, and thereafter.

B. Ventilation

1.06.B Delete if only exterior work.

1. Provide ventilation for drying of installed cement plaster.
2. Cover all wall openings with plastic film when building is subject to hot, dry winds or day-to-night temperature differentials are more than 20°F (10°C).

1.06.B.2 For unglazed buildings.

C. Protection

1. Protect adjacent finished surfaces, installed prior to plastering, by covering with plastic sheets, non-staining Kraft paper, removable type masking tape, non-staining petroleum jelly, or other appropriate means.
2. Maintain protection in place until completion of plastering.

PART 2 - PRODUCTS

2.01 MATERIALS

2.01 Coordinate materials selection with 2.02.B on mix proportions.

A. Cement

2.01.A Check availability of cements. Combinations of cements should be allowed. Refer to ASTM C 926. List only the cements relevant to this project.

1. Portland cement: ASTM C 150 Type ___; ASTM C 1157 Type ___; CSA A5 Type ___

2.01.A.1 Enter Type [I], [IA], [II], [IIA], [III], or [IIIA]; [GU], [HE], [MS], [HS], or [MH]; [10], [20], [30], [50]. Can be used with masonry cement, plastic cement, or lime.

2. Blended cement: ASTM C 595 Type ___; ASTM C 1157 Type ___

2.01.A.2 Enter Type [IP], [IP(M)], [IS], [IS(M)]; or their air-entrained counterparts [IP-A], [IP(M)-A], [IS-A], and [IS(M)-A]; [GU], [HE], [MS], [HS], or [MH]. Can be used with masonry cement, plastic cement, or lime.

3. Masonry cement: ASTM C 91 Type ___; CSA A8 Type ___

2.01.A.3 Enter Type [M], [S], or [N], White [M, S, N]; [N], [S], White [N, S]. Can be used alone or with portland cement.

4. Plastic cement: ASTM C 1328, Type ___: [UBC Standard 25-1]

2.01.A.4 Enter Type [M] or [S] for ASTM C 1328. No type designation is required for UBC Standard 25-1. Primarily available in southwest and west coast states. Available as plastic cement or gun plastic cement.

5. White portland cement: Conform to ASTM C 150 Type ___.

2.01.A.5 Enter Type [I], [II], [III], [IA], [IIA] or [IIIA]. Less commonly available in Type II. Can be used alone, with masonry cement, or with lime for finish coat.

6. Colored masonry cement: Conform to ASTM C 91 Type ___, Color.

2.01.A.6 Enter Type [M], [S], or [N]. Designate color. Can be used alone or with portland cement for finish coat.

B. Hydrated Lime

2.01.B Can be used only with portland cement or blended cement.

1. Finishing hydrated lime: ASTM C 206 Type S.

** OR **

1. Hydrated lime for masonry purposes: ASTM C 207 Type ___.

2.01.B.1 Enter Type [S] or [SA] for ASTM C 207. Type SA indicates air-entrained hydrated lime. Require preconstruction testing of plaster mixture for air content when two air-entraining materials are combined.

C. Aggregate

1. Base coats: ASTM C 897, natural or manufactured sand.
2. Finish coat: Natural or manufactured sand graded to pass the No. 16 (1.18 mm) mesh sieve, light colored.

2.01.C.2 Delete "light colored sand" when not required. Delete if finish coat is to be factory prepared. Change if special texture requires different gradation.

D. Water: Potable and free from impurities.

E. Admixtures

2.01.E Delete if none required. Discourage indiscriminate use of admixtures.

1. Fibers: _____ in. (mm) _____ fibers meeting the requirements of ASTM C 1116.

2.01.E.1 Indicate length and identify kind of fiber.

2. Bonding compound: __________ as manufactured by ____________.

2.01.E.2 Indicate by brand name and manufacturer. Use only non re-emulsifiable bonding compounds.

3. Other: _________ as manufactured by _________ to provide ________.

2.01.E.3 Indicate by brand name, manufacturer, and purpose for including admixture. Testing to confirm enhancement of desired property is recommended.

F. Surface-applied bonding compound: ASTM C 932, non-oxidizing, non-crystallizing, non re-emulsifiable compound.

2.01.F Delete if not required.

G. Coloring compounds

2.01.G Delete if coloring compound admixture is not required. Delete if colored masonry cement or colored factory-prepared finish-coat mixture is required.

1. ASTM C 979 mineral oxide pigment _________ as manufactured by __________.

2.01.G.1 Identify color compound brand name, color code, and manufacturer.

2. Use coloring compound as prepared by factory certifying compliance to product standard and demonstrating no effect on setting and hardening of plaster mixture when used within recommended dosage range. Do not use carbon black or lampblack or organic pigments.

H. Factory-Prepared Finish Coat

2.01.H Delete if factory-prepared finish-coat mixture is not required.

1. Factory-prepared mixture produced by _________, under the product designation of __________.

2.01.H.1 Indicate producer's name and identification of mixture required.

2. Color: ________________.

2.01.H.2 Specify color required.

3. Texture:________________.

2.01.H.3 Specify texture required.

2.02 MIXES

A. Mixing

1. General

a. Size mixer to produce batches that will be applied within maximum of 1½ hours after mixing.

b. Accurately proportion materials for initial plaster mixture using measuring devices of known volume. Shovelsful of sand can be used after mixer is calibrated with known volumes of materials, including water.

c. Use damp, loose sand.

d. Add pigments or other specified admixtures to batch in accordance with manufacturer's recommendations.

e. Retempering of base-coat cement plaster is permitted one time only after initial mixing. Plaster not used within 1½ hours of initial mixing shall be discarded.

f. Retempering of finish-coat cement plaster is not permitted.

2. Mechanical mixing

a. Mix each batch separately; double batching with single batch discharge shall not be permitted.

b. Maintain mixer in clean condition before, during, and after plaster preparation. Remove partially set and hardened plaster from mixer drum before next batch. If mixer has been previously used in preparing gypsum plaster, thoroughly clean prior to use to prepare cement plaster.

c. Maintain mixer in continuous operation while charging mixer. Add water to bring plaster to desired consistency. Continue mixing for 3 to 5 minutes after all ingredients have been added to the mixer.

d. Mix factory-prepared finish-coat plaster in accordance with manufacturer's recommendations.

3. Hand mixing

2.02.A.3 Mechanical mixing is preferred since it usually results in more uniformly mixed batches.

a. Hand mixing shall be allowed only when authorized by Architect/Engineer.

b. Provide waterproof protection around mixing tub and water barrels when mixing inside the building.

B. Mix Proportions

1. Dash-bond coat: 1 part of portland cement and maximum 2 parts of sand, proportioned by volume.

2.02.B.1 Delete if no dash-bond coat is required. A dash-bond coat is used to improve bond between plaster and dense, low-absorption surfaces such as concrete.

2. Base coat(s):

2.02.B.2 Specify base-coat plaster by reference standard and plaster mix designation only (first option) or by reference standard, plaster mix designation, and definition of proportions for each base coat (second option). Delete other paragraph.

a. ASTM C 926 Plaster Mix __________.

2.02.B.2.a Indicate appropriate plaster mix symbol(s) [C], [CL], [M], [CM], [MS], [P], or [CP]. Mix selection is dependent upon materials available, base material, and exposure conditions in service. Coordinate plaster mix designation(s) and 2.01 on materials.

OR

a. ASTM C 926 Plaster Mix __________. Proportion base coats by volume as follows:

(1) Proportion scratch-coat cement plaster to contain the following volumes of plaster materials:

___ volume part of blended cement, Type ___;

___ volume part of portland cement, Type ___;

___ volume part of masonry cement, Type___;

___ volume part of plastic cement, Type ___;

___ volume part of lime, Type ___; and

___ to ___ total volume parts of sand.

2.02.B.2.a Indicate appropriate plaster mix symbol(s) [C], [CL], [M], [CM], [MS], [P], or [CP]. Mix selection is dependent upon materials available, base material, and exposure conditions in service. Coordinate plaster mix designation(s) and 2.01 on materials.

2.02.B.2.a(1) Indicate plaster mix proportions consistent with selected plaster mix symbol(s). When defining proportions, delete unused cementitious materials. Note that ASTM C 926 defines the proportion of aggregate as a ratio relative to the sum of the separate volumes of the cementitious materials rather than as total volume parts of sand as indicated here. For example, a plaster Mix CM having an ASTM C 926 aggregate ratio of 3 parts sand per sum of the separate volumes of cementitious materials would be proportioned to have 1 part portland cement, 1 part masonry cement, and 6 total volume parts sand.

(2) Proportion brown-coat cement plaster to contain the same proportions of cementitious materials as indicated for scratch-coat cement plaster, except provide ___ to ___ total volume parts of sand.

2.02.B.2.a(2) Delete for two-coat applications. Brown-coat plaster should have a greater volume of sand than the scratch-coat mix.

b. Add __________ fiber to the __________ coat cement plaster at the addition rate of ____ lb (kg) per 94 lb (42.6 kg) cement.

2.02.B.2.b. Delete if not required. Otherwise, identify fiber as defined in 2.01.E.1; indicate whether it is to be added to scratch coat, brown coat, or both; and indicate addition rate.

c. Add __________ admixture to base-coat cement plaster at the addition rate of __________.

2.02.B.2.c. Delete if not required. Otherwise, indicate addition rate for admixture of type defined in 2.01.E.2 or 2.01E.3.

3. Finish coat

2.02.B.3 Specify factory-prepared finish-coat plaster; site-prepared finish-coat plaster by reference standard and plaster mix designation only; or site-prepared finish-coat plaster by reference standard, plaster mix designation, and definition of proportions. Delete other paragraphs.

a. Factory prepared: Proportion factory-prepared mixture produced by ___________________, under the product designation of ______________with water as recommended by manufacturer.

2.02.B.3.a Indicate producer's name and identification of mixture as given in 2.01.H.1.

OR

a. Site prepared: ASTM C 926 Plaster Mix ________.

2.02.B.3.a Indicate appropriate plaster mix symbol(s) [F], [FL], [FM], [FCM], [FMS], or [FP], basing selection on materials available, base-coat selection, desired appearance, and exposure conditions in service. Coordinate plaster mix designation(s) and 2.01 on materials.

OR

a. Site prepared: ASTM C 926 Plaster Mix ________. Proportion finish-coat cement plaster to contain the following volumes of plaster materials:

___ volume part of cement, Type ___, Color _____;

___ volume part of lime, Type ___;

___ volume part of masonry cement, Type ___, Color _____;

___ volume part of plastic cement Type ___; and

___ to ___ total volume parts of sand.

b. Add pre-weighed quantities of ______________ mineral oxide pigment at a dosage rate of ___ lb (kg) per bag of cement or as established by accepted color sample, but not to exceed 10% by weight of cement.

2.02.B.3.b Delete if not required. Identify color compound brand name, color code, manufacturer, and addition rate.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that bases to receive plaster conform to the requirements of ASTM C 926.

B. Verify that areas and conditions under which work is to be performed permit proper and timely completion of the work.

C. Notify Architect/Engineer in writing if conditions are not acceptable.

3.02 PREPARATION

A. Wet high-suction solid bases with fine water spray to produce a uniformly damp surface.

3.02. A Delete if not applicable to project.

B. Apply dash coat of cement plaster to solid base and moist cure for a minimum of 24 hours before applying first coat of cement plaster.

3.02.B Delete if not applicable.

OR

B. Apply bonding agent directly to concrete surface as recommended by bonding agent manufacturer's instructions.

C. Install building paper and metal base in accordance with Section 09205.

3.02.C Building paper and metal base are required over metal and wood frame construction, and may be used over solid bases. Specify installation of building paper and metal base in Section 09205 in accordance with ASTM C 1063 and applicable building codes.

3.03 APPLICATION

A. Apply individual coats of cement plaster using ______ application to achieve the required thickness.

3.03.A Indicate application procedure: [hand]; [machine]; or [both hand and machine].

B. Apply cement plaster with interruptions occurring only at junctures of plaster planes, at openings, or at control joints.

C. Install movement joints in accordance with drawings.

D. Install plaster over metal base in accordance with the requirements of ASTM C 926 for the application of cement plaster on metal plaster bases.

3.03.D Select applicable paragraph(s). When plaster is installed over metal base, check that: 1) building paper, flashing, accessories, and metal lath are specified in Section 09205; 2) requirements for installation of these materials are specified in Section 09205; and 3) location of control joints is shown on drawings.

OR

D. Install plaster in accordance with the requirements of ASTM C 926 for the application of three-coat cement plaster on solid bases.

OR

D. Install plaster in accordance with the requirements of ASTM C 926 for the application of two-coat cement plaster on solid bases.

E. For interior plaster, delay application of brown coat a minimum of ____ hours after completion of the scratch coat.

3.03.E Delete for interior two-coat plaster applications. Refer to applicable building code and industry guides for recommendations on delay period between scratch and brown coat.

F. For exterior plaster, delay application of brown coat until scratch coat has attained sufficient rigidity to resist cracking or other physical damage when the next coat is applied.

3.03.F Delete for two-coat plaster applications. This wording permits the "double-back" application often currently used. As an alternative, specify minimum time delay between coats indicated by paragraph below.

OR

F. For exterior plaster, delay application of brown coat a minimum of ____ hours after completion of the scratch coat.

3.03.F Delete for exterior two-coat plaster applications. Refer to applicable building code and industry guides for recommendations on delay period between scratch and brown coat.

G. Rod the base coat, which is to receive finish-coat plaster, to a true, even plane, and fill any defects in plane with plaster.

H. Float the base coat which is to receive finish-coat plaster to provide a surface texture that is receptive to the application of the finish coat.

I. Tool through second and finish coats of cement plaster to produce a "V" joint at intersection of frames or other items of metal or wood that serve as plaster grounds.

J. Delay application of finish coat a minimum of ____ days after completion of the base coat.

3.03.J Refer to applicable building code, industry guides, and finish-coat manufacturer's literature for recommendations on delay period between base coats and finish coat.

K. Curing

1. When ambient relative humidity will be below 75% during non-work hours, moist cure the set and hardened base-coat plaster at the end of the workday by spraying a fine mist of water over the entire surface. Repeat application of a fine mist of water morning and evening until plaster has been in place ___ hours. Alternatively, coverage of the base-coat plaster with plastic membrane until application of subsequent coat or finish-coat plaster is permitted.

3.03.K.1 Consider applicable codes, industry guides, and anticipated climatic conditions to determine moist curing period. Recommended minimum moist curing times generally range from 24 to 48 hours.

2. When ambient relative humidity will be above 75% during non-work hours, neither water spraying nor coverage with plastic membrane is required.

L. Finish Coats

1. Apply finish-coat plaster to a minimum thickness of ⅛ in. (3 mm).

2. ______ finish to a true and even surface when moisture content of plaster is reduced to proper level for finishing.

3.03.L.2 Enter finish desired: [trowel]; [float]; [___].

** OR **

1. Apply plaster finish coats in number of coats and consistency necessary to achieve required texture.

2. Texture finish coat to match accepted sample.

** OR **

1. Two-coat finish

a. __________ first coat and texture to match accepted sample.

3.03.L.1.a Enter option desired: [machine apply]; [broom dash by hand]; [___].

b. __________ second coat to obtain uniformity of color and texture to match accepted sample.

3.03.L.1.b Enter option desired: [machine apply]; [broom dash by hand]; [___].

c. Complete both coats the same day with second coat applied as soon as first coat is firm.

3.04 TOLERANCE

Complete plaster work such that the deviation from true plane (exclusive of texture) is no greater than ⅛ in. (3 mm) as measured from line of a 10-ft (3.5-m) straightedge placed at any location on surface.

3.05 FIELD QUALITY CONTROL

3.05 Delete if not required.

A. Inspection: The inspection agency will:

3.05.A Delete if not required. The level of inspection may vary depending on project complexity and owner requirements.

1. Confirm and document that bases to receive plaster meet requirements of ASTM C 926 prior to application of plaster.
2. Confirm and document that materials used in base-coat and finish-coat plaster meet the requirements of 2.01 of this Section.
3. Confirm and document, _______________, that plaster proportioning and mixing procedures are in accordance with 2.02 of this Section.

3.05.A.3 Indicate frequency of inspection (twice per day, daily, first batch mixed, etc.).

4. Confirm and document, _______________, that preparation of bases and application of plaster are in accordance with 3.02 and 3.03 of this Section.

3.05.A.4 Indicate frequency of inspection (twice per day, daily, prior to and during first day of plaster application, etc.).

B. Testing

3.05.B Delete if not required.

1. The testing agency will perform tests on plaster mix in accordance with ASTM C 780 for ____________.

3.05.B.1 Indicate property to be evaluated. See 1.03.E and 1.04.D.

2. Test every ___________.

3.05.B.2 Indicate testing frequency either per unit of time or per area of construction.

3.06 ADJUST AND CLEAN

A. Patching

1. Point-up plaster around trim and other locations where plaster abuts dissimilar materials.
2. Remove defective and damaged plaster by cutting it out.
3. Remove by cutting out stained and discolored finish-coat plaster scheduled to remain natural and unpainted.
4. Replace removed plaster using plaster with same composition and brought to desired texture and color consistent with surrounding area.

B. Cleaning

1. Remove protective materials masking adjacent surfaces.
2. Remove stains that affect uniformity of plaster finish.
3. Use cleaning methods approved in advance by the Architect/Engineer.

C. Color Uniformity

To correct non-uniform color throughout the field of the plaster, fog coat spray entire finish-coat surface. Fog coats shall consist of finish-coat materials, except aggregate, spray applied to entire finish-coat surface on discolored elevations identified by the Architect/Engineer.

APPENDIX F - TEXTURES

The versatility and beauty of plaster is enhanced by the variety of colors and textures that can be utilized. The plasterer achieves the desired texture by selecting the size and shape of aggregate, the consistency of the finish mix, the equipment and tools employed to apply the plaster, and subsequent treatment of the plaster surface. The possibilities are limited only by the imagination and skill of the craftsman.

The following pages contain examples of several different colors and textures along with brief descriptions of the techniques used to achieve them. The photos and descriptions are provided courtesy of BNI Building News of Los Angeles, California. The identification of texture and the description of application techniques listed herein may differ from that used by craftsmen in various localities. Therefore, selection of finish color and texture should be made on the basis of examination of suitably sized sample panels using the same base, plaster mixes, and application techniques as proposed for use on the project. The approved sample panel should be maintained on site for reference during construction and until the finished work is accepted.

LIGHT DASH

Suggested Application Procedures

1. Apply a first dash coat to produce complete color coverage.
2. Apply a second dash coat for texture depth and uniformity when first coat is dry, using a plaster mix of thinner consistency.
3. Use proportionately more atomizing air at the gun nozzle.

MEDIUM DASH

Suggested Application Procedures

1. Apply a first dash coat to produce complete color coverage.
2. Apply a second dash coat for texture depth and uniformity when first coat is dry.
3. Use a medium amount of atomizing air at the gun nozzle.

KNOCKDOWN DASH

Suggested Application Procedures

1. Apply first dash coat in thin consistency to produce complete color coverage.
2. Apply a coarse second dash coat for texture depth and uniformity, allowing some of first coat to show through.
3. Trowel lightly after moisture leaves surface.

MONTEREY

Suggested Application Procedures

1. Trowel on a first coat, leaving relatively smooth.
2. Apply second coat in a random texture, using overlapping strokes of the trowel.

HEAVY DASH

Suggested Application Procedures

1. Apply a first dash coat to produce complete color coverage.
2. Apply a second dash coat for texture depth and uniformity when first coat is dry, mortar to be of a relatively stiff consistency.
3. Use relatively less atomizing air at the gun nozzle and lower water ratio of the plaster.

TUNNEL DASH

Suggested Application Procedures

1. Apply a first dash coat to produce complete color coverage.
2. When surface moisture leaves—or on second day—apply a second heavy texture coat.
3. Use low atomizing air and reduce water ratio of the plaster.

LIGHT LACE

Suggested Application Procedures

1. Trowel, float, or dash on a first coat to completely cover base.
2. When surface moisture leaves, trowel-apply light second coat in random directions.
3. Knock down surface lightly with trowel.

HEAVY LACE

Suggested Application Procedures

1. Trowel, float, or dash on a first coat to completely cover base.
2. When surface moisture leaves, trowel-apply second coat in random directions.

FINE SAND FLOAT

Suggested Application Procedures

1. Trowel on a finish coat and double back with a second application. Plaster mix is to be formulated with a 30-mesh (600 µm) aggregate or a blend of 20-30 (850 µm-600 µm).
2. Using circular motion, rub surface with float to achieve uniform pattern, bringing sand particles to surface. An absolute minimum of water should be used in floating.

MEDIUM SAND FLOAT

Suggested Application Procedures

1. Trowel on a finish coat and double back with a second application. Plaster mix is to be formulated with a 20-mesh (850 µm) aggregate.
2. Using circular motion, rub surface with float to achieve uniform pattern, bringing sand particles to surface. An absolute minimum of water should be used in floating.

HEAVY SAND FLOAT

Suggested Application Procedures

1. Trowel on a finish coat and double back with a second application. Plaster mix is to be made with coarse aggregate or relatively coarse blend.
2. Using circular motion, rub surface with float to achieve uniform pattern, bringing sand particles to surface. An absolute minimum of water should be used in floating.

SCRAPED

Suggested Application Procedures

1. Apply finish coat approximately ¼ in. (6 mm) thick and allow to take up until surface moisture leaves.
2. Scrape vertically with a steel joint rod or trowel held at right angles to the plane of the wall. Remove sufficient material to leave a torn surface, free from smooth spots and joinings.

ROCK ’N ROLL
Suggested Application Procedures
1. Trowel on a first coat to completely cover base coat.
2. Apply a second coat of a specially prepared finish plaster containing selected size pebbles to achieve desired texture.
3. The action of the trowel or float rolls the pebbles to create miniature troughs in a linear or circular pattern.

GLACIER
Suggested Application Procedures
1 Trowel on a first coat to completely cover base.
2. Float the surface to raise the aggregate.
3. Trowel on a light texture coat over the floated surface.

COMBED
Suggested Application Procedures
1. Apply finish coat in sufficient thickness to accommodate depth of grooves without exposing base (brown) coat.
2. Rod and darby, leaving surface reasonably straight and true.
3. Using a strip as a guide, comb surface vertically (or horizontally) with a template, formed to achieve pattern detailed on drawings.
   Note: Special mix required.

DEEP RELIEF
Suggested Application Procedures
1. Trowel on a heavy texture coat.
2. After surface moisture is absorbed, apply heavy second coat, leaving it rough under the trowel.

FRIEZE

Suggested Application Procedures

1. Trowel on a first coat using double-back method, and rake with a coarse brush or broom.
2. Splatter dash sparingly with dash broom, using mortar of fairly stiff consistency to partially cover the surface.
3. After moisture leaves surface, trowel down high spots, retaining general pattern of dash texture.

ENGLISH

Suggested Application Procedures

1. Trowel on a first coat to completely cover base.
2. Using a rounded trowel, apply a thick texture coat with short strokes in varying directions, leaving a rough, irregular pattern.

TROWEL SWEEP

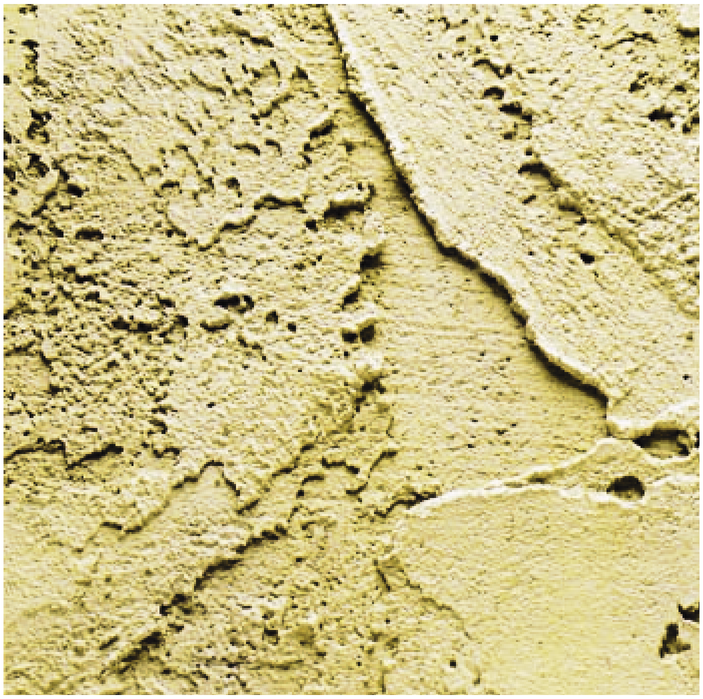
Suggested Application Procedures

1. Trowel on a first coat to completely cover base.
2. Apply a second coat with fan-shaped strokes, lapping each other so as to form narrow, high ridges where mortar flows over the toe of the trowel.

WEB

Suggested Application Procedures

1. Trowel on a first coat and broom lightly in varying directions, using a sweeping motion.
2. Using a trowel, apply a texture coat in strips approximately 2 in. x 6 in. (50 mm x 150 mm), forming a more or less rectangular pattern.
3. Trowel surface lightly.



SPANISH

Suggested Application Procedures

1. Trowel on a first coat, leaving relatively smooth.
2. Apply a second coat in random texture, using overlapping strokes of the trowel.

CALIFORNIA

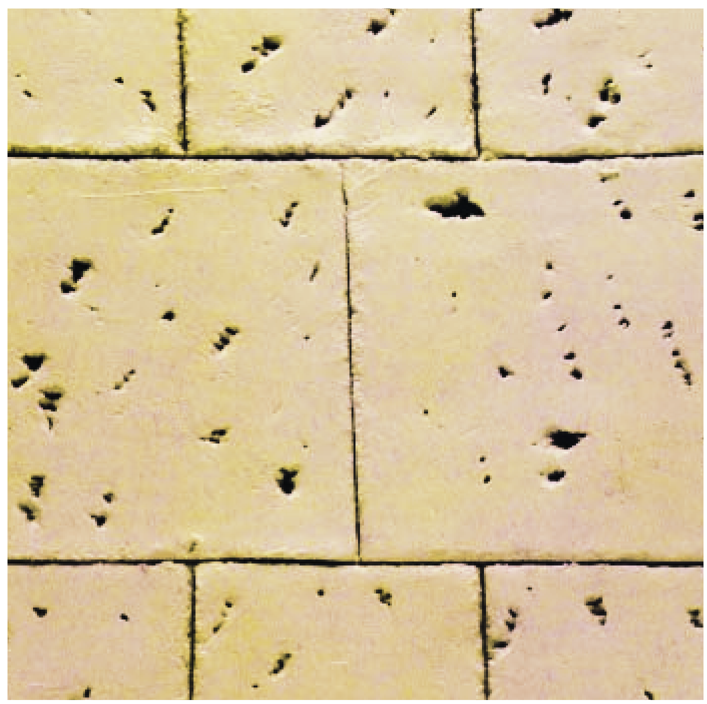
Suggested Application Procedures

1. Trowel on a first coat to completely cover base.
2. Apply a thin texture coat with trowel in a random pattern, overlapping strokes.
3. Flatten higher areas with a trowel.

ARIZONA

Suggested Application Procedures

1. Trowel on a heavy texture coat.
2. After surface moisture is absorbed, apply heavy second coat, leaving it rough under the trowel with small area texture pats.



TRAVERTINE

Suggested Application Procedures

1. Apply travertine finish coat ¼ in. to ⅜ in. (6 mm to 9.5 mm) thick over damp base.
2. Rod and darby.
3. Lay out travertine design as shown on drawings. To simulate joints, stamp in lines with a joint rod or rake out with raking tool.
4. With spring steel or a wire brush, pick out small portions of surface to imitate indentations of travertine stone.
5. Water-trowel smooth, retaining indentations.

BRIAR

Suggested Application Procedures

1. Trowel on first coat to completely cover base.
2. Apply a texture coat, holding trowel at angle to surface. With heel of trowel serving as a pivot point, produce fanlike ridges in radiating pattern.
3. Flatten higher areas with trowel.

BRICK

Suggested Application Procedures

1. Trowel on a first coat of mortar-colored joint material.
2. Trowel on a second coat of brick-colored stucco material.
3. Comb or broom the surface with a coarse fiber brush or broom to achieve desired grain. A light troweled texture may also be applied.
4. Using brick template or straightedge, rake joints to depth required to expose mortar joint material.

MARBLECRETE

Suggested Application Procedures

1. Apply bedding coat to proper thickness.
2. Straighten with rod and darby, leaving surface reasonably smooth.
3. Apply aggregate to bedding coat.

SIMULATED TIMBER

Suggested Application Procedures

1. Spread finish-coat plaster to desired panel texture.
2. Lay on a narrow band (e.g., 6 in. to 8 in. [150 mm to 200 mm] wide) of same material in pattern of half-timber.
3. Cut shallow groove on each side of simulated timber.
4. Lightly trowel face of simulated timber to relatively smooth surface.
5. If peg marks are desired, lightly press large screw head near end of simulated timber.

PCA
Portland Cement Association

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