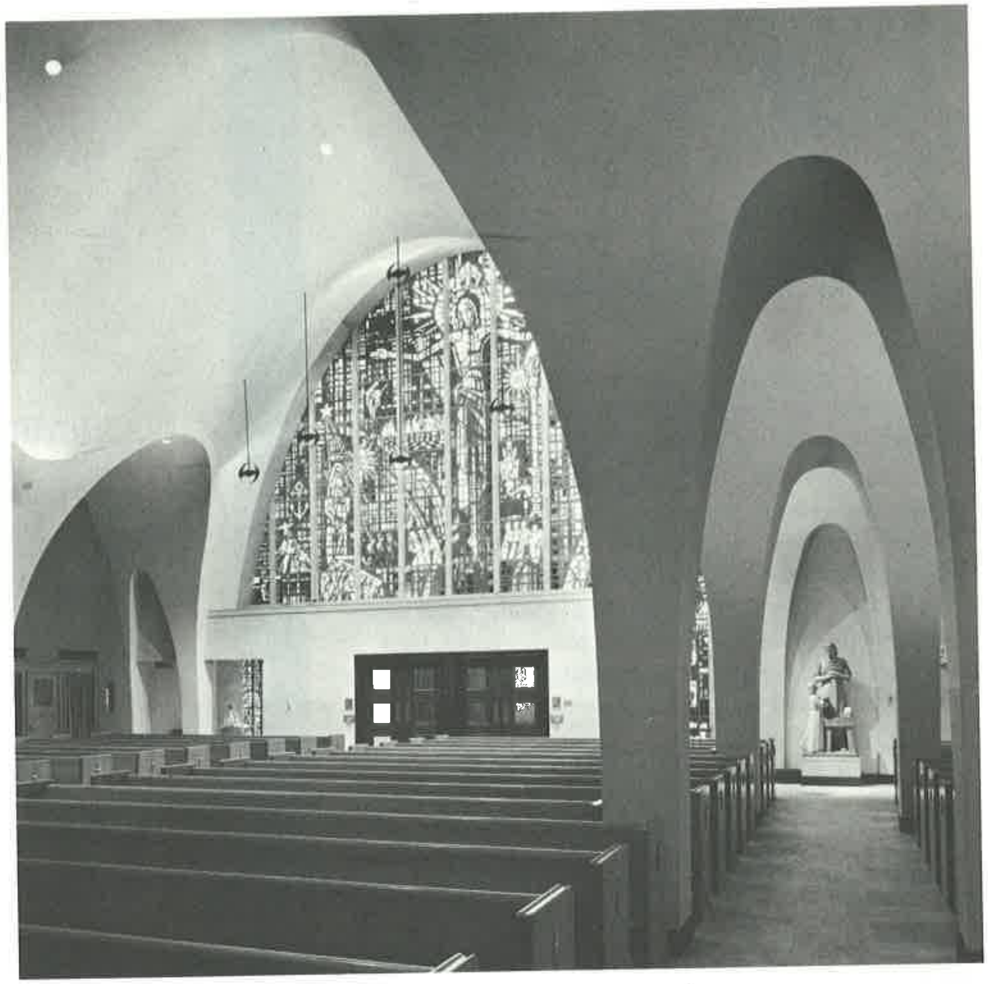

MANUAL OF GYPSUM

LATHING & PLASTERING

(GA 101-72)

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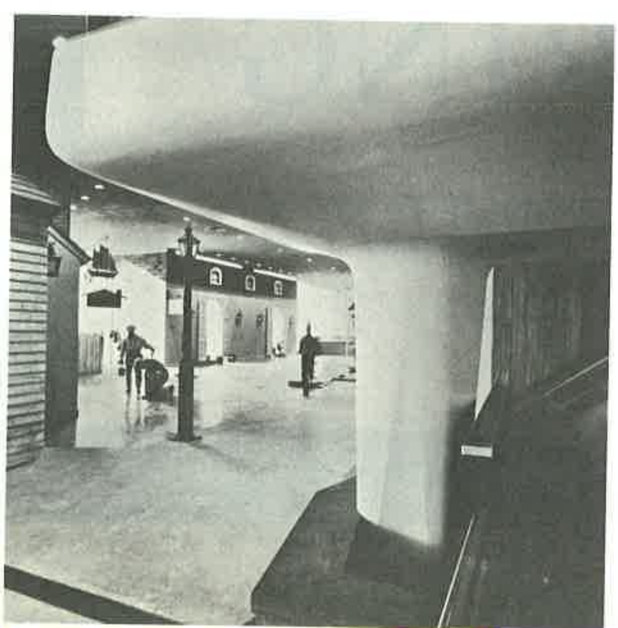
FOREWORD

To paraphrase an old saying, "New products come and go but plaster goes on forever!" The reason is easy to understand. Gypsum plaster is the one material that incorporates all the qualities that could be desired in a wall and ceiling finish—beauty, durability, permanence, adaptability, fire protection, economy and resistance to sound. Through the years, plaster has demonstrated these qualities so conclusively that it continues to enjoy a top ranking position in the building world as the leading wall finish.

However, it cannot be emphasized too strongly that the lasting beauty of plaster interiors is dependent in large measure upon these all-important factors—the plaster base and its correct application, the use of the particular type of plaster best suited to the job, the proper admixture of plaster and aggregate, the workmanship of the artisan.

In the interest of good plastering, this book has been prepared by the gypsum plaster manufacturers of America. It comprises a description of basic materials and their manufacture together with complete standards governing workmanship that will insure the ultimate in beautiful and enduring walls and ceilings.

Characteristics, properties or performance of materials or systems herein described are based on data obtained under controlled test conditions. The Gypsum Association makes no warranties or other representations as to their characteristics, properties or performance under any variation from such conditions in actual construction. Test condition details will be furnished by the Gypsum Association on request.



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GYPSUM IS FIRE RESISTANT

Although fire is one of mankind's most faithful servants, it becomes a dreaded menace when uncontrolled. As a safeguard, early Roman rulers prescribed death to a builder who failed to provide fireproof surfaces for walls and ceilings. In spite of this, Rome burned.

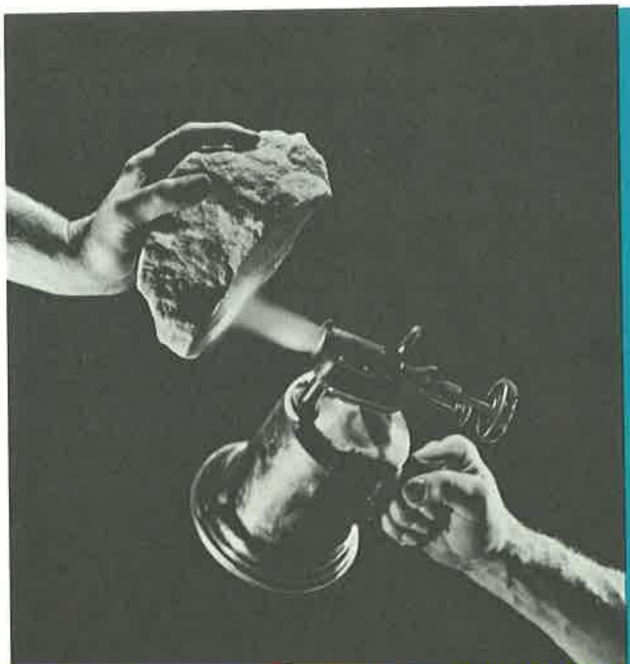
Our modern cities of today require by law a degree of fire protection, but in spite of these provisions about 10,000 people die annually, and about $500 million of real property is lost each year as a result of fires in the United States. Yet, only when a catastrophe occurs which takes many lives do we realize and evaluate the importance of fire protection—then it's too late.

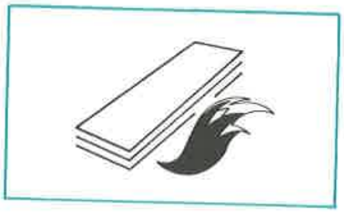
Great strides have been made against this demon menace, particularly with respect to the strategic use of fire-resistant materials in building construction. Millions of dollars have been spent in fire protection research to provide techniques by which fire safety can be built into structures by the proper use of fire-resistant materials.

The term fire resistant, by definition, means resistance to burning or supporting combustion. But the exclusive use of fire-resistant materials in buildings does not necessarily imply that they are fire safe or have sufficient fire-resistive qualities. For example, metals that are used structurally to carry loads are generally fireproof because they will not burn, but when subjected to intense heat they lose strength, fail to carry the intended load, and collapse. Similarly, wood used in building construction, when subjected to sufficient heat, will ignite even though not in direct contact with fire and cause a collapse.

So these structural elements require protection against fire, and the technique of the fire protection engineer is to interpose a material that is not only fireproof but one which will prevent the rapid transfer of heat so that the structural members will not be endangered for a certain period of time. It should be noted that relatively few fire-resistant materials possess the insulating qualities necessary to restrain rapid and excessive heat flow. Gypsum is one of these rare materials, for not only is it fire resistant, but is possesses a phenomenal characteristic that literally repels fire by virtue of the fact that it provides its own "sprinkler system." Gypsum is a rock, a mineral of unusual composition. Although hard and stone-like, it is capable of releasing water to the extent of about half its volume. It is known as hydrous calcium sulphate, and although the water is not in liquid form, it is ever present and ready to be released when attacked by fire. This is the composition of the gypsum used in fire-protective walls and ceilings.

This crystalline mass of gypsum may be likened to a solid block of ice. If the intense heat from a blowtorch is played on one face of the block the ice melts. Yet, one may safely hold his hand on the opposite side of the block, because the temperature there will remain at 32° F. until the heat from the torch has melted all the way through the ice. Even though the ice thickness is only ¼ in., it will not transmit the intense heat until completely melted.



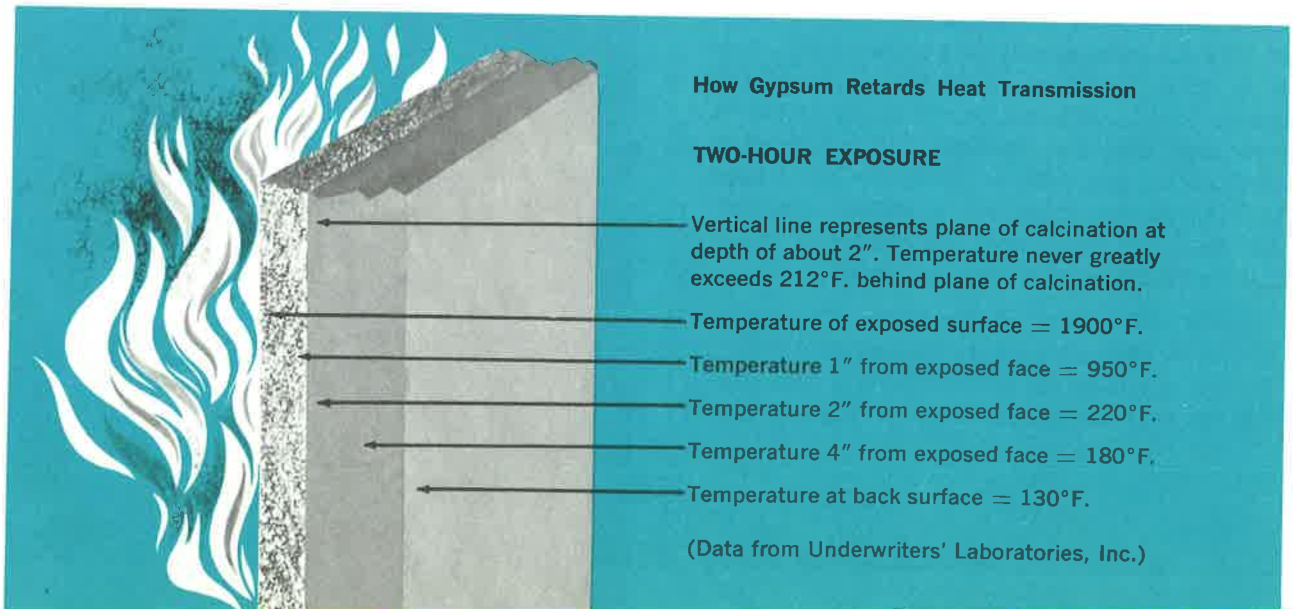


Similarly, the water in crystalline gypsum dissipates the intense heat of fire. As the surface is heated to 212° F., the boiling point of water, the crystalline water "melts out" from the gypsum and quickly becomes steam which repels the fire and dissipates the heat. With continued application of the intense heat, more water of crystallization is released, but the process is slow and requires intense heat. As water leaves the gypsum mass, a white chalky material remains on the surface to further insulate against the flame. After about 15 minutes of exposure to intense heat of fire, the crystallized water will be released to a depth of approximately ¼ in. Following the phenomenon described for melting ice, the temperature immediately behind the ¼ in. depth cannot greatly exceed 212° F., because the combined water in the gypsum would boil at that temperature. After 30 minutes of fire exposure, the water in the gypsum will be released to a depth of about ½ in. Similarly, the temperature at a depth of ⅝ in. will not, theoretically, exceed 212° F. This process of calcination is extremely slow as shown by the accompanying chart.

Consider the protection that this phenomenon provides for wood and steel used in building construction. It is significant that wood will ignite and burn at temperatures of about 350°-450° F. Steel begins to lose its strength at about 850° F. When we consider that many fires are of sufficient intensity to melt glass, plumbing fixtures, faucets and so forth, we must realize the great necessity for protecting wood and steel framing members against this extreme heat. Gypsum protects these vital load-carrying elements against temperatures greatly exceeding 212° F. until all water contained in the gypsum, about half its total volume, has been driven off. For example, a 2 in. thickness of gypsum protects a steel column for a four-hour fire-resistive classification; similarly a ⅞ in. thickness of gypsum on wood studs produces a one-hour rating.

Fire protection engineers, through long experience and research, are able to predict the fire intensity to be expected in buildings of a given type and occupancy. As a result, they have established standards for fire resistance for such buildings which assure reasonable safety to the occupants and adequate protection for the structural integrity of the building. They know that a one-hour fire-resistive partition will not pass flame or smoke or permit excessive heat transfer for one hour. Based upon these facts, building codes require specific fire-resistive values for building construction depending entirely upon the anticipated hazards.

For these reasons, gypsum in its many forms has been widely tested for its fire protective values to provide the varying degrees of fire-resistive ratings as required by building codes. Most of these fire-resistive ratings for assemblies using gypsum products are listed by the National Bureau of Standards and the National Board of Fire Underwriters. The results so published are generally used by building code administrators to determine compliance with standards of fire protection as required by their building codes.



HISTORY AND DEVELOPMENT

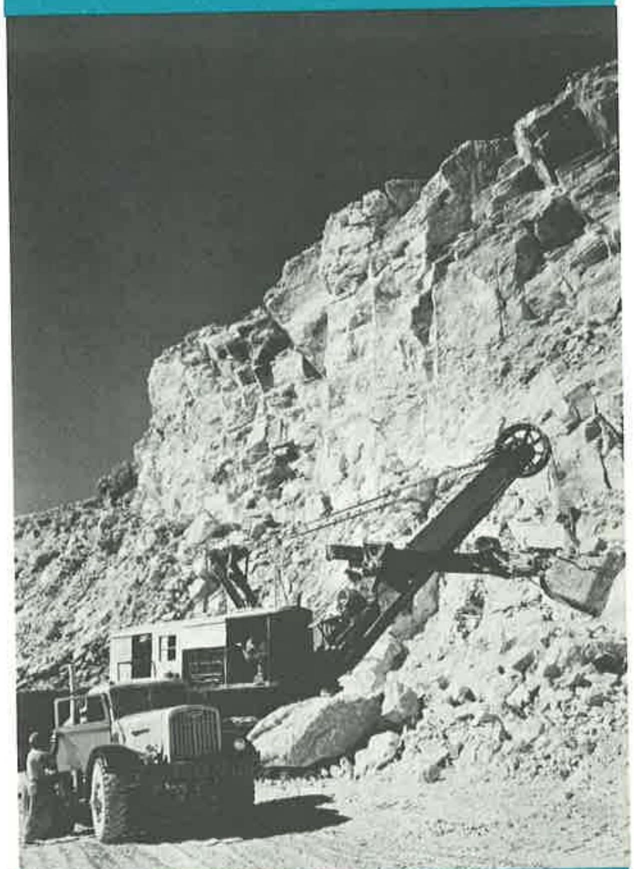
The art of plastering and the use of gypsum dates back to ancient Egypt and Rome, more specifically, to about 2,000 B.C. The Egyptian pyramids offer proof of the early use of gypsum for plastering. There are records of old Roman laws which required builders to plaster their construction to prevent fire spread. Fire losses have plagued man from time immemorial. It is notable that ancient rulers recognized the fire protective qualities of gypsum just as our building officials and building codes do today.

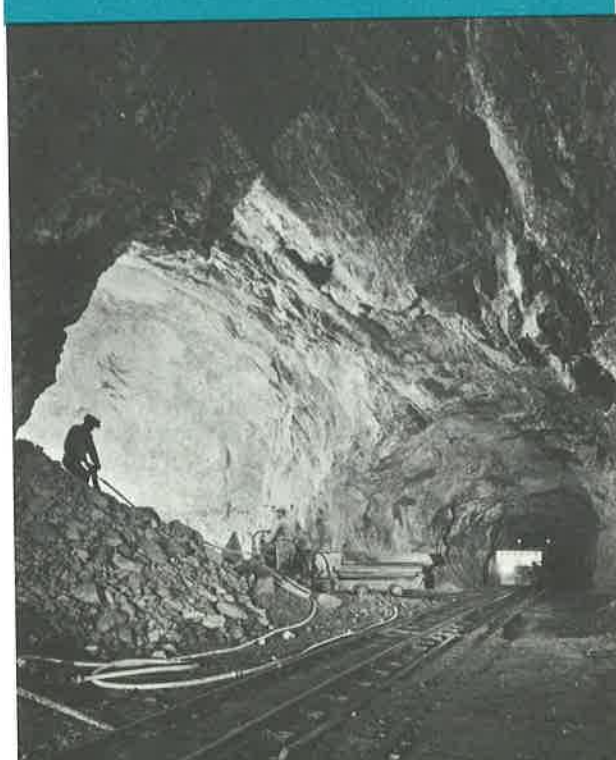
Paris is built over vast beds of very pure and white gypsum. It was mined and processed to a product then called plaster of paris. Even today, gypsum plaster is sometimes referred to as plaster of paris. The processing consisted solely of burning the crude rock in an open pit. Nothing was known about retardation and control of setting time. The product, so produced, set in a few minutes. Its use and application was thus limited. When used for plastering purposes only very small quantities could be mixed in single batches.

Late in the 19th century retarders were discovered which provided a means of delaying the setting action. This marked the beginning of large scale commercial uses of gypsum.

Gypsum was produced in this country in 1835 at the J. B. King plant in New York City from rock imported from Nova Scotia, Canada. Subsequently, large domestic deposits have been discovered and exploited throughout the United States, particularly in western New York State, northern Ohio, Michigan, Iowa, Texas, California, and Kansas.

Lime was the accepted material used for interior plastering in this country until the early part of the 20th century. Hydrated lime was little known—quicklime was in general use. Long slaking periods were required. In fact, a builder would first construct his slaking bins and soak





the quicklime even before starting foundations, because a minimum of three weeks aging was required before the quicklime would be ready for use. When used for plastering, the lime was applied in thin coats with ample drying time between applications. Even then, the resulting wall was soft and had little strength because lime never reaches its ultimate strength until it has thoroughly carbonated. The calcium oxide of the lime gradually absorbs carbon dioxide from the air, thus changing to calcium carbonate. This process was so slow that interior walls were seldom decorated until a year or two after completion. Even so, only a surface carbonization was possible and the ultimate strength and hardness was never realized.

But the building industry demanded greater speed of construction, a stronger and harder wall, early decoration, and early occupancy. With progressive research in retardation of setting time, gypsum provided the logical solution and within the span of a few years it replaced materials and methods now considered obsolete. Gypsum plasters are the nationally recognized basecoat plasters. They constitute one of the major ingredients in finish plasters. Several types of basecoat and finish coat plasters are provided, each for a specific use and purpose.

Today gypsum is mined and/or processed in more than 70 plants located strategically to serve every community in the United States. It is one of our large industries—developed from a very small original investment.

MANUFACTURE OF GYPSUM LATH AND PLASTER

Gypsum is one of the common minerals of the earth and is generally white or gray in color, although some deposits have a pinkish cast. Most extraction operations involve mining, sometimes to a depth of as much as 700 ft. Other deposits are on the surface or have shallow overburdens that lend themselves to quarrying operations.

After extraction, the gypsum rock is passed through a heavy jaw-type crusher and is reduced to 2-3 in. sizes. The next reduction in size occurs in the hammer mill where it emerges with a maximum size of about ½ in. The rock is now ready for calcination or cooking in the rotary calciner. For the kettle process, the rock is further reduced in size to a fine powder.

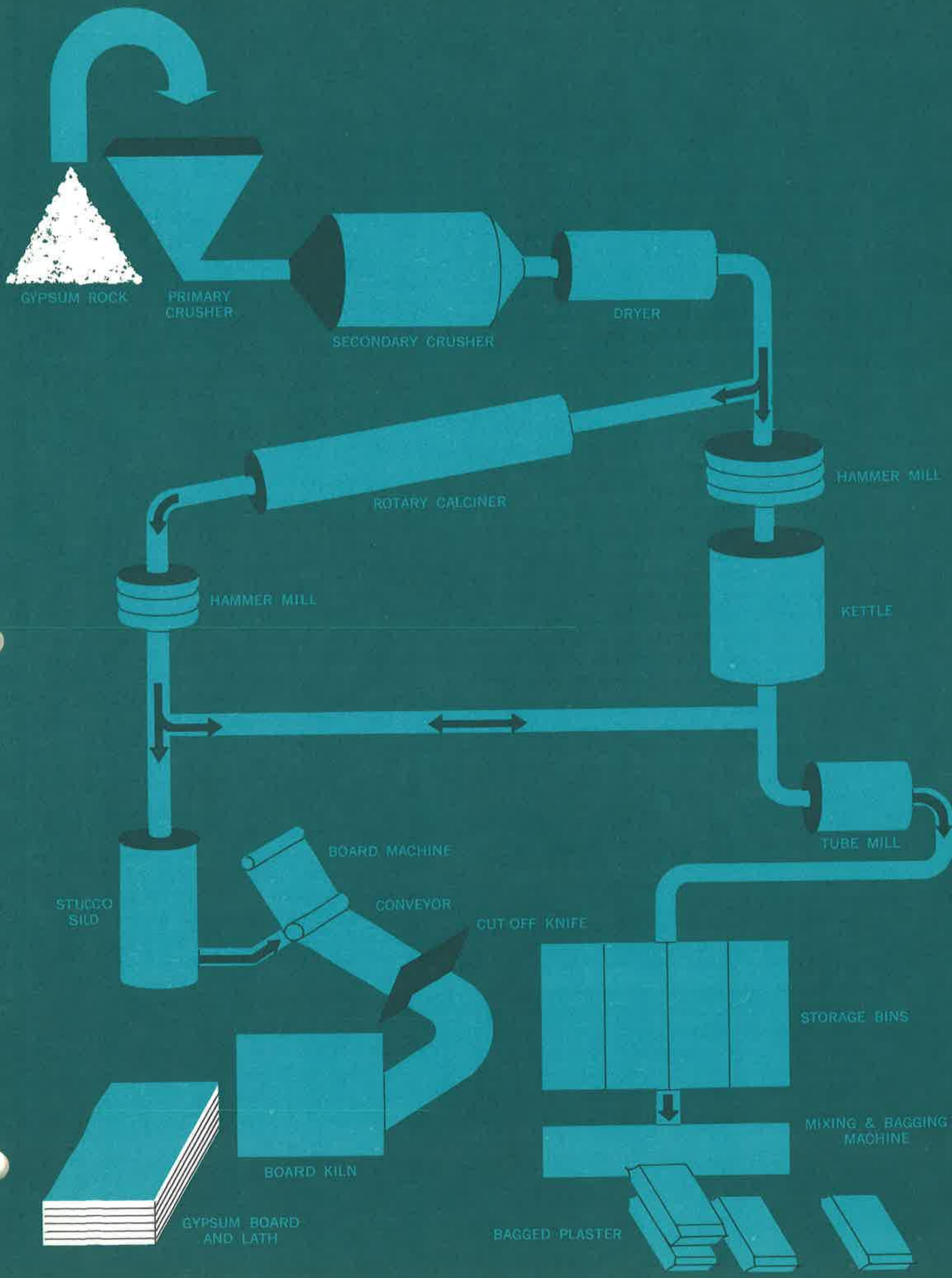
The gypsum rock is known chemically as hydrous calcium sulphate, which is calcium sulphate with two molecules of water in chemical combination, ($CaSO_4 \cdot 2H_2O$). After crushing, the rock is heated in the calciner or kettle (known as calcining) to remove about three-quarters of the combined water, reducing it to $CaSO_4 \cdot \frac{1}{2}H_2O$. Essentially, this is the material that is delivered to the plasterer on the job. It has an affinity for water, and when the plasterer adds water for mixing, that affinity is satisfied. Upon setting, the mass reverts to its original chemical composition—$CaSO_4 \cdot 2H_2O$, the mineral form as found in the earth.

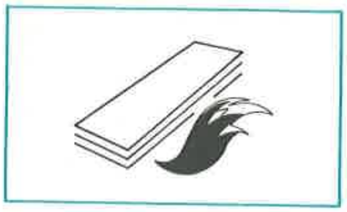
CALCINATION IS ACCOMPLISHED BY THE ROTARY CALCINER OR BY THE KETTLE PROCESS

The rotary calciner is a large steel cylinder lined with firebrick. It is 12-15 ft. in diameter and as much as 150 ft. in length.

The ½ in. rock is fed into one end of the calciner which is somewhat elevated from the horizontal position. As the calciner rotates, the rock gravitates to the lower, or discharge end. Fire or heat is injected into the lower end to produce a temperature of about 350° F. Under these conditions the rock emerges at the lower end having been changed to $CaSO_4 \cdot \frac{1}{2}H_2O$.

The kettle process is an older method of calcination. A kettle is a vertical cylinder usually about 10-12 ft. in diameter, and has agitators that rotate about a central shaft. It is fired at the bottom to about 350° F. Smoke and gases are vented away. Before the rock is fed into the kettle it must be dried and ground to powder. Charges of as much as 30 tons are made every two or three hours, the batches being emptied into the hot pit below. The release of the chemi-


GYPSUM ROCK
PRIMARY CRUSHER
SECONDARY CRUSHER
DRYER
ROTARY CALCINER
HAMMER MILL
KETTLE
HAMMER MILL
TUBE MILL
BOARD MACHINE
STUCCO SILO
CONVEYOR
CUT OFF KNIFE
STORAGE BINS
MIXING & BAGGING MACHINE
BOARD KILN
GYPSUM BOARD AND LATH
BAGGED PLASTER



cally combined water from the gypsum is accompanied by a violent reaction. If the charge is observed from the charging door of the kettle, it can be seen that the reaction is so violent that the mass of gypsum appears to "boil," like water in a kettle over an intense flame. The releasing of the chemically combined water, which quickly turns to steam, is the phenomenon by which gypsum is today recognized by all authorities as the most effective fireproofing material used commercially in building construction.

GYPSUM PLASTER

The calcined gypsum from the kettle or rotary calciner is used to make basecoat plasters and gypsum lath. During recent years many producers have introduced, at the point of manufacture, the tube mill as a further refinement of basecoat plasters. It consists of a steel cylinder containing many thousands of steel balls. The tube mill is charged at one end with the calcined gypsum from the kettle or rotary calciner, and is made to rotate gradually. The action of the steel balls on the gypsum produces a material having a finer grind, higher consistency, more plasticity — greater workability.

The gypsum is now ready for retardation of set in the batch mixers, prior to packaging as plaster for shipment.

Calcined gypsum at this point of manufacture sets very fast and would be unsuitable for plastering. The amount of retarder added is calculated to give not more than a four-hour job set. However, the type of plaster aggregate used (perlite—vermiculite—sand) will affect the setting time. So will impurities in the mixing water and job practices such as pumping through a hose, so each batch must be retarded in set to suit the particular market where the plaster will be used. Some markets require substantially more retardation than others—less retardation usually is required in summer use than in winter. Manufacturers have a complete tabulation of all these variables and have learned during past years to produce plasters that are "tailored" for particular use. Also, at this point, hair or inorganic fibers are added to produce fibered-basecoat gypsum plaster, wood fibers for wood-fibered plasters and suitable lightweight mineral aggregates for ready-mixed gypsum plasters. The plaster is then ready for packaging and shipment.

Much can be said about quality control, but suffice it to say that departmental laboratories, staffed with expert personnel, are located at each major point of manufacture. The sole purpose is to upgrade quality and safeguard the purchaser. Finally, a small sample of each plaster batch is retained at the mill for future reference or appraisal of quality.

GYPSUM LATH

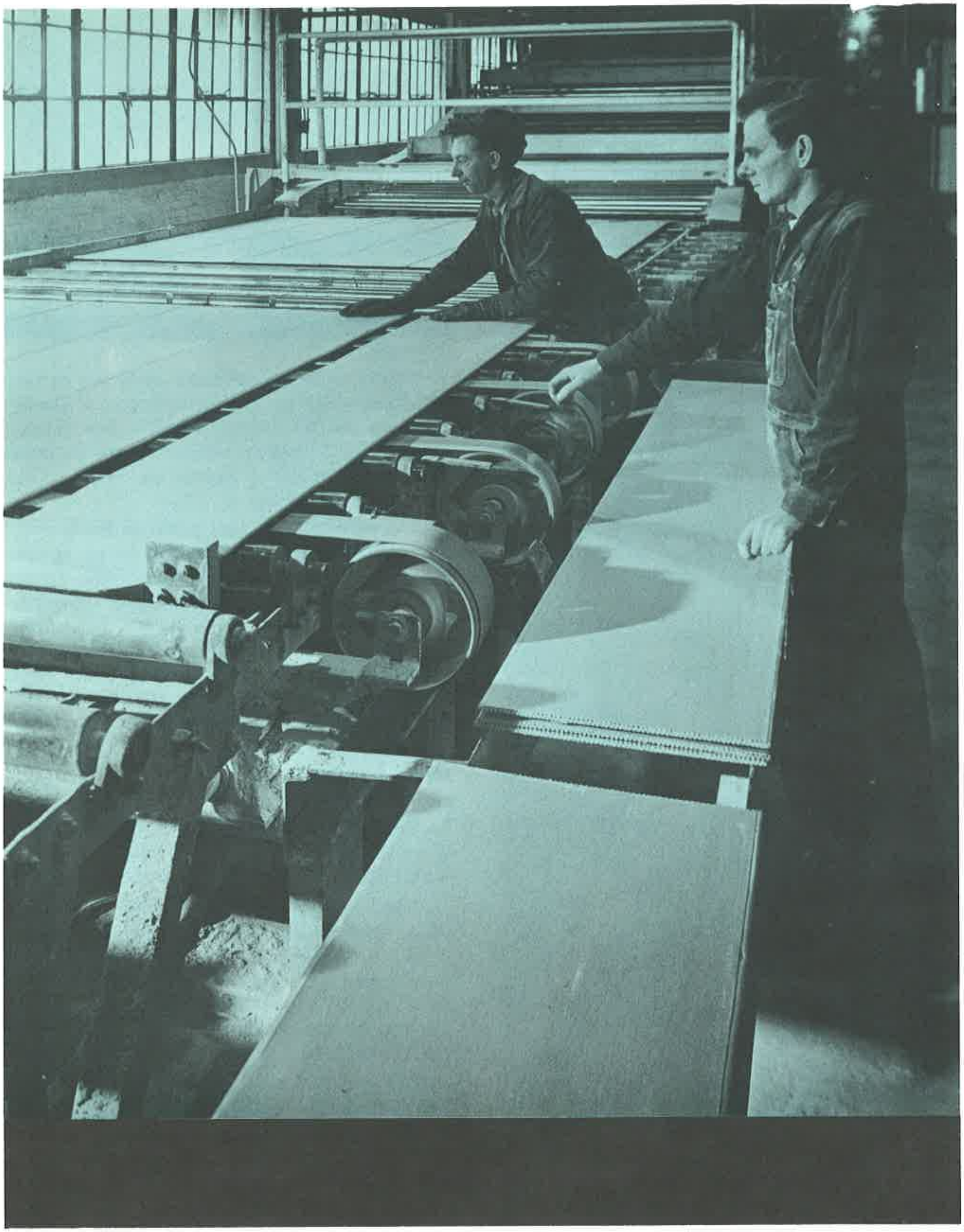
As suggested by the flow chart, calcined gypsum usually without tube milling is used for the manufacture of gypsum lath, which is principally calcined gypsum mixed with water and sandwiched between two paper sheets.

Lath is made on a specially designed board machine which is essentially an endless belt about 54 in. wide supported on rollers. The belt travels continuously, supporting three streams of lath, each 16 in. wide. Gypsum lath paper comes to the plant in large rolls. Each stream of lath is supplied from two rolls of paper. One is fed from below, forming the face of the lath directly on the belt; the other feeds from above and becomes the back face of the lath on the wall.

The calcined gypsum is mixed with water, fiber and other additives. This slurry is fed into the machine between the two layers of paper, thus forming the core of the lath. After the wet slurry has traveled down the belt for three or four minutes between the two papers it begins to set and soon attains sufficient strength to be cut to length. This is accomplished by means of a knife blade which drops on the board at proper intervals to produce the required lengths.

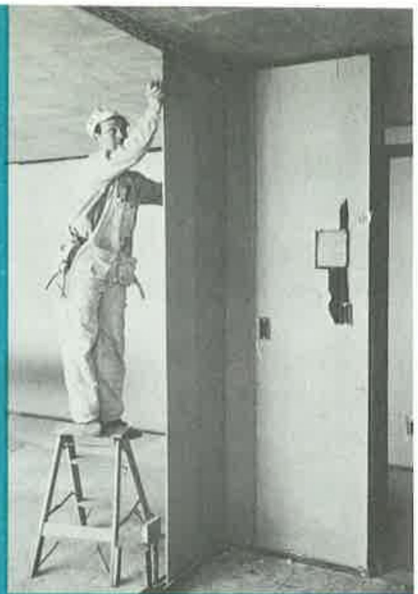
The lath is then fed into drying ovens to eliminate excess water. Individual pieces are assembled into bundles ready for shipment.

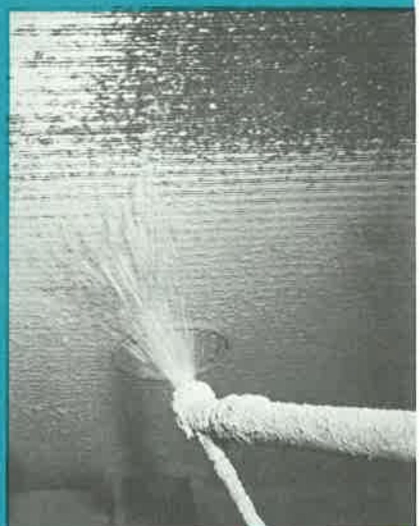
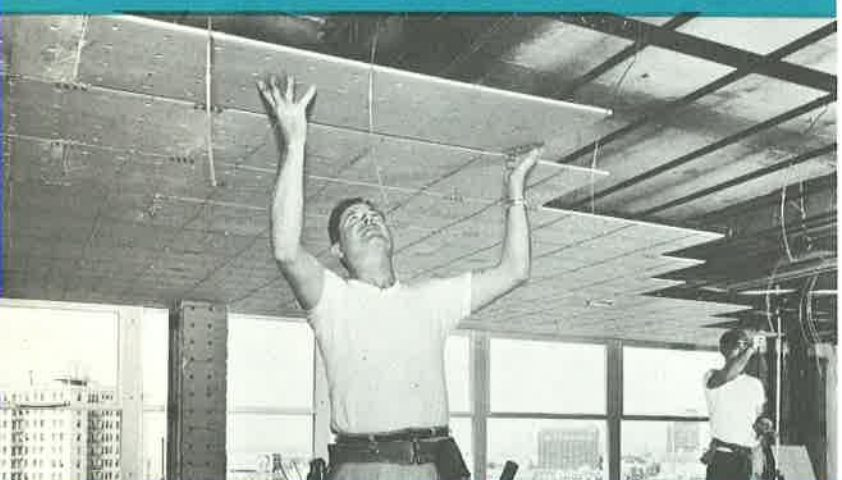
Perforated gypsum lath is produced by punching holes through the lath at regular in-

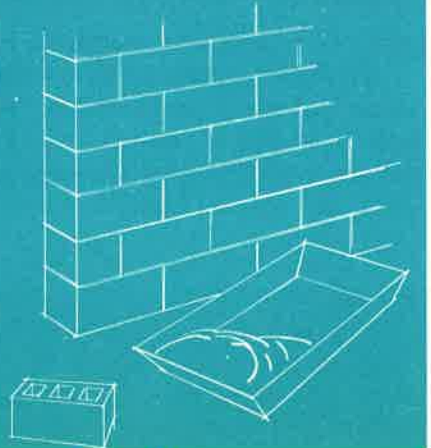


tervals. This is sometimes done by a wet punch press, a mechanical perforator located just before the cutoff knife. After the lath is bundled, the entire unit is placed under a mechanically operated gang drill press which perforates the entire bundle in one operation.

Insulating gypsum lath is made by cementing a sheet of shiny aluminum to the back of plain lath. It is used to provide a vapor barrier and to provide reflective insulation against heat losses.



PLASTER BASES

GENERAL

Plastering bases are those materials or constructions which receive the base coat of plaster. They are readily segregated into two classes: (1) lath bases that are secured to the structure to provide a relatively smooth and level surface, and (2) masonry bases.

The rigidity of the base to which the basecoat plaster is applied is an important factor in plaster crack prevention. Under comparable circumstances a board type of lath usually provides a higher degree of performance than does a flexible lath. The contribution of the lath and the other variables of design, as they affect visual performance, are discussed in the section, "Design Factors For Lath and Plaster Systems," page 32.

LATH BASES

GYPSUM LATH

Generally gypsum lath is ⅜ in. thick by 16 in. wide and 48 in. long, either plain or perforated. Other sizes and thicknesses are available.

Gypsum lath is the most widely used plastering base today. It may be nailed, stapled, screwed or clipped to wood or metal framing or furring members. It is economical because plaster is applied to a thickness of only ½ in. Yet the combination provides fire protection because the lathing base also protects against fire.

Before application of the lath, the framing, whether wood or metal, should be inspected for proper spacing and alignment. Framing members should not exceed 16 in. o.c. when ⅜ in. lath is used or 24 in. when ½ in. lath is used.

Lath shall be applied with its long dimension perpendicular to the framing and with the end joints of the lath staggered between courses. All lath ends must have bearing on the framing except where a special system calls for ends to fall between framing (clip attachments) and be securely fastened. All lath should be placed with folded or lapped edges toward the framing. Edges and ends of lath should be in moderate contact. Over ½ in. spaces between laths should be reinforced with self-furring metal lath strips secured to the adjacent lath.

Each piece of lath should be secured with four nails, staples or screws to each framing member it covers. They should be driven home so the head is just below the paper surface without breaking the paper. These fasteners give the holding power necessary to meet the established fire rating requirements. If the fasteners are not driven home to compress (without crushing) the gypsum core, there is grave possibility of a plaster "pop" over the loose fastener. These "pops" fracture the plaster over the fastener head leaving a conically shaped hole or crater in the base coat and finish coat.

When gypsum lath is clipped to framing, the lath edges must be secured to the framing at each intersection. Clips must be strong and well secured. Detailed specification for clip attachment must be followed implicitly.

Holes for electrical outlets and plumbing must be neatly cut. All interior corners should be reinforced with cornerite, except where the design calls for resilient or clip attachment of the lath or where unrestrained interior angles are to be used. To provide unrestrained angles the abutting lath and plaster surfaces are completely separated at the intersection.

Cornerite and metal lath stripping should be secured to the gypsum lath with staples or tie

GYPSUM LATH

TYPE	THICKNESS (Inches)	WIDTH (Inches)	LENGTH (Inches)	USE
PLAIN	⅜ ½	16 16	48 or 96 48	Application to wood or metal framing, by nails, staples, screws or clips.
PERFORATED	⅜ ½	16 16	48 or 96 48	Same as above except not used for ceiling attachment where the only attachment is by clips at edges of lath or where insulation is placed on the ceiling.
INSULATING	⅜ ⅜ or ½	16 24	48 or 96 as requested to 12 ft.	Same as for plain and where a vapor barrier is required.
LONG LENGTH	½	24	as requested to 12 ft.	Primarily used in 2 in. solid gypsum lath and plaster partitions.

TABLE 1.

Types and Weights of Metal Lath, Wire Lath, and Wire Fabric and Spacing, Center to Center of Supports.[a]

Type of lath	Minimum weight of lath, lb. per sq. yd.	Maximum allowable spacing of supports, in. — Vertical supports: Wood	Vertical supports: Metal — Solid partitions	Vertical supports: Metal — Others	Horizontal supports: Wood or concrete	Horizontal supports: Metal
Flat expanded metal lath	2.5 3.4	16 16	16 16	12 16	0 16	0 13½
Flat rib metal lath	2.75 3.4	16 19	16 24	16 19	16 19	12 19
⅜-in. rib metal lath[b]	3.4 4.0	24 24	. . . .	24 24	24 24	19 24
Sheet metal lath	4.5	24	24	24	24	24
Wire lath	2.48	16	16	16	13½	13½
V-stiffened wire lath	3.3	24	24	24	19	19
Wire fabric	[c]	16	0	16	16	16

[a] Lath may be used on any spacings, center to center, up to the maximum shown for each type and weight.

[b] Rod-stiffened or V-stiffened flat expanded metal lath of equal rigidity and weight is permissible on the same spacings as ⅜-in. rib metal lath.

[c] Paper-backed wire fabric, No. 16 gauge wire, 2 by 2-in. mesh, with stiffener.

wire. They must not be secured by nailing through the lath and into the framing because stresses from warping or twisting of framing members or other structurally imparted stresses would be readily transmitted into the plaster coats, and may induce plaster cracks.

All exterior angles should be finished with cornerbeads, set to true grounds. Cornerbeads, casing beads, metal grounds and picture molds, which serve as grounds should be secured to the framing or furring.

Grounds should be provided around all openings and wherever baseboards or moldings are to be used. They must provide for a full ½ in. thickness of plaster. Otherwise, the plastering will be materially weakened.

METAL LATH

Metal lath is second only to gypsum lath in usage and volume produced. It is a widely-used base for plastering because the steel becomes imbedded within the plaster and adds to the strength of the total assembly. All other laths provide suction for the plaster bond, but metal lath provides only a mechanical bond for the scratch coat of plaster which in turn provides suction for the brown coat.

The two most common types of metal lath used for plastering are diamond mesh and ⅛ in. flat rib lath.

Space does not permit a detailed study of good lathing technique and the data and specifications published in America Standards Association's A42.4 are recommended for this purpose. The following, however, are vulnerable points that should be inspected before plastering is started.

The lath must be of proper type and weight for the spacing of supports and for the intended purpose. Otherwise it may be too flexible to withstand trowel pressure when applying the scratch coat of plaster; or it may provide insufficient reinforcement to the plaster, resulting in a weak slab that will crack under normal usage.

Metal furring must be of proper size to prevent undue deflection. It must be adequately anchored to the supporting construction, and furring channels attached to runner channels.

Metal lath must be properly tied to furring and have proper side and end laps and returns at all angles. When applied to wood supports the nailing must be within specifications.

Cornerbeads should provide reinforcement and proper grounds at all exterior angles. Grounds must be provided around all openings and at baseboards to provide a minimum plaster thickness of ⅝ in. over the lath; ¾ in. from back side of the lath.

MASONRY BASES

GYPSUM PARTITION TILE

Gypsum partition tile provides an excellent base for plaster. In addition to the natural bond of gypsum to gypsum, both faces of gypsum partition tile are roughened or scored to provide a mechanical bond. Tiles are 12x30 in. in face dimension and provide an unwarped plastering surface because they are dried without burning. Hence, the mechanic can lay a straighter wall which requires less plaster than with many other units. Only gypsum plaster should be applied to gypsum partition tile, since lime and portland cement plasters do not bond adequately. Likewise, only gypsum grouting mortar should be used for tile erection. Gypsum partition tile should not be used in exterior masonry.

CLAY PRODUCTS

Brick and clay tile are two common plaster bases. They are rigid and offer good dimensional stability. However, some brick and tile are quite nonporous and provide little suction for the plaster. Plastering direct to such units should be avoided unless the surface is provided with a means of developing a mechanical bond, such as scored clay tile.

Plaster should not be applied directly to smooth-surfaced clay tile, especially when such units are burned to produce a semi-glazed surfacing. Such units do not permit the water from the plaster to strike into the surface. Hence, the crystalline structure of the set plaster cannot interlace into the pores of the base to form a good and permanent bond.

CONCRETE BLOCK

This product has been used quite extensively for back-up in exterior walls and for partitions. It is also used as filler blocks in concrete floor and roof constructions. Those of standard manufacture and complying with American Society for Testing and Materials' (ASTM) specifications have proved very satisfactory for walls and partitions when properly aged. They are relatively stable and strong. They are not generally subject to warping and are capable of being erected in a straight and true wall. However, they should be plastered with caution.

Concrete block ceilings (filler blocks) should always be plastered with gypsum bond plaster. On ceilings or other horizontal surfaces normal gypsum plasters will not bond with the portland cement in the block with sufficient strength to assure permanence. Due to the naturally rough surface of the block there is a mechanical bond but this is variable and not wholly dependable. For that reason, special bonding plasters have been developed in the gypsum industry and they alone should be used as the first coat of plaster over concrete block ceilings.

Where walls are constructed of concrete blocks and the surface is reasonably rough, any gypsum basecoat plaster is adequate. Bond of plaster to walls is far less critical than bond to ceilings, and the mechanical bond provided by gypsum plaster to a rough textured block has proved very satisfactory in wall construction.

MONOLITHIC CONCRETE

The surface of poured concrete to which plaster is to be applied may be rough or smooth, depending upon the system of forming used and the method of pouring concrete. The method of plastering depends entirely upon the surface texture. During recent years, a stronger concrete has been produced by mechanically vibrating the forms while pouring the concrete. Such operations require tight forming to prevent waste and this has led to use of steel or plywood forms. Under such conditions the undersurface of the slab is very smooth and dense, requiring special preparation which is discussed under "Bond Plasters," page 27.

It is unwise to apply a thick coat of bonding plaster to any concrete surface. The forms for pouring concrete should be accurately placed and held true and level until removed. Otherwise, considerable "filling in" becomes necessary to produce a true surface plaster job. If a thickness of more than 3/8 in. on concrete ceilings or 5/8 in. on concrete walls is necessary in certain areas, metal lath should be secured to the concrete befor plastering. In that event, sanded plaster or woodfibered plaster may be used. With that exception only, bonding plaster should be used over concrete.

EXTERIOR MASONRY WALLS

The practice of plastering direct to exterior masonry walls is not recommended. Masonry walls in general are not waterproof and are subject to considerable water leakage, especially during driving rains. Moisture may permeate the entire wall thickness, wet the plaster, and damage the interior decoration. Furthermore, heat losses are high through masonry with direct plastering. They permit summer heat to penetrate and warm the interior. They permit high and costly heat losses during the winter and are subject to vapor or moisture condensation that damages decoration. Exterior masonry walls should always be furred to provide an air space of at least 1 in. between the lath and the masonry. The use of insulating gypsum lath is recommended because of its superior vapor barrier property.

BITUMINOUS COMPOUNDS

Occasionally a coating of bituminous waterproofing is applied to exterior masonry or monolithic concrete surfaces and plaster is applied directly to this coating.

While such treatment may reduce water seepage into the building, this practice cannot be condoned in lieu of furring because the plaster bond to such waterproofing is highly questionable. Such treatments kill all inherent suction and plaster cannot adhere satisfactorily to such materials, even though they contain sand granules. Again, furring is recommended.

GYPSUM BASECOAT PLASTERS — GENERAL

Gypsum basecoat plaster is defined as that portion of the plaster coat which is applied to lath or masonry bases and which supports the finish coat. It is used to fill in whatever additional thickness is required to square a room and provide a true surface for a monolithic finish.

The base coat is the most important element of a plastered surface. It supplements the strength of the plaster base to provide resistance against minor structural movements. The relationship of basecoat plaster strength to crack resistance is discussed on page 32 along with other factors that have an effect on performance.

Furthermore, a basecoat plaster must fully develop the purpose of the finish coat. An extremely hard finish coat such as Keene's cement-lime trowel finish should be applied only to strong basecoat plasters to develop the full value of the finish coat in resisting impact loads and unusual abrasions.

There are several distinct basecoat plasters—each intended for a specific use. It is suggested that the designer choose the proper base coat in relation to the surface to which it is to be applied, the finish which it supports and the degree of performance he requires.

GYPSUM NEAT PLASTER

Often known as gypsum cement plaster or hardwall, this calcined gypsum plaster must be mixed with sand, perlite or vermiculite aggregate and water—available fibered or unfibered.

GYPSUM READY-MIXED PLASTERS

Ready-mixed gypsum plasters are mill prepared basecoat plasters that require the addition of only water on the job. They are composed of calcined gypsum plaster mixed with an aggregate, usually perlite or sand, and are available as fibered or unfibered.

GYPSUM WOOD-FIBERED PLASTER

Gypsum wood-fibered plaster is a neat basecoat plaster requiring the addition of only water on the job. The calcined gypsum plaster is integrally mixed with selected wood fibers to give slightly more bulk and coverage.

GYPSUM BOND PLASTER

Bond plaster is a specially formulated gypsum plaster for use on interior monolithic concrete surfaces. It is factory prepared requiring only the addition of water at the job site.

PLASTER AGGREGATES AND THEIR PROPORTIONING

Gypsum basecoat plasters are mixed with an aggregate, either at the gypsum plant or on the job, to increase the bulk and coverage of the plaster mass. These aggregates are either wood fibers, sand, perlite or vermiculite—sand is the most popular.

Aggregate gradation and plaster to aggregate proportioning exert a tremendous influence upon finished plaster performance. Improper gradation or over-aggregating both reduce the basecoat plaster strength. The relationship of plaster strength to finished performance is discussed on page 32.

A properly graded plaster aggregate will have a definite ratio of coarse to small particle size allowing for a uniform coating of each particle with gypsum plaster. If the percentage of coarse particles is too high or if the particles themselves are too large, voids will exist between them and there will be insufficient plaster to completely and homogeneously surround the particles. The same will be true if the aggregate size is too small. Therefore, a good plaster aggregate will have a balanced gradation. This is set forth in the American Society for Testing and Materials' publications.

The importance of proportioning is discussed later as it applies to each aggregate.

SAND

Sand is the most commonly used plaster aggregate because it is extremely economical and generally available. When we consider that approximately three-quarters of all plastering employs sand as an aggregate and that approximately three-quarters of the weight of this plaster mass is sand, we must realize its importance. The plaster manufacturer may produce a most excellent material and the mechanic may use the best workmanship and skill in the application, but the finished plaster can be no better than the quality of sand.

The first qualification of sand used for plastering pertains to the particle size. It should be constantly borne in mind that each particle of sand must be completely coated with the cementitious material.

This can be accomplished only with a proper gradation from coarse to small size particles. Proper gradation of sand particles adds workability to the mix. Field experience, together with thousands of strength tests, have resulted in a standard specification for the use of sand in plaster. The ASTM C-35 establishes the following gradation, and other minimum standards, for good plastering sand:

SIEVE SIZE	Percentage Sand Retained By Weight	
	Max.	Min.
No. 4 (4760-micron)	0	—
No. 8 (2380-micron)	5	0
No. 16 (1190-micron)	30	5
No. 30 (590-micron)	65	30
No. 50 (297-micron)	95	65
No. 100 (149-micron)	100	90

Sands complying with this standard are generally available and those which do not comply should never be used. Failure to comply with this specification will result in greatly weakened walls that may appear to be oversanded.

Sand should be clean—it is generally unsatisfactory to purchase sands that have not been washed. Dirt, clay and other foreign materials disturb the setting time of plaster. They may accelerate the set to make plaster unusable or delay setting action and greatly weaken the plastered wall. Dirt in sand reduces the strength and hardness as does a long delayed set.

The presence of dirt and foreign matter may be detected by placing a small sample in a bottle with water, agitating the mass and allowing it to stand for a few moments. The sand, being heavier than the foreign material, will settle to the bottom and the foreign material may be suspended in the water or settle into a layer over the sand. Such foreign matter may reduce the strength of plaster as much as 50 per cent.

Assuming that sand complies with the standards above, the proportioning of sand to plaster is the most important operation in good plastering. There are three standard mixes of sand and plaster. All are based on 100 lb. of gypsum plaster. These mixes are:

1:2 —scratch coat over all lath in three-coat plaster work.

1:2½—over gypsum lath in two-coat plaster work.

1:3 —brown coat over all lath in three-coat plaster work and for all work over masonry.

Even though sand is of the finest quality, there is no justification for using a leaner mix (more sand) because the plaster strength will most certainly be impaired. No plaster is manufactured to be sanded in proportions greater than those just stated.

These proportions are easily maintained if a measuring box is used on the job This box usually is built to hold one cu. ft. of sand. Because sand tends to bulk when damp and because of added lack of uniformity in a "shovelful" of sand, the box measuring system is highly recommended. However, an alternative (but less satisfacory) method is to regulate the number of "shovelfuls" of sand using a No. 2 shovel. This shovel will hold approximately 16 lb. of moist sand. One hundred lb. of moist sand is considered equal to one cu. ft., therefore:

a 1:2 mix will require 100 lb. of gypsum plaster and two cu. ft. or 12 shovels of sand.

a 1:2½ mix will require 100 lb. of gypsum plaster and 2½ cu. ft. or 15 shovels of sand.

a 1:3 mix will require 100 lb. of gypsum plaster and three cu. ft. or 18 shovels of sand.

PERLITE

Expanded perlite as a plaster aggregate is the newest of the basic plastering materials.

Raw perlite is a volcanic glass and is mined from open pits or quarries. The crude ore is crushed to various particle sizes and these are flash roasted at temperatures of 1,400-2,000° F. This process expands or "pops" the perlite to form a frothy mass of glass bubbles, 4-20 times the original volume of the raw perlite.

Chemically, perlite is primarily silica, aluminum and combined water. The material is generally considered to be chemically inert and free from impurities that could alter the setting properties of gypsum plaster. For this reason, a different degree of retardation is sometimes built into plasters which are to be mixed with perlite rather than sand.

Weighing from 7½-15 lb. per cu. ft., expanded perlite effectively reduces the dead weight of plaster to approximately half that experienced when sand aggregate is used. A 1:2 mix of perlited plaster weighs approximately 50-55 lb., dry weight, per cu. ft.

Perlited plasters are very effective fire retardants. Fire-resistance ratings for perlite plaster constructions are usually considerably higher than equivalent constructions in which sanded plasters are used. Ratings of four hour fire resistance are readily obtainable.

The strengths of perlited basecoat plasters are less than those using sand aggregate but are higher than those with vermiculite aggregate. Compressive strengths are given on page 18 and the relationship of this to plaster performance is discussed on page 32.

Because these perlited plasters tend toward lesser strengths, it is important that specifications for proportions of plaster to perlite aggregate be followed rigidly. Not more than two cu. ft. of perlite should be used with each 100 lb. of gypsum neat plaster over all types of plastering bases except (1) over masonry and (2) for brown coat plastering (three-coat work) where the total plaster thickness is one in. or greater. For these two exceptions only, the proportions should not exceed three cu. ft. per 100 lb. of plaster.

Gradation of the perlite aggregate is as important as it is with sand and for the same reasons ASTM C-35 sets forth the standards for gradation (given at the close of this section).

VERMICULITE

Vermiculite is another lightweight aggregate that may be used in lieu of sand to reduce the total weight of the plaster and to increase the fire-resistance of the plastered assembly.

Vermiculite is a micaceous mineral that, when exposed to intense heat, expands 6-20 times its original volume. It is mined as a rock and is crushed and graded prior to exfoliation (expansion by heat). It is then subjected to temperatures ranging from 1,600-2,000° F. when exfoliation takes place.

The expanded vermiculite is manufactured in five types (I, II, III, IV and V) classified according to particle size. Type III is used for plastering and meets the gradation standards set forth in ASTM C-35. This aggregate weighing from 6-10 lb. per cu. ft. effectively reduces the dead weight of plastering. Vermiculite basecoat plaster, like perlited plaster, weighs approximately 50-55 lb. per cu. ft.

Vermiculite imparts greater fire-resistance into basecoat plasters—greater than those using sand and generally considered equal to those using perlite. Ratings of four hours are readily obtainable on many assemblies.

The strength of vermiculite base coats are lower than comparable mixes of sand or perlite (see page 18). Therefore, it is quite important that proper gradation and proper proportioning be rigidly followed. In addition, a greater amount of mixing water is used and greater care must be taken to permit the excess water to evaporate.

It is recommended that not more than two cu. ft. of vermiculite aggregate be mixed with each 100 lb. of gypsum neat plaster for all types of work, except for (1) plastering over unit masonry, or (2) brown coat plastering (three-coat work) where the total plaster thickness is one in. or greater. For these two exceptions only, the proportions should not exceed three cu. ft. per 100 lb. of plaster.

GRADATION OF PERLITE AND VERMICULITE PLASTER AGGREGATES ASTM C-35

SIEVE SIZE	Percentage Retained on each Sieve			
	Perlite by volume		Vermiculite by volume	
	Max.	Min.	Max.	Min.
No. 4 (4760-micron)	0	—	0	—
No. 8 (2380-micron)	5	0	10	0
No. 16 (1190-micron)	60	10	75	40
No. 30 (590-micron)	95	45	95	65
No. 50 (297-micron)	98	75	98	75
No. 100 (149-micron)	100	88	100	90

BASECOAT STRENGTH AND HARDNESS

As stated at the beginning of this section, plaster to aggregate proportioning exerts a tremendous influence upon finished plaster performance. The importance of adhering to the recommended proportioning cannot be overemphasized whether the aggregate be sand, perlite or vermiculite.

The effect upon strength and hardness of the base coat when proportions are varied is given below using sand as an aggregate. The performance of perlited or vermiculited basecoat plasters would be affected in the same manner.

REDUCED STRENGTH FROM OVERSANDING

Basecoat plaster strength gives resistance to framing distortions, minor framing movements and impacts and abuses which cause cracking.

The compressive and tensile strength that may be expected with varying plaster mixes is expressed in the accomanying charts.

The data herein shown was obtained by testing cylinders and briquettes according to ASTM's Standard Methods for Testing Gypsum. A medium grade sand, complying with ASTM's Specifications for Sand, and an average plaster were used for the test.

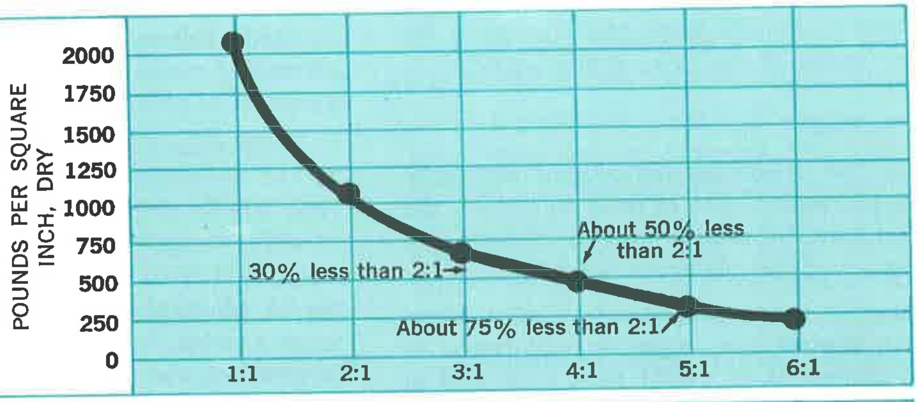
It is noteworthy that starting with a mix of 1:1, the compressive strength is reduced by about one-half each time the sand content is doubled.

OVERAGGREGATING DECREASES HARDNESS

The surface hardness of the base coat of plaster is essential to the permanence of the finish coat. Finish coats are but thin applications of

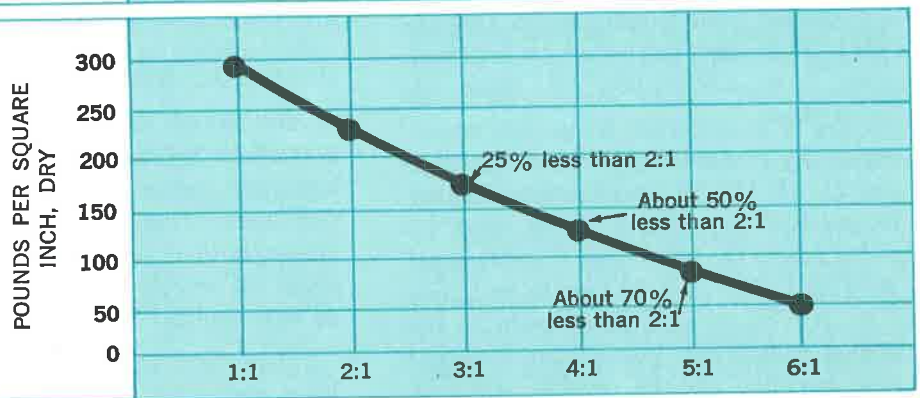
COMPRESSIVE STRENGTH

DECREASE OF COMPRESSIVE STRENGTH OF PLASTER WITH INCREASE IN SAND CONTENT



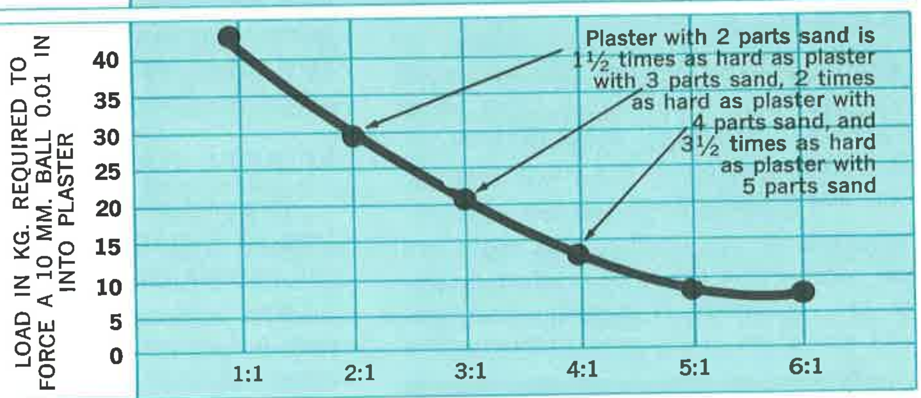
TENSILE STRENGTH

DECREASE OF TENSILE STRENGTH OF PLASTER WITH INCREASE IN SAND CONTENT



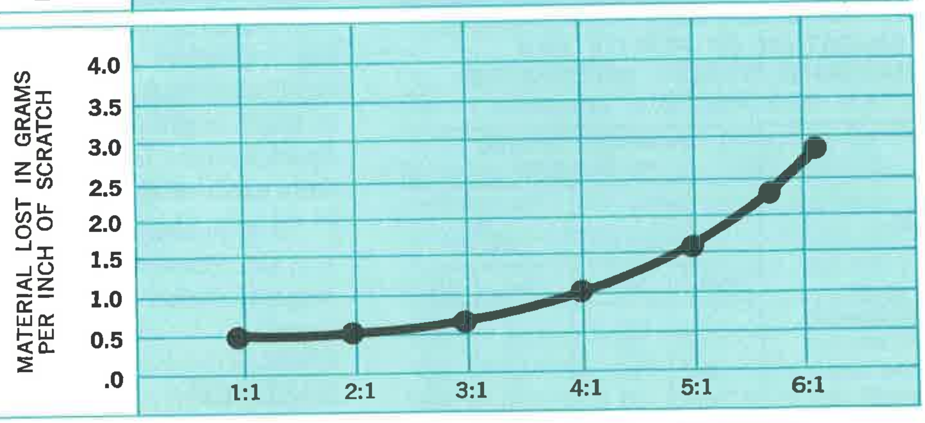
HARDNESS TEST

DECREASE OF HARDNESS OF PLASTER WITH INCREASE IN SAND CONTENT



SCRATCH TEST

INCREASE OF WEIGHT OF MATERIAL PLOWED UP PER LINEAL INCH OF SCRATCH



PARTS SAND PER PART PLASTER — BY WEIGHT

tough, brittle wearing surfaces and must be applied to a firm, hard base. Otherwise, they are subject to check cracking, indentations, and spalling. The surface hardness of plasters having varying sand contents was determined by the Monotron Hardness Tester and is tabulated in the accompanying diagram. This instrument measures the load required to force a steel ball of a fixed diameter into the plaster for a given distance of .01 in. Plaster sanded with two parts of sand develops twice the hardness of plaster with four parts of sand.

The scratch test is a simple visual method of determining hardness. It consists of a pronged device which is drawn across the surface of the panel at a uniform rate of speed and carrying a fixed weight. The softer the plaster, the deeper will be the abrasion and the more material will be dislodged by the abrasion. The accompanying photos reveal the depth and nature of the abrasions on plasters of varying sand content.

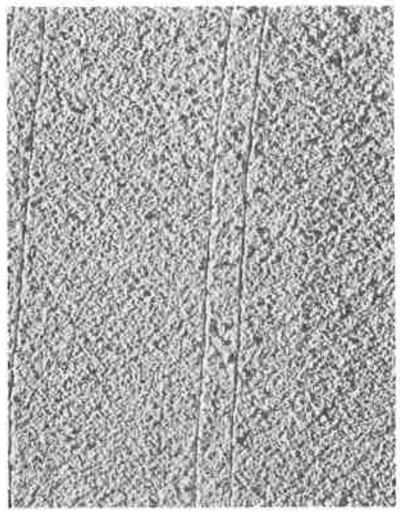
The amount of material that is displayed by the abrasions is then weighed and the results are shown in the accompanying chart. Four times as much material is dislodged from a 1:6 plaster panel as compared to plaster sanded 1:3.

Many inspectors of plastering jobs use a nail or other similar device for hand scratching the surface of the brown coat to visually determine its hardness. While this is quite inaccurate, nevertheless an inferior base coat can be readily detected by this means.

WATER RATIO

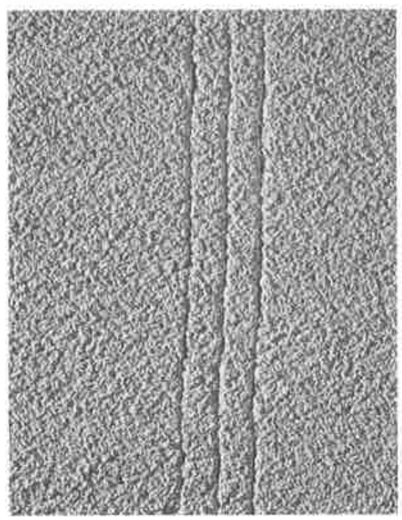
All plasters are designed to be mixed with a definite proportion of aggregate and a definite amount of water. The required strength and hardness is based upon that correct mixture. If excessive water is used, the plaster will set with an excess of free water included in the mass—this ultimately evaporates, leaving numerous voids. The presence of voids in any masonry construction is injurious to its strength. When plaster is overaggregated the extra aggregate requires additional water to bring the mass to a normal workable consistency. The water-gypsum ratio is thereby increased, leaving voids in the plas-

SCRATCH TESTS

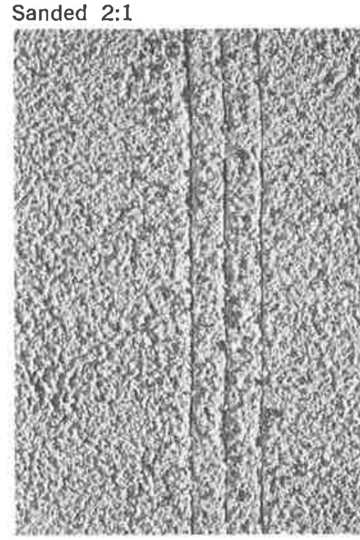


Sanded 1:1

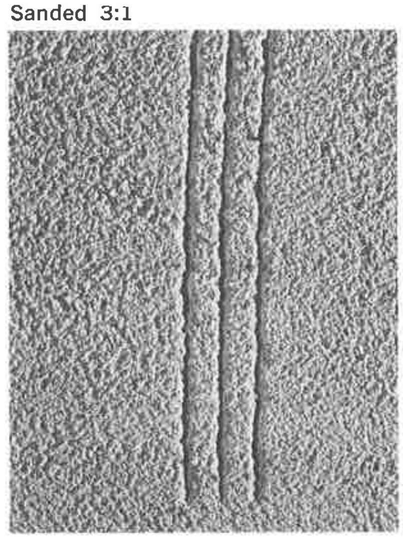
Sanded 2:1



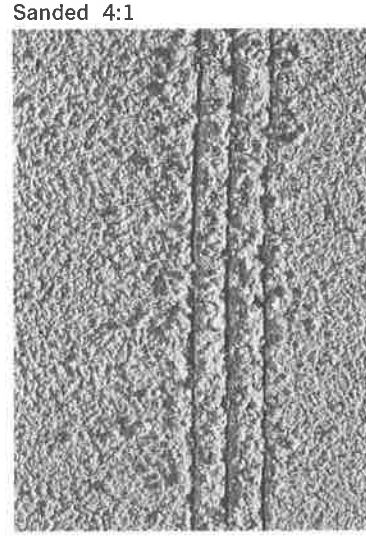
Sanded 3:1



Sanded 4:1



Sanded 5:1



Sanded 6:1

tered wall when dry. In addition, the aggregate particles will not be coated with gypsum.

It can be readily seen that overaggregating introduces two factors which materially weaken the strength. If this is avoided there is no reason to increase the water content and this double hazard is then avoided.

FIBERED VERSUS UNFIBERED PLASTERS

Those basecoat plasters which require an aggregate are furnished with or without fibers. Fibering consists of mixing a definite proportion of hair or sisal fibers with the plaster at the time of manufacture. This fibered plaster is used for a scratch coat on metal lath and serves no other purpose than to aid in forming mechanical keys behind the metal lath.

There is a general belief within the industry that hair or sisal fibering adds strength to the base coat with the resultant misuse of the product. Undoubtedly this is a "hand-me-down" theory resulting from the general use of lime basecoat plasters many years ago. Lime does not set. It hardens from carbonization which is the process of absorbing carbon dioxide from the air, thus changing the lime from calcium oxide to calcium carbonate. This is an extremely slow process, and in fact, lime plasters seldom, if ever, completely carbonate. Consequently lime plaster required fibering to add cohesiveness to the mass.

Gypsum plasters, on the other hand, set hard within two-three hours and do not require fibers. In fact, fiber adds no strength whatsoever to gypsum plasters. However, in the scratch coat application to metal lath, the fiber serves a very useful purpose in allowing only a sufficient amount of plaster to go through the openings of the lath to produce good mechanical keys. Otherwise the plaster would go through the metal lath and fall to the floor. For this reason, fibered plaster should always be used as a scratch coat application over metal lath.

Differentiation should be made here between hair or sisal fibering, wood fibering or other fibering which is used in some plasters for the purpose of adding strength, bulk or coverage.

WATER FOR MIXING

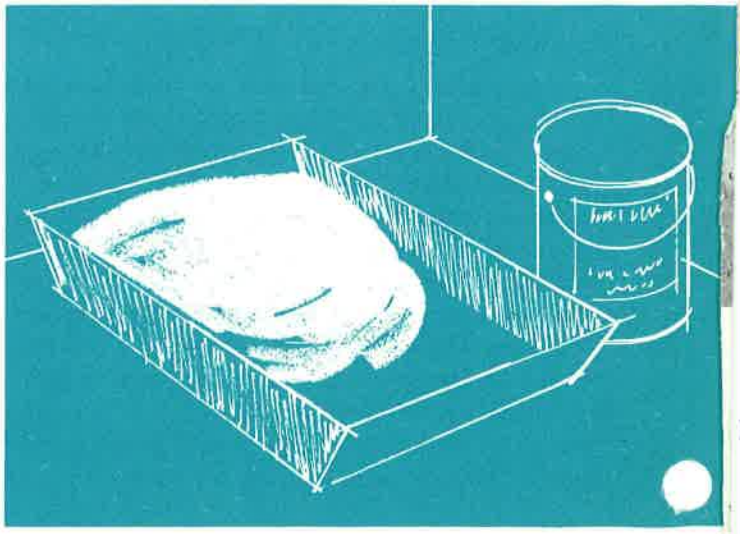
Water should be clean, fresh, suitable for domestic consumption, and free from amounts of mineral and organic substances which affect the set of the plaster. Water which is used for rinsing or cleaning containers and tools should not be used as it accelerates the plaster set.

MIXING

A mechanical mixer is preferred to hand or box mixing, because the plaster, aggregate and water are more evenly interspersed. The mixer operates continously during the preparation of each batch. The proper procedure is as follows:

1. Hold approximately 90 per cent of the anticipated water requirements in the mixer.
2. Add approximately half the required sand. If perlite or vermiculite is used, add all the aggregate.
3. Add all the plaster.
4. Add the remainder of sand.
5. Mix not less than a half minute, nor more than three, depending upon the speed of mixer.
6. If necessary, add water to obtain the proper consistency.
7. Dump the entire batch at once.

If gypsum wood-fibered plaster without aggregate or ready-mixed plaster is being used, no aggregate is added.



It is good practice to hold back one-tenth of the initial water requirement for use later to bring the plaster to proper consistency. This avoids the need for adding dry material to the batch when too much water has been used.

The above procedure will keep the mixer clean when in continuous operation. When the mixer is used intermittently, a small amount of water is placed in the mixer and allowed to run for a few minutes or until the next batch is to be mixed. This water must be dumped before starting a new batch because it probably contains partially set material. Even a small amount will act as a powerful accelerator.

When mixing by hand, plaster aggregate should be mixed dry to a uniform color in a mixing box, the water added and the plaster hoed into the water immediately and thoroughly mixed to a proper consistency. The tendency to undermix should be avoided as the resulting material will be difficult to apply and will produce soft and hard spots in the plastered wall.

ADDITIONAL PRECAUTIONS

Do not use a batch of plaster that has started to set. All such plaster should be discarded. Keep all tools clean and do not wash them in mixing water. Keep plaster stored in a dry location. Do not allow it to be in contact with earth or against a damp wall.

BASECOAT PLASTER APPLICATION

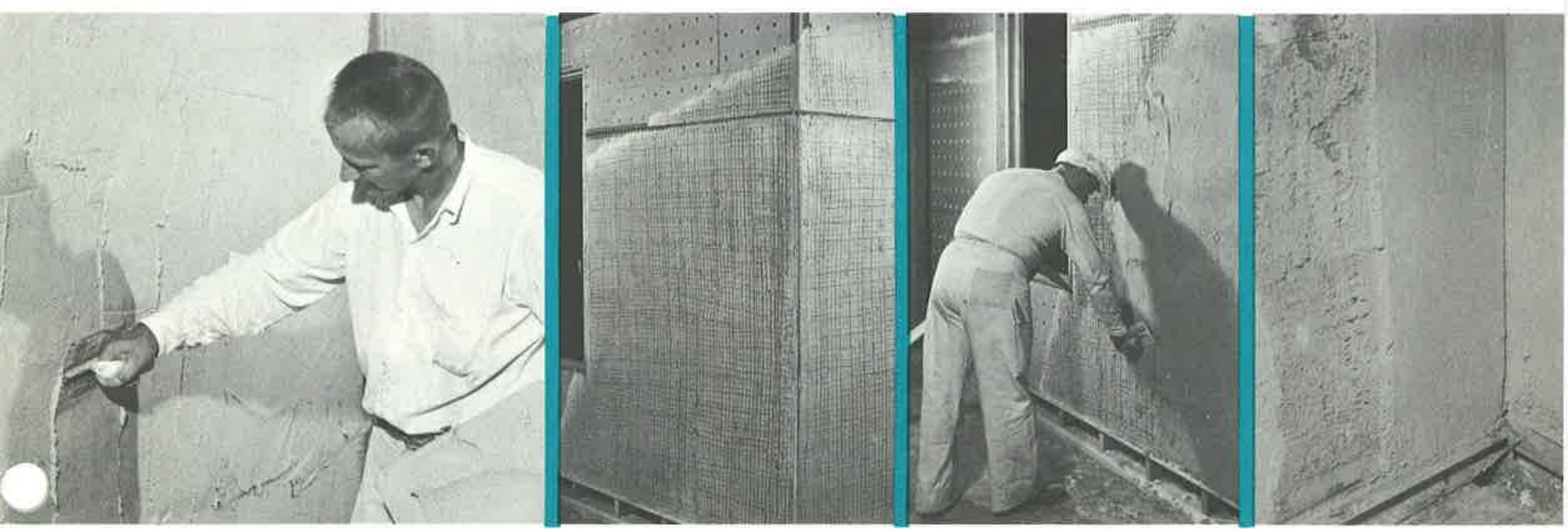
The basecoat plaster may be applied by hand or by machine with equally successful results. The technique is the same and the work is accomplished by one of two methods, three-coat work or two-coat (double-back) work.

THREE-COAT WORK

A three-coat plaster application may be described as, first, a scratch coat of plaster which is applied directly to the plaster base, cross raked after is has "taken up," and allowed to set and to partially dry; second, the application of a brown coat of plaster which is surfaced or brought out to the proper grounds, darbied, allowed to set and to partially dry; and third, the application of the finish coat. Three-coat plastering is required over metal lath, over ½ in. gypsum lath attached to horizontal supports greater than 16 in. o.c., over gypsum lath on ceilings where the lath is attached by clips providing edge support only and over ⅜ in. perforated gypsum lath on ceilings.

TWO-COAT WORK

The two-coat application is similar in every



respect except that the cross raking of the scratch coat is omitted and the brown coat of plaster is applied (doubled-back) within a few minutes to the unset scratch coat.

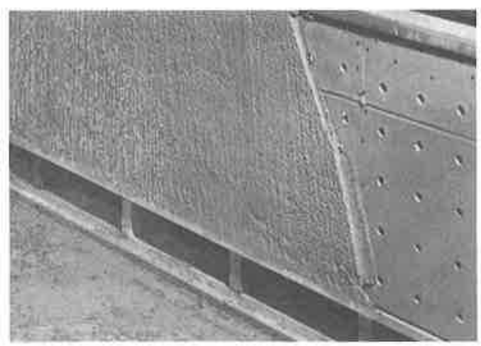
The latter method is generally accepted in applying plaster to masonry and gypsum lath.

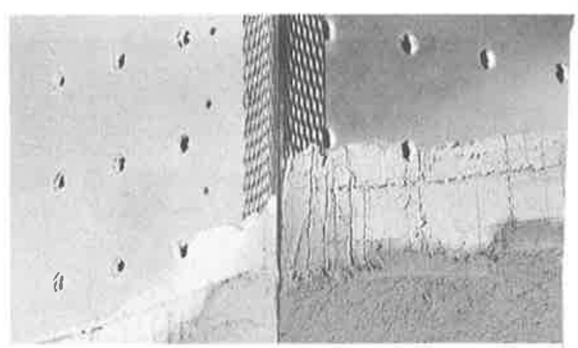
It should be said that the three-coat application is somewhat preferred. It develops a harder and stronger base coat, because a set and partially dried scratch coat has considerable suction which draws much of the excess water from the brown coat. The brown coat is thereby densified because the water-to-gypsum-ratio is reduced, thus producing a stronger plaster.

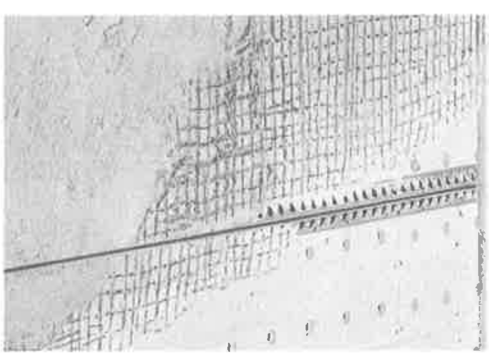
PLASTER THICKNESS

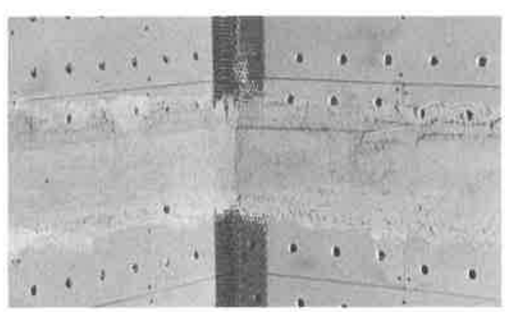
The thickness of the basecoat plaster is one of the important elements of good plastering. The thickness is controlled by the use of grounds. These may be defined as wooden or metal strips applied at the perimeter of all openings; or a continuous strip of plaster applied at intervals along the wall or ceiling and carefully faced out straight and true to serve as screeds or guides for plastering the space between them. A good plaster job must have grounds or screeds (sometimes both) and the mechanic uses his rodding tool between them to develop the true plaster plane and a proper thickness. Plaster screeds bond with the adjacent plaster and become an integral part of the base coat.

Years of experience and research have determined the minimum plaster thickness that can be expected to give satisfactory results. A plaster job should be inspected constantly for base coat thickness. For example, the proper grounds for basecoat plaster on gypsum lath is established at ½ in. Unless grounds or plaster screeds are used on ceilings or large walls without openings, it is most difficult for a mechanic to maintain a uni-









form $\frac{1}{2}$ in. thickness. Should the thickness be reduced to $\frac{3}{8}$ in. there are strong possibilities that the plaster job will possess insufficient strength to resist normal framing distortions without cracking. A $\frac{1}{2}$ in. thickness of plaster possesses almost twice the resistance to bending as a $\frac{3}{8}$ in. thickness.

GROUNDS

For different plaster bases the grounds should be set to provide a minimum plaster thickness, including finish coat of:

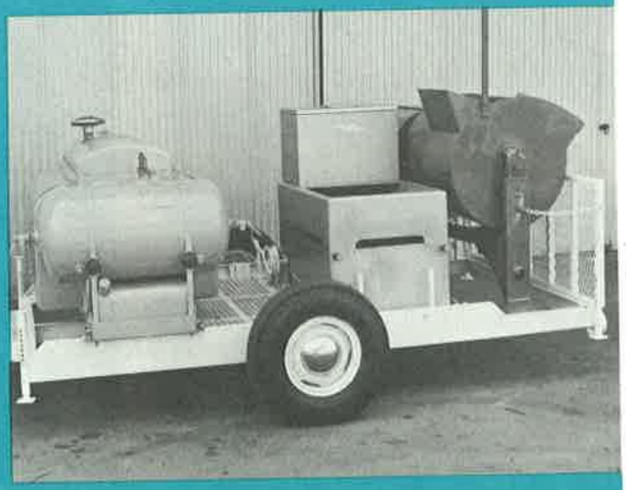
1. $\frac{1}{2}$ in. over gypsum lath and gypsum partition tile.
2. $\frac{5}{8}$ in. over brick, clay tile or other masonry.
3. $\frac{5}{8}$ in. over the face of metal lath ($\frac{3}{4}$ in. from the back of the metal lath).

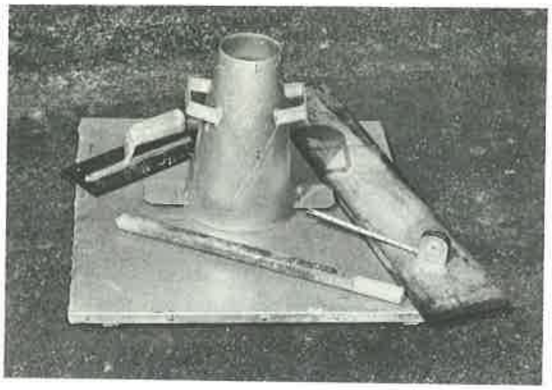
Grounds should be placed around all openings, and plaster screeds should be used on all large area plaster surfaces at intervals that will permit rodding between grounds and/or screeds to assure proper base coat thickness, allowing $\frac{1}{16}$ in. for the thickness of the finish coat.

MACHINE APPLICATION OF BASECOAT PLASTER

Perhaps the most recent development in the plastering industry centers around the plastering machine. Plastering machines are used almost universally on large jobs. Because this modern method of application has greatly increased the rate of production per unit of cost, it has changed work methods and opened new opportunities for plastering. It is also used to spray fireproofing directly to steel and to apply plaster finishes, including acoustical plaster.

With machine application, the plaster is put in place by only one plasterer, the nozzle man.





One to four plasterers follow behind him to darby the wall and laborers are used to mix the plaster and move the hose. An excellent quality of plaster may be expected when the machine is properly used, equal to or better than plaster applied by hand. The lapsed time between mixing of the plaster and its application is shortened, thus permitting a quicker setting time that improves quality. The machine makes possible the densification or compacting of the plaster base coat to improve its strength.

The use of special additives or excess water, under the guise of increasing fluidity should be avoided. It is detrimental to the strength of plaster (see water-gypsum ratio, page 20).

The extensive use of the plastering machine has emphasized the need for a method of determining consistency of plasters before the set takes place. Accordingly, there has been developed an adaptation of the so-called "slump test" sometimes used in pouring of concrete. In cannot be used for precise determinations of strength but rather as a guide. Plaster as delivered from the nozzle is poured into a standard 12 in. high cone which is then removed. By measuring the total slump of the plaster a rough indication is obtained of the strength of the dry, set plaster.

Machine application of plaster is the modern way of plastering and is generally used on large plaster operations.

DRYING

Proper drying of plastered surfaces is important to their ultimate performance. Drying too fast before the plaster has set may leave insufficient water for the chemical reaction that produces the set when the plaster become hard. However, rapid drying after the plaster has set is conducive to high strength and should be encouraged. Slow drying should be avoided at all costs because it may cause a "sweat out" condition that impairs strength. Like most cementitious building materials, rapid changes of temperature set up structural stresses in plastered surfaces. And since the strength of wet plaster is but a fraction of its dry strength, every precaution should be taken to avoid thermal shock during application and while drying.

In cold weather, the minimum temperature of 55° F. should be maintained in the building for a period of at least seven days before plastering, during the plastering operation and until the plaster is dry. When temporary heat is provided, proper measures should be taken to insure even distribution of heat in all plastered areas. Deflection screens should be used to prevent concentrated or uneven temperatures near the heat source. Care also should be taken to prevent unusual drafts before the plaster has set, especially in hot weather, because water may leave the wall before the plaster has set, thus causing a dry-out. In hot, dry weather, all openings should be closed with cloth or sash during the application of plaster and until it has set. After the plaster has set, ventilation should be provided until it is dry. There is a common tendency to restrict the amount of ventilation after the plaster has set. This should be avoided. The excess moisture should be removed quickly.

GYPSUM NEAT PLASTER

Gypsum neat plaster, when mixed with an aggregate such as sand, perlite or vermiculite, is used over gypsum lath, metal lath, gypsum partition tile and with clay tile and brick having moderate suction. It is also recommended as a base coat over portland cement (concrete) block walls. Fibered-gypsum neat plaster is used as a scratch coat over metal lath—for all purposes unfibered gypsum may be used. The physical properties of the base coats differ with the type of plaster aggregate used.

GYPSUM-SAND BASE COAT

FUNCTION

This is the most widely used basecoat plaster where good sand is available. It will meet most design requirements except where high fire ratings or weight reduction is required. It may be hand applied or machine applied.

WEIGHT

The density of 1:2 proportioned gypsum-sand base coat is 100-115 lb. per cu. ft.; a 1:3 mix will weigh 104-120 lb. per cu. ft.

FIRE RESISTANCE

Fire-resistance ratings up to 2½ hours are obtainable with gypsum-sand base coats on most partition and several floor-ceiling assemblies.

STRENGTH

Proportions (gypsum to aggregate)	Compressive Strength (psi)	Tensile Strength (psi)
1:2	775-1050	150-200
1:3	525- 700	100-150

WATER REQUIRED

Average water requirements to bring the following mixes to a workable consistency are:

1:2—57 lb. water per 100 lb. plaster
1:3—68 lb. water per 100 lb. plaster

HARDNESS RATING—TWO

INSULATION

Conductance (C) (Btu./sq. ft./Hr./°F./ one in. thick)	Mix	C
	1:2	5.51
	1:3	5.60

COST

This is generally the most economical base coat, particularly if good plastering sand is available and not too expensive.

GYPSUM-PERLITE BASE COAT

FUNCTION

This plaster performs all of the functions enumerated for gypsum-sand base coats and offers, in addition, increased fire resistance and decreased weight. It is used also where plastering sand is unsuitable or too expensive. The aggregate may be job mixed or mill mixed.

WEIGHT

The density of a 1:2 proportioned gypsum-perlite base coat is 50-56 lb. per cu. ft.; a 1:3 mix will weigh 41-45 lb. per cu. ft.

FIRE RESISTANCE

Increased fire-resistance ratings, through four hours, are obtainable with gypsum-perlite base coats on all systems and assemblies.

STRENGTH

Proportions (gypsum to aggregate)	Compressive Strength (psi)	Tensile Strength (psi)
1:2	600-800	165-170
1:3	450-600	90-150

WATER REQUIRED

1:2—64 lb. water per 100 lb. plaster
1:3—76 lb. water per 100 lb. plaster

HARDNESS RATING—THREE

INSULATION

	Mix	C
Conductance (C)	1:2	1.64
	1:3	1.31

COST

Material costs are generally slightly higher than with sand but this may be offset by increased production due to lighter weight.

GYPSUM-VERMICULITE BASE COAT

FUNCTION

This plaster performs all the functions enumerated for gypsum-perlite base coats.

WEIGHT

The density of a 1:2 proportioned gypsum-vermiculite base coat is 50-55 lb. per cu. ft.; a 1:3 mix will weigh 42-45 lb. per cu. ft.

FIRE RESISTANCE

Same as for gypsum-perlite basecoat plasters.

STRENGTH

Proportions (gypsum to aggregate)	Compressive Strength (psi)	Tensile Strength (psi)
1:2	400-525	130-160
1:3	250-325	70-100

HARDNESS RATING—FOUR

INSULATION

	Mix	C
Conductance (C) (Btu./sq. ft./Hr./°F./one in. thick)	1:2	1.74
	1:3	1.42

COST

Costs are generally considered equal to gypsum-perlite base coats.

GYPSUM WOOD-FIBERED PLASTER

Gypsum wood-fibered plaster is a neat base-coat plaster requiring the addition of only water on the job. It is integrally mixed with selected wood fibers which serve as an aggregate. It may be used over the same plaster bases as gypsum neat plaster. Although generally used neat, one cu. ft. of sand may be added to each 100 lb. of wood-fibered plaster for unit masonry.

FUNCTION

Gypsum wood-fibered plaster base coats are used where good plastering sand is not available—where greater base coat strength is desired—where fire resistance greater than that afforded by sand is required—and for alterations, repairs and patching. It is sometimes used as a scratch coat to which a sanded brown coat is applied to extra strength to the base and base coat.

WEIGHT

The density of gypsum wood-fibered plaster used neat is 79-82 lb. per cu. ft.

FIRE RESISTANCE

Gypsum wood-fibered plaster gives consistently higher fire-resistive ratings, generally 50 per cent greater than those plasters containing sand. It is not as efficient as perlite or vermiculite base coats for ratings of two hours or more.

STRENGTH

Proportions	Compressive Strength (psi)	Tensile Strength (psi)
Neat	1750-2350	280-400
1:1 (Sand)	1600-2200	240-250

WATER REQUIRED

Neat—65 lb. water per 100 lb. plaster

HARDNESS RATING—ONE

INSULATION

	Mix	C
Conductance (C)	neat	3.15

COST

Material costs are slightly higher than for sanded, perlited and vermiculited base coats. Labor costs are generally about the same as for sanded base coats.

GYPSUM READY-MIXED PLASTER

Gypsum ready-mixed plasters consist of gypsum neat plaster and an aggregate combined or mixed at the manufacturing plant. Usually the aggregate is perlite but in some instances may be sand or vermiculite.

This plaster possesses all the features and advantages of gypsum neat plasters mixed on the job. In addition, it offers mill control and responsibility for the quality, gradation and proportioning of the aggregate.

The physical properties are the same as those enumerated for gypsum neat plaster depending upon the type of aggregate mixed with the plaster at the plant.

BOND PLASTER

WHERE USED

Bond plaster is used as a basecoat plaster on interior monolithic concrete surfaces. It is often used on concrete as a scratch coat to be followed by a thin brown coat of plaster.

BOND

Portland cement concrete is very dense and provides an unsatisfactory base to receive the more commonly used gypsum plasters—bond is inadequate and their use invites failure. Bond plaster is specially designed to adhere directly to concrete when the surface is properly prepared. Refer to *Recommended Specification—Gypsum Plastering* published by the Gypsum Association, for surface preparation and application.

THERMAL EXPANSION

The thermal expansion of concrete is somewhat lower than for gypsum neat plasters or wood-fibered plaster. However, bond plaster is designed to equalize this difference and approximate the thermal expansion of concrete thereby reducing the possibility of shear and spalling.

COST

Labor and material costs for bond plasters are approximately equal to those for a scratch coat of wood-fibered plaster.

FINISH COAT PLASTERS

GENERAL

The finish coat of plaster is the last plastering operation before decorating. Since the walls and ceilings are about 75 per cent of visible room area, the finish coat cannot be dwarfed in importance. The type of finish must be architecturally correct and yet meet the use requirements and be compatible with the lath and basecoat plaster used.

The proper materials must be selected and applied in a manner that will provide a lasting and durable surface. In addition, they must provide an adequate bond with the brown coat of plaster and have sufficient plasticity for the mechanic to manipulate. Judged purely from utility, finishes may be classified according to texture, color, and hardness.

There are six finish coat plasters, each with a specific function, that are universally available to provide a wide latitude of selection. They are:

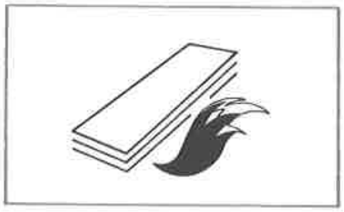
- Smooth Finishes
  - Gypsum-lime putty trowel finish
  - Keene's cement-lime putty trowel finish
  - Prepared gypsum trowel finish
- Float Finishes
  - Keene's cement-lime sand float finish
  - Gypsum-sand float finish
- Acoustical Plaster Finishes

LIME

Lime is used in three of the most common finishes and deserves general consideration.

The purpose of lime is to provide plasticity and bulk to the finish coat. Lime, however, does not set and will not produce a hard finish when used alone. Furthermore, the lime is subject to considerable shrinkage when drying. For these reasons, it is mixed with gypsum plaster, either gauging or Keene's cement, to provide the necessary hardness and resistance to shrinkage.

Lime is made from limestone by the simple burning process in a kiln which reduces the lime-



stone ($CaCO_3$) to calcium oxide (CaO). This is known as "quicklime." It is slaked or soaked in water at the job site, changing the quicklime (CaO) to $CA(OH)_2$, ready for use on the wall. It produces a white, buttery consistency lime putty, with good plasticity and workability.

HYDRATED LIME

Hydrated lime is quicklime which has been partially hydrated during the manufacturing process. After delivery to the job, it is soaked or slaked for as much as 24 hours depending upon the type of lime to complete the hydration to $CA(OH)_2$ and produce a plastic lime putty, similar to that obtained by soaking quicklime. The hydration process at the time of manufacture merely reduces the required slaking period.

There are two basic types of hydrated lime:

> Normal hydrated lime (Type N) requires 12-24 hours soaking.
>
> Special hydrated lime (Type S) does not require soaking and, after mixing with water, may be used immediately.

The great majority of lime for finish coats is shipped from the Ohio fields and is known as dolomitic lime. Unlike other limes made from pure limestone ($CaCO_3$ or calcium carbonate), these dolomitic limes from Ohio contain both calcium carbonate and magnesium carbonate. It was believed that the magnesium in dolomitic limes behaved exactly as did the calcium carbonate and that the magnesium would hydrate as readily as the calcium.

However, this has proved a fallacy and it has been discovered that the magnesium oxide only partially hydrates during the slaking period and that, after being placed on the wall in the finish coat, the magnesium continues to hydrate for many years. This hydration of lime is sometimes accompanied by expansion and it was found that, under certain conditions, the continued hydration of the magnesium gradually expanded the finish coat of plaster until considerable areas were forced away from the brown coat.

Having established these facts, the lime industry, through exhaustive research, developed a manufacturing process whereby the magnesium in these dolomitic limes might be almost completely hydrated. That process is known as pressure hydration or the autoclave process of hydration. Much of the dolomitic lime shipped from the Ohio fields is now manufactured by one of these processes.

Many federal specifying agencies now require this type of lime by inserting a clause in their specifications requiring a minimum of 92 per cent hydration (or a maximum of eight per cent of unhydrated oxides). Those limes shipped from the Ohio fields which are pressure hydrated or autoclaved are shipped in bags bearing the statement that they contain no more than eight per cent of unhydrated oxides. Slaking or soaking is generally unnecessary.

GAUGING PLASTERS

Gauging plasters are specially ground gypsum plasters—a coarse grind with low consistency. They soak up the mixing water readily and blend easily with the lime putty. Contrary to the opinion of many, neat gypsum plaster should never be used for gauging because it will not readily soak up the water and does not thoroughly blend with the putty except after much manipulation on the board. Furthermore, is sets slowly, whereas gauging plasters have a much faster setting action. Gypsum gauging plasters are not designed for ornamental cornice work or run moldings. This type of work requires a finer grind of material and gypsum molding plaster is specially designed for this purpose.

Gypsum gauging plasters are available in "quick set" and "slow set." These two setting periods are provided to make it unnecessary for the mechanic to use retarder or accelerator because they are difficult to properly blend. Their use should be discouraged. Gauging plasters are also available as white gauging plaster and local gauging plaster. The latter is somewhat darker in color, thus reducing the whiteness of the finish coat when gauged with putty. For brilliant white finishes, white gauging plaster should always be used.

KEENE'S CEMENT

Keene's cement is another form of gypsum gauging plaster and is used with lime for harder than average finishes. Unlike other gypsum plasters, Keene's cement is burned in a kiln instead of a calciner or kettle. It is considered to be dead-burned since practically all of the chemical-

ly combined water has been removed in the burning process. It is manufactured from selected white rock to provide the hardest white gypsum finish available. Since more water of crystallization has been removed, it is a denser material, thus providing unusual resistance to impacts or abrasions. Its density also provides a lower rate of water absorption than other gypsum products.

Regular Keene's cement has an initial set of about one and a half hours and a final set of approximately four to six hours. There is available, however, a quick setting Keene's cement which provides a final set of approximately two hours.

Keene's cement is used in exactly the same manner as described for gauging plaster, except for the difference in proportioning as set forth on page 28. Strict adherence to the proportioning must be observed in the use of Keene's cement.

MOLDING PLASTER

Molding plaster is another gypsum plaster sometimes used for gauging lime putty finish coats. The grind is much finer than that for other gauging plasters, thus providing a smooth surface free from streaks or indentations as might be obtained with coarser ground materials. This feature makes molding plaster an ideal gauging for intricate or close tolerance work. Equal parts of lime putty and molding plaster are normally used. This is equivalent to 50 lb. of dry hydrated lime and 100 lb. of molding plaster.

AGGREGATES FOR FINISH COATS

TROWEL FINISHES

The addition of a fine silica sand or perlite fines increases the crack resistance of gauging-lime putty or Keene's cement-lime putty trowel finishes when these are used over lightweight aggregate basecoat plasters. Not only does it increase the resistance to cracking caused by structural stress, but the incidence of map or craze cracking is greatly reduced over lightweight aggregate basecoat plasters by "spiking" the finish coat. A minimum of ½ cu. ft. of aggregate is recommended for each 100 lb. of dry gauging or Keene's cement. This is added to the mix during the blending or kneading of the lime putty and the gauge. It is important to have the aggregate evenly interspersed throughout the mix.

FLOAT FINISHES

Where textured surfaces are required, the addition of graded, clean sand is made to a mixture of Keene's cement and lime putty. The desired texture of the finish dictates the coarseness of the sand. Usually this sand will be graded to pass through either a No. 12, 16 or 20 sieve. The proportions are given on page 15.

OTHER AGGREGATES

There are other aggregates used in plaster finishes such as vermiculite. In these, the recommendations of the manufacturer should be followed closely.

GAUGING OF LIME

The mixing of lime, gauging plasters and fine aggregate represents the most important operation in the use of lime putty trowel finishes. To use an insufficient amount of gauging, whether it be gypsum gauging plaster, Keene's cement, or molding plaster is to invite trouble such as check cracking or soft and spotty finishes. The specific quantities of materials are as given on page 25. Proportions may be specified by weight or by volume. In converting lime proportions consider 100 lb. of dry hydrated lime equal to 200 lb., 2¼ cu. ft. or 17½ gal. of lime putty. The following procedures apply to all types of lime putty trowel finishes.

After the lime has been properly slaked to a smooth putty, it is brought to the plasterer's board and formed into a doughnut-like ring. Water to absorb the gauging is placed in the ring. The dry gauging plaster, Keene's cement or molding plaster is sifted into the water.

At this time the recommended volume of silica sand or perlite fines is added if the finish is to be applied over lightweight aggregated base-coat plaster. The mixture of lime putty, gauging and aggregate is kneaded thoroughly to produce an even distribution of gauging and aggregate throughout the putty. This mixture may also be used over sanded base coats.

A more satisfactory method of mixing is to use a mechanical mixer of a type designed specifically for mixing lime and gauging materials. This machine consists of a drum with a motor-driven agitator which blends lime putty, gauging and aggregate very rapidly with a thoroughness not generally obtainable by conventional hand-mixing methods. The intense agitation beats the material into a creamy consistency that produces high yields and superior working qualities. This procedure is particularly recommended when the Type S finishing limes, which require no soaking, are to be used.

APPLICATION OF TROWEL FINISHES

Trowel finishes are applied over a dry or nearly dry base coat using sufficient pressure to force the material into the slightly roughened base coat, a very thin application is made over the wall or ceiling. Suction in the base coat is desirable because that draws the finish into the pores of the base coat. After this tightly scratched coat has "drawn up," the second or leveling coat is applied and left smooth under the trowel. This is the last coat of plaster and must be applied evenly and uniformly to a true and level surface.

The base coat suction will gradually draw the water from the finish surface and the mechanic then starts his final troweling. With a large brush dipped in water, he moistens the surface of the finish and trowels at the same time over the entire area. Considerable pressure must be exerted on the trowel to densify the surface and produce the smooth, close grain, hard finish. It is advisable, especially if the surface has not been slicked down to a mirrorlike finish, to repeat this operation, usually just as the finish begins to set. The final operation consists of merely wetting down the surface with the brush and clean water.

SAND FLOAT FINISHES

MIXING AND APPLICATION

The techniques for mixing lime with gauging plaster or Keene's cement and an aggregate for float finishes follow, generally, the same procedures outlined for trowel finishes. In some instances, the quantities mixed are greater, particularly if an integral limeproof coloring material is used. This is to insure a uniform intensity of color. Particularly with job-mixed colored float finishes, care should be taken to prepare enough material to finish full panels.

The base coat over which the float finish is to be applied should be uniformly damp. This prevents water being drawn from the finish before it can be floated. Variation in dampness will result in varying degrees of coarseness of the finish because the aggregate will come to the sur-

face more readily when excess water is present.

The application procedure also is quite similar to that for trowel finishes. The floating of the surface, in lieu of final troweling, takes place when the finish starts to take up. Two operations are generally used. First the surface is rough floated, using a wooden float with additional water brushed onto the finish, then followed immediately by a final working with a rubber float.

TYPES OF FINISHES

GYPSUM-LIME PUTTY TROWEL FINISH

This is commonly known as white coat finish. Composed of lime putty and gypsum-gauging plaster, it is by far the most commonly used finish in the United States. Quicklime or hydrated lime may be used for the putty.

ADVANTAGES

Appearance: This finish provides a beautiful and pleasing surface for a most subtle decoration. When properly applied it provides a gleaming white surface, completely devoid of texture. It is adaptable to any form of decoration.

Hardness: This finish is designed for normal uses and is amply hard for that purpose. If a harder finish is necessary, the gauging content may be increased to one part of gauging to two parts of lime putty by volume, or Keene's cement may be used in lieu of gauging plaster.

Plasticity: This finish has excellent workability because it has high plasticity and spreads easily under the trowel.

Permanence: For normal usage and the purpose for which it is intended, it will last the life of the building provided it is applied to a reasonably strong base coat of plaster.

Low Cost: Generally, a gypsum-lime putty trowel finish is the lowest cost finish available. The material costs are low and they provide an exceptionally high yield or coverage.

Proportions: The proportions of gypsum gauging to lime by weight of dry materials is 100 lb. of gauging to not more than 200 lb. of dry hydrated lime. When this finish is applied over perlite or vermiculite base coats not less than ½ cu. ft. of silica sand or perlite fines is added for each 100 lb. of gauging.

Precautions: Under no circumstances should this finish be applied unless it is proportioned according to specifications; otherwise checkcracking, crazing, bond failure or lack of hardness are almost inevitable. Decorations involving oil paints may saponify with the lime if applied too early. The finish coat should be allowed to stand for at least thirty days before the application of such decorations.

KEENE'S CEMENT-LIME PUTTY TROWEL FINISH

This is similar in most respects to gypsum-lime trowel finish except that Keene's cement is used in lieu of gauging plaster. Lime-Keene's finishes should be used where a harder surface is desired such as walls of bathrooms, kitchens, service corridors, hospitals, etc. The Keene's content may be increased for greater hardness.

ADVANTAGES

Hardness: Keene's cement-lime putty trowel finishes provide a surface hardness ranging from slightly harder than gypsum-lime to the hardest of all finishes, depending upon the proportioning with lime. Hardness values are given under proportions below. The extra hard finish is recommended for usage such as gymnasiums, school corridors, hospitals and trucking areas.

Adaptability: This finish may be troweled to a smooth monolithic surface or it may be scored to simulate ceramic tiles. There is no limitation to the decoration that may be applied.

Proportions: The proportioning of Keene's cement to lime by weight of dry materials varies according to the degree of hardness desired. These are:

Medium Hard—100 lb. of Keene's cement to 50 lb. dry hydrated lime.

Extra Hard—100 lb. of Keene's cement to 25 lb. dry hydrated lime.

When these finishes are applied over perlite or vermiculite base coats not less than ½ cu. ft. of silica sand or perlite fines is added for each 100 lb. of Keene's cement.

Precautions: It should be noted that Keene's cement-lime putty trowel finishes should be ap-

plied only to a very strong base coat. The surface should be observed and occasionally troweled until completely set to produce a dense finish.

KEENE'S CEMENT-LIME
SAND FLOAT FINISH

This is a widely used float finish wherein the type of sand aggregate and the amount of sand used are varied to produce the required texture. Its use is recommended over all types of basecoat plasters and plaster bases where maximum visual performance and plaster integrity is required. It is particularly recommended for use over lightweight aggregate basecoat plasters.

ADVANTAGES

Crack Resistance: Sand float finishes provide a higher factor of safety against cracking than do smooth trowel finishes.

Appearance: Textures that float finishes provide, add character to wall and ceiling surfaces.

Low Cost Decoration: Sand float finishes may be integrally mixed with color prior to application for a low cost finish or may be painted afterwards in the usual manner.

Permanence: For normal usage, these finishes will last the lifetime of the building.

Proportions: Depending on the texture desired, 400-600 lb. of silica sand per 150 lb. of Keene's cement and 100 lb. dry hydrated lime may be used.

Precautions: In mixing color with sand float finishes, limeproof colors must be used. The color should be blended thoroughly and mixed with the dry plaster to prevent streaking and color variations. Enough material should be mixed at one time to complete the job or a full panel. This avoids the risk of color variations.

PREPARED GYPSUM TROWEL FINISH

This is a factory prepared gypsum finish requiring only the use of water at the job. An exceptional bond is assured over a gypsum base coat. Possessing an extremely hard surface, it provides excellent protection from the most severe abuses. It may be decorated as soon as it becomes dry—paint saponification is avoided.

Gypsum trowel finishes possess good workability. The finish is applied in the same manner as for other trowel finishes, although, possessing a moderately fast set, this finish should be finish-troweled earlier than normal and before this takes place. A third and very thin leveling coat may be applied to achieve the very best results.

PREPARED GYPSUM FLOAT FINISHES

These finishes are similar in every respect to Keene's cement-lime sand float finishes except they are factory prepared. They possess all their advantages and in addition offer factory blending of color and other materials. These finishes are applied in the same manner as for job-mixed float finishes. No water should be used for floating; floating should be uniform and the suction of the basecoat plaster must be uniform.

MILL PREPARED FINISHES

ACOUSTICAL PLASTERS

These plasters are designed primarily to absorb sound. In almost every case they are ready-mixed plasters requiring only the addition of water on the job. Depending on the type, they may be hand or machine applied—however, most acoustical plasters today are machine applied. In general, noise reduction coefficients that may be obtained with these products vary from .40-.60. The outstanding advantages of acoustical plasters over other acoustical materials is fire resistance, noncombustibility and the ability to follow complex shapes and contours. Resistance to cracking is equal to sand float finishes.

Acoustical plasters are generally softer than a conventional finish coat. For this reason their use normally is confined to ceilings and to the upper part of walls where abrasion is not likely to be encountered.

DESIGN FACTORS FOR LATH AND PLASTER SYSTEMS

The ultimate performance of lathing and plastering systems can be predicted now with a much higher degree of accuracy. This section deals with the factors that affect visual performance.

The degree by which the various components of plastered systems contribute to better performance of the systems is shown in the "Rating Table, page 34." It as based upon years of intensive research, both laboratory and applied, and recorded field experiences.

The following general observations may be made of the relative effect of the several components of lath and plaster systems as they influence performance.

FINISH COAT OF PLASTER

The various finish coats of plaster exhibit a wide range of performance, hence, selection of the finish coat becomes very important.

Sand float finishes provide a high factor of safety against cracking and are highly recommended. Acoustical plasters and certain texture finishes are considered to be equal to sand-float finishes, thus are equally recommended.

Smooth troweled finishes, such as gypsum gauging with lime putty, require a much higher degree of rigidity and strength in the lath and basecoat plaster for good visual performance. When the use of high strength basecoat plasters is impractical, consideration should be given to the elimination of perimeter angle restraint.

The visual performance of troweled finishes is considerably improved by the addition of ½ cu. ft. of fine silica sand or perlite to each 100 lb. of gauging plaster or Keene's cement. The Gypsum Association recommends this fine aggregate proportioning for lime-putty trowel finishes applied over lightweight aggregate base coats.

PLASTER BASE

The rigidity of the base to which plaster is applied is an important factor. Under certain conditions the selection of lath is not critical, but when the design calls for a plaster base coat in the moderate to lower range of strengths with a trowel finish, consideration should be given to the selection of a rigid lath and/or the cutting of restraint at the perimeter angles.

BASECOAT PLASTER

Under comparable circumstances, crack resistance is closely related to the strength of the basecoat plasters, the higher ranking base coat strengths generally providing a higher degree of resistance. If good performance is to be expected of intermediate or lower strength plasters, extreme care must be directed to selection of the finish coat and lath, and to the possible need for elimination of perimeter angle restraints.

PLASTER AGGREGATE PROPORTIONS

For the above reasons, the Gypsum Association recommends the following proportioning of aggregate per 100 lb. of gypsum neat plaster regardless of whether it is aggregated on the job site or in the factory (see chart below).

CEILING CONSTRUCTION

Integration of walls and ceilings at the perimeter angles becomes very significant under some circumstances. Differential movement is always a factor, its extent being governed by the building's rigidity and the climatic changes. The performance of lath and plaster depends upon the extent of such movement and the ability of the wall and ceiling surfaces to move independently without transfer of undue stresses from one to the other, and other factors, such as the finish coat, the lathing base and the strength of the plaster. It is believed, however, that restraint in the vertical angles of lath and plaster systems is less significant than in the perimeter angles of ceilings, and that performance in partitions is dependent upon the other factors.

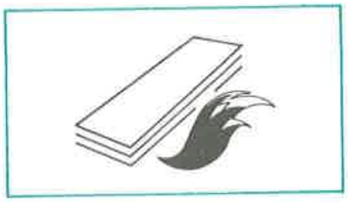
It is recommended that serious consideration be given to the use of details that will help to eliminate continuity of lath and plaster at ceiling perimeters to the extent indicated in the "Rating Table."

In addition to perimeter consideration, large unbroken ceiling areas should be divided by relief joints. The maximum recommended distance

PLASTER BASE	SAND damp-loose		PERLITE OR VERMICULITE	PLASTER BASE	SAND damp-loose		PERLITE OR VERMICULITE
	Volume (cu. ft.)	Weight (lb.)	Volume (cu. ft.)		Volume (cu. ft.)	Weight (lb.)	Volume (cu. ft.)
GYPSUM LATH				METAL LATH			
Two-coat work	2½	250	2	Three-coat work			
				—scratcn	2	200	2
Three-coat work				—brown	3	300	2*
—scratch	2	200	2				
—brown	3	300	2*	MASONRY			
				Two- or three-coat	3	300	3

*Where the plaster is 1 in. or more in total thickness, the proportions for the brown coat may be increased to 3 cu. ft.

NOTE: For three-coat work over gypsum or metal lath the proportions of sanded plaster only may be 1:2½ for both scratch and brown coats in lieu of above.



between such joints is 60 ft. with a maximum undivided area of 2,400 sq. ft.

SUGGESTIONS FOR USE OF RATING TABLE

In fire-resistive construction, a fundamental criteria for the selection of lathing and plastering systems relates to the need for fire resistance. The criteria for sound control may also influence the selection.[1]

Having resolved the question of fire resistance and sound control, the designer is then ready to consider those factors that influence the ultimate visual performance—crack resistance—of lath and plaster systems. It should be noted that the same criteria of excellence need not prevail throughout the structure. For example, excellent performance may be required for certain walls and ceilings, whereas a considerably lesser degree may be satisfactory in elevator shafts.

[1]The *Fire Resistance Design Manual* published by the Gypsum Association shows a wide range of systems with their hourly fire rating, sound transmission loss values, weight and other factors.

Having determined the degree of expected performance, it is suggested that consideration first be directed to the choice of finish coat plasters. If a float finish (or acoustical plaster) meets the visual requirement, its choice would be prudent because the selection of acceptable systems is widened.

The element of design next in importance relates to the possible need for relieving the restraint of the lath and plaster at the ceiling angles, to the extent shown in the table. If excellent performance is to be expected of a ceiling with trowel finish, unrestrained angles are recommended, as shown in the table.

	RESTRAINED CONSTRUCTION			UNRESTRAINED CEILING CONSTRUCTION		
PERFORMANCE	LATH BASE	BASECOAT PLASTER	FINISH COAT	LATH BASE	BASECOAT PLASTER	FINISH COAT
EXCELLENT	G or M	WF	F	G or M	WF	F
	G or M	S	F	G	S or P	F
				G or M	WF	T
				G	S	T
				M	S	F
GOOD	G or M	WF	T	G2	S or P	F
	G	P	F	G	V	F
	G	S	T	M	P	F
	G2	S	F	G2 or M	S	T
	G	V	F	G	P or V	T
	G2 or M	P	F	M	V	F
	G2 or M	S	T			
	G	P	T			
ACCEPTABLE	G2 or M	V	F	G2	V	F
	G	V	T	G2 or M	P	T
	G2 or M	P	T			

G—Gypsum Lath—3-Coat Plastering
G2—Gypsum Lath—2-Coat Plastering
M—Metal Lath—3-Coat Plastering
WF—Neat Wood-Fiber Scratch and Gypsum-Sanded Brown
S—Sanded Plaster
P—Perlited Plaster
V—Vermiculited Plaster
F—Sand Float Finish
T—Smooth Trowel Finish
NOTE: All proportioning of base coat and finish coat plaster shall be as recommended herein. All trowel finishes to be aggregated as recommended herein.

PLASTERING TERMS

ACCELERATOR: Any material added to gypsum plaster which speeds up the natural set.

ACOUSTICAL PLASTER: A finishing plaster designed to correct sound reverberation or reduce noise intensity.

ADMIXTURE: Any substance added to a plaster component or to plaster mortar for the purpose of altering its properties.

AGGREGATE: Inert material, used as a filler for mixing with any cementing material. The word used with or in connection with plastering usually means sand or vermiculite.

ANHYDROUS CALCIUM SULPHATE: A stable form of gypsum from which practically all of the water of crystallization has been removed. Described by the term dead-burned gypsum.

ARCH: Curved top of opening. Structurally designed to carry load to side members.

ARRIS: A sharp edge, forming an external corner at the junction of two surfaces.

BACK-PLASTERING: A term denoting plaster applied to one face of a lath system following application and subsequent hardening of plaster applied to the opposite face. Back-plastering is used primarily in construction of solid plaster partitions and certain exterior wall systems.

BASE COAT: The plaster coat or combination of coats applied previous to the finish coat.

BEAD: A strip of sheet metal usually formed with a projecting nosing and two perforated or expanded flanges. The nosing serves to establish plaster grounds while the flanges provide for attachment to the plaster base. Used at the perimeter of a plaster membrane as a stop or at projecting angles to define and reinforce the edge. Types are corner beads, base beads and casing beads.

BED MOLD OR BED: A flat area in a cornice, designed to have enrichments planted later.

BLISTERS: Protuberances on the finish coat of plaster caused by application over too damp a base coat, or troweling too soon.

BONDING AGENT: A substance applied to a surface to improve the quality of the bond between it and succeeding plaster application.

BOND PLASTER: A specially formulated gypsum plaster designed as a first coat application over monolithic concrete.

BOSS: A gothic ornament planted at the intersection of moldings.

BRACKET: A superficial structure, usually in angles forming a frame to support lath. Its main purpose is to save material and weight in ornaments or cornice.

BREAK: An interruption in the continuity of a plastered wall or cornice.

BROWN COAT: Coat of plaster directly beneath the finish coat. In two-coat work, brown coat refers to the basecoat plaster applied over the lath. In three-coat work the brown coat refers to the second coat applied over a scratch coat. Brown coats are applied with a fairly rough surface to receive the finish coat.

BUCKLES: Raised or ruptured spots which eventually crack, exposing the lath beneath. Most common cause for buckling is application of plaster over dry, broken or incorrectly applied wood lath.

BULL NOSE: This term describes an external angle which is rounded in order to eliminate a sharp corner. Used largely at window returns and door frames. Advantages are ease of cleaning and its durability. Can be made by running with plaster or obtaining a bull nose corner bead with the proper radius.

BUTTERFLIES: Color imperfection on a lime putty finish wall. Large varieties which smear out under pressure of the trowel. Caused by lime lumps not put through a screen; insufficient mixing of the gauging.

CALCINED GYPSUM: Gypsum that has been partially dehydrated by heat.

CAPITAL OR CAP: The ornamental head of a column or pilaster.

CASE MOLD: Plaster shell used to hold various parts of a plaster mold in correct position. Also used with gelatine and wax mold to prevent distortions during pouring operation.

CASING BEAD: A bead used at the perimeter of a plaster membrane or around openings to provide a stop and, to provide separation from adjacent materials.

CASTS: Finished product from a mold. Sometimes referred to as staff. Used generally as enrichments and stuck in place.

CATFACE: Flaw in the finish coat comparable to a pock mark.

CEMENT PLASTER: Gypsum plaster formulated to be used with the addition of sand for basecoat plaster. Sometimes called neat or hardwall.

CHECK CRACKS: Cracks in plaster caused by shrinkage, but still bonded to its base.

COFFERED CEILINGS: Ornamental ceilings made up of sunken or recessed panels.

CONTACT CEILING: A ceiling which is secured in direct contact with the construction above without use of furring.

CRAZE CRACKS: Fine, random fissures or cracks which may appear in a plaster surface caused by plaster shrinkage. Also termed "check cracking," these cracks are generally associated with a lime finish coat that has not been properly gauged or troweled.

CURE: To provide conditions conducive to completion of the hydration process. Generally used in conjunction with portland cement plaster to insure complete hydration throughout the period required for this process to take place.

DARBY: A flat wooden or metal tool about 4 in. wide and 42 in. long with handles; used to smooth or float the brown coat; also used on finished coat to give a preliminary true and even surface.

DENTILS: Architectural terms for small rectangular blocks which are often planted in a series in the bed mold of a cornice.

DOLOMITIC: Term used to denote a type of lime or limestone containing calcium carbonate in combination with up to 50 per cent magnesium carbonate.

DOPE: Term used by plasterers for additives made to any type of mortar to either accelerate or retard its set.

DOUBLE-UP: When plaster is applied in successive operations without a setting and drying interval between coats.

DRY OUT: Soft, chalky plaster caused by water evaporating before setting.

EFFLORESCENCE: White, fleecy deposit found on the face of plastered walls. Caused by salts in the sand or backing. The process of efflorescing is also "whiskering" or "saltpetering."

EGG AND DART: Enrichments frequently used in cornices. The design is that of an oval and a dart used alternately. It is said the egg represents life and the dart death.

EGGSHELLING: Refers to the condition of chip-cracked plaster, either base or finish coat. The form taken is concave to the surface and the bond is partially destroyed.

ENRICHMENTS: Any cast ornament which cannot be executed by a running mold.

EXPANDED METAL: Sheets of metal which are slit and drawn out to form diamond shaped openings. This is used as a metal reinforcing for plaster and termed "metal lath."

FAT: Material accumulated on the trowel during the finishing operation and used to fill in small inperfections. Also a term to describe working characteristics of any type mortar.

FEATHER EDGE: A tool of metal or wood having a bevelled edge; used in finish coat work to straighten re-entrant angles.

FENCE: Term used in cast shops describing a wall of plaster or clay placed around model before pouring material to make the mold.

FIBER: Two types used—hair and sisal. Hair fiber is a product of the packing house, while sisal is a vegetable fiber. One is equal to the other and both act as a binder to keep the keys from breaking off until set takes places.

FINES: Term usually pertaining to small aggregate particles capable of passing through a No. 200 sieve.

FINISH: Last and final coat of plaster. Used as the base for decoration.

FISHEYES: Spots in finish coat approximately $\frac{1}{4}$ in. in diameter caused by lumpy lime due to age or insufficient blending of material.

FLOAT: A tool or procedure used by the plasterer to straighten and level the finish coat surface to correct surface irregularities produced by other tools and to impart a distinctive surface texture.

FLOAT FINISH: A finish coat texture which is rougher than a trowel finish. The roughness is derived primarily from aggregate particles contained in the plaster mortar.

FRAMING: Wood or metal members, such as studs, joists, headers, to which lath is applied.

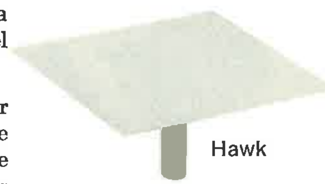
FURRING: Wooden strips nailed over joists and rafters, which are too far apart or crooked. Term also applies when strips are attached to masonry to support lathing. This construction permits a free circulation of air behind the plastering; hence, is used on walls in damp situations. The term also applies to a grillage of lightweight metal shapes to which lath is attached for wall or ceiling construction.

GAUGING: Mixing of gauging plaster with lime putty in order to acquire the proper setting

PLASTERER'S TOOLS

Darby

Float



Hawk

Rod

Pointer

Scratcher

time and its initial strength. Term also used to denote type of plaster to be used for mixing with lime.

GELATIN: A product of the packing house, which can be cast into a semi-rigid mold. On account of its flexibility, it is particularly adaptable to molds containing undercuts, etc.

GRADATION: The particle size distribution of aggregate as determined by separation with standard screens. Sieve analysis, screen analysis, and mechanical analysis are terms used synonomously in referring to gradation of aggregate. Gradation of aggregate is expressed in terms of the individual percentages retained on U.S. standard screens designated by the numbers 4, 8, 16, 30, 50 and 100.

GREEN: Wet or damp plaster.

GROUNDS: A piece of wood or metal attached to the framing with their exposed surfaces acting as a gauge to determine the thickness of plaster to be applied. Also used by carpenter as a nailing base to support trim.

GYPSITE: An earthy deposit found at or near the surface of the ground, consisting of finely crystalline gypsum mixed with loam, clay, sand and humus. Gypsum content generally ranges from 60 to more than 90 per cent.

GYPSUM: A naturally occurring mineral consisting of calcium sulphate combined with two molecules of water in crystalline form, having the chemical formula $CaSO_4 \bullet 2H_2O$.

HARDWALL: Term used for gypsum basecoat plaster. Regionally the term differs; in some cases it refers to sanded plaster, others to neat.

HEMIHYDRATE: A hydrate containing half a molecule of water to one of the material forming the hydrate.

HIGH CALCIUM LIME: A type of lime containing principally calcium oxide or hydroxide and not more than five per cent magnesium oxide or hydroxide.

HIGH MAGNESIUM LIME: A type of lime containing more than five per cent magnesium oxide or hydroxide.

JOINING: Point where two mixes on same surface meet.

KEENE'S CEMENT: A dead-burned gypsum product which results in a much stronger material due to its processing. Used where strength and hardness are of great importance.

LAND PLASTER: A term used to describe coarsely ground natural gypsum used agriculturally as a soil conditioner.

LATH: A base to receive plaster. It is generally secured to framing or furring members. There are five types: gypsum, insulating, metal, wood, and wire.

LIME: Oxide of calcium (CaO) produced by burning limestone ($CaCO_3$). Heat drives out the carbon dioxide (CO_2) leaving calcium oxide, commonly termed "quicklime." Addition of water to quicklime results in chemical changes which are thereafter known as hydrated or slaked lime.

LIME PLASTER: A term generally referring to basecoat plaster consisting essentially of lime and an aggregate.

LIME PUTTY: A plastering material resulting from slaking quicklime or soaking and mixing hydrated lime with a sufficient quantity of water to form a thick paste.

MAREZZO: An imitation marble formed with Keene's cement to which colors have been added. Cast on smooth glass or marble beds.

MECHANICAL BOND: A term used to describe the physical keying of one plaster coat to another or to the plaster base. Examples of mechanical bond are the clinching of plaster keys to metal laths, and the interlock obtained between adjacent plaster coats by scratching or cross raking. Distinguished from "chemical bond" which implies formation of interlocking crystals or fusion.

MITRE: Joining of moldings at their angles.

MODEL: The original from which a mold or copy is made.

MOLD: Molds used by plasterers are two in number; namely, running and casting. Running molds are used for cornice, rails, ribs, molding or anything run in place. Casting molds are used for additional ornamentation that cannot be run in place.

MORTAR: A material used in a plastic state, which can be troweled and becomes hard in place. The term is used without regard to the composition of the material or its specific use.

NEAT: Generally referred to as basecoat plaster to which sand is added at the job.

NICHE: Either a curved or square recess in a wall depending on the architecture and the use for which it is intended. They are used for housing vases, telephones or door chimes.

PERLITE: A mineral aggregate (see Vermiculite).

PINHOLE: A small hole appearing in a cast when the water-stucco ratio has not been accurately measured. Excess water causes pinholes.

PLASTER OF PARIS: Calcined gypsum (calcium sulphate hemihydrate) without addition of material to control set. Principal use is in casting and industrial applications.

PLASTICITY: That property of plaster mortar that permits continuous and permanent deformation in any direction.

POLISH: To make plaster finish coat smooth and glossy by troweling.

PULP: Term often used by the trade when referring to wood fiber or wood-fiber plaster.

PUTTY: Product resulting from slaking, soaking, or mixing lime and water together.

PUTTY COAT: A term generally denoting a smooth troweled finish coat containing lime putty and a gauging material.

READY-MIXED: A term denoting a plaster which is mixed at the mill with mineral aggregate and other ingredients which control time of set.

RETARDER: Any material added to gypsum plaster which slows up its natural set.

RETURN: The terminal of a cornice or molding which takes the form of an external mitre and stops at the wall line.

REVEAL: The vertical face of a door or window opening between the face of the interior wall and that of the window or door frame.

SCAGLIOLA: An imitation marble which is fast becoming a lost art. Scagliola is usually pre-cast, using Keene's cement.

SCRATCH COAT: First coat of plaster in three-coat plastering work.

SCREEDS: Devices or materials run across the base surface of a wall or ceiling to serve as thickness and alignment guides for the plasterer in subsequent applications. Plaster screeds are generally about 4 in. wide and of full base-coat thickness.

SISAL: (See Fiber.)

SKIM COAT: Last and final coat, referred to as such in some localities.

SLAKING: The act of hydrating quicklime into a putty by the addition of water.

SOFFIT: The underside of an archway, cornice, bead, etc.

SPLAY ANGLE: Where two surfaces come together forming an angle of more than 90 degrees.

STAFF: Plaster casts made in molds and reinforced with fiber. Usually wired or nailed.

STUCCO: 1. A term denoting plaster used on exposed exterior locations. The term stucco is used without regard to specific composition of the material. Also termed "exterior plaster." 2. A term used within the manufacturing segment of the plaster industry to denote gypsum that has been partially or fully calcined but not yet processed into finished plaster. Also used to denote gypsum formulations for certain special industrial uses.

SUCTION: The power of absorption possessed by a plastered surface. Example: the base coat must have suction in order to absorb the water out of the finish coat.

SWEAT OUT: Soft, damp wall area caused by poor drying conditions.

TEMPER: Mixing plaster to workable consistency.

TEMPLATE: A gauge, pattern or mold used as a guide to produce arches, curves and other work.

VERMICULITE: A mineral with the faculty of expanding, on heating, into a lighter weight material. Lately manufacturers are promoting its use as an aggregate for plaster, claiming lighter weight and fire-resistive qualities.

WADDING: The act of hanging staff by fastening wads made of plaster of paris and excelsior or fiber to the casts and winding them around the framing.

WAINSCOT: The lower three or four feet of an interior wall when it is finished differently from the remainder of the wall.

WHITE COAT: A term denoting a gauged lime-putty trowel finish.

WOOD FIBER: Ground or shredded, nonstaining wood used as an aggregate with gypsum plaster.

WORKABILITY: A property of plaster mortar closely related to plasticity which determines the ease and speed with which the mortar can be applied and finished.

PLASTER PROBLEMS

AND THEIR SOLUTIONS

GENERAL:

Gypsum plaster, as delivered to the job, has a definite chemical composition which "sets" on the wall or ceiling with a definite chemical reaction. It is always "tailor made" for the particular city in which it is to be used with respect to aggregate, sand, water, and the time of the year. Gypsum plasters are somewhat sensitive to unusual conditions that may disturb the chemical reaction. Occasionally adverse conditions develop on a job which may be avoided or corrected by the mechanic, and the purpose of this section is to list these conditions, define the trouble, and indicate the remedy.

CONDITIONS DUE TO SET:

SLOW-SET: For the best results plaster should set within two or three hours after having been mixed with water, and it should always set within four hours. Early setting is conducive to stronger walls and conversely, delayed setting action may produce a soft wall. Impure sand, or water, or other foreign matter, generally delays setting action. Cold weather may contribute or the plaster may be over retarded. Two precautions should be taken.

First, the unset plaster on the wall or ceiling should be made to set as soon as possible. It is recommended that the unset surface be sprayed with a solution consisting of one lb. of zinc sulphate to each 8-10 gal. of water, followed by briskly floating the surface with a darby or float. Agitation of the surface accelerates the set.

Second, the unmixed plaster on the job should be accelerated to set within proper time limits by one of the following methods:

1. Add sufficient accelerator as prepared by the manufacturer, usually about four-five oz. (one handful) to each 100 lb. bag of plaster.
2. Screened plaster droppings, or scrapings from the mixing box may be used, approximately one handful per bag of plaster.
3. About 15-20 lb. of unretarded plaster, such as gauging or molding, may be thrown into a barrel of mixing water at least one hour before using. Water should be stirred thoroughly.
4. Add alum or zinc sulphate, in the proportion of one lb. to 20 gal. of water.

QUICK-SET: as the name implies, means the premature setting of plaster, thus permitting insufficient time for application and manipulation. It is often caused by using water in which the tools have been washed; permitting set plaster to accumulate in the mixing box; the use of water which has been treated with alum or other salts in the filtration system; the use of a dirty, or silt sand; permitting plaster and sand to stand "dry-mixed" in the box; the use of too much sand; or failure to clean the mixing box or mixer between batches.

Quick-set is characterized by setting of the material in the mortar box, or during the process of mixing; and sometimes by setting on the wall with insufficient time to darby. In any event, the plaster mix should never be retempered and the material should be discarded as soon as it begins to stiffen. The use of partially set plaster will result in weakened walls.

The local conditions responsible for quick setting plaster should be thoroughly investigated and corrected and if this fails to produce the required setting time, the use of retarder as provided by the manufacturer is recommended. Generally one-two oz. of retarder for each 100 lb. of plaster will be sufficient. Increase or decrease this amount to secure the desired set. Mix the retarder in 8-10 quarts of water, breaking all lumps completely, and add this solution to the mixing water. Use no more retarder than is required because excess use weakens the strength of plaster. If standard retarder is not available, mix pulverized glue in proportion of one lb. to five gal. of water, and use about one qt. of this solution with mixing water for each 100 lb. of plaster.

CONDITIONS DUE TO WEATHER:

DRY-OUT: as the name implies, results from a rapid evaporation of the water from the plastered wall, with insufficient water remaining for the setting action of the gypsum. This generally occurs during hot summer months, particularly when window and door openings are not screened to prevent the drying effect of hot winds. If properly cared for, dry-outs do not injure plastered walls.

A dry-out is easily identified because the surface is soft and crumbly, with a light chalky appearance. A partial dry-out will be detected by spots or areas, usually at window or door openings, as previously described.

To correct this condition water should be applied to the dry-out portions, with a spray pump or garden hose with a soft nozzle spray, until the affected area no longer absorbs water. Avoid an excess of water. This operation should be continued at intervals of about two hours, until the plaster sets hard and firm. It should be remembered that the unset plaster will eventually set and be entirely satisfactory.

To avoid continuing difficulty, the openings should be screened with a coarse mesh fabric to shield the plaster from hot winds. Also check the thickness of plaster because thin applications are conducive to rapid drying.

SWEAT-OUTS: describe a condition which is the reverse of dry-out. The plaster has set but the excess water has not evaporated and the walls remain damp for an extended period. This condition is more likely where the humidity has continued high for an extended period or the walls have been subjected to slow drying. Under these extreme conditions the walls will remain damp, dark in color, and soft.

When the sweat-out is detected, the doors and windows should be opened to permit rapid drying. In cold or very damp weather artificial heat should be supplied, with windows and doors open, to induce drying. It should be remembered that the excess water in plaster should always be allowed to leave the walls as quickly as possible after the plaster has set. If a sweat-out condition exists for an extended length of time the plaster acquires a musty odor, loses its strength and becomes worthless. There is no way the original strength can be restored.

FROZEN-PLASTER: known as the freezing of plaster before the set has taken place, resulting in damp, dark colored walls with reduced strength. Frequently ice crystals are detectable on the surface.

Obviously artificial heat should be provided when temperatures are below approximately 55° F. After the plaster has thawed and set, provide ventilation in addition to heat to remove the moisture and prevent a sweat-out. It should be noted here that frost does not injure plaster after the set has taken place, but every precaution should be taken to evaporate the water as quickly as possible after plaster has set.

SAND QUALITY AND PROPORTIONING:

The quality of sand and its fineness gradation has already been discussed. In addition to complying with the ASTM Standard Specifications for gypsum plastering, the sand must be clean, sharp, and free from clay, loam, or other foreign matter.

To determine whether sand contains loam or clay, note whether the hands are dirtied when a sample of the damp sand is rubbed between them. The amount of clay or loam may also be detected by placing a substantial sample of sand in a bottle, adding sufficient water to cover the sample, shaking well and allowing it to stand for a few minutes. The clean sand will fall to the bottom and the clay or loam sediment will settle on the upper layers of sand.

Proportioning of sand is very important and has been thoroughly discussed. A brown coat of plaster should contain no more than three parts of sand to one part of gypsum plaster by weight. Oversanding is characterized by weak walls and may be detected by vigorously abrading the surface with a nail or similar object, known as the scratching test. If plaster is weak due to oversanding there is no remedy.

PLASTER CRACKS:

When gypsum plaster is properly mixed and applied it will not crack or loosen unless it is subjected to abuses that cause failure. There is nothing in plaster which causes cracking. Plaster cracks generally result from extraneous forces and those enumerated below are the most commonly known that contribute to the great majority of instances where plaster cracks.

1. STRUCTURAL FRAME. Unusual deflection of framing members, particularly floor joists, may create cracks. Most building codes establish safe limits for floor joists and where these are exceeded, or when joists deflect because the super-imposed load is more than the designed load, the gypsum plaster is subjected to an unusual strain, which sometimes causes cracking.

   Vertical or horizontal cracks are often caused by shrinkage in wet lumber used for framing. Conversely, dry lumber expands when subjected to unusual moisture, thus causing similar cracks. Gypsum lath, however, does not absorb sufficient water from plaster to create an undue swelling of framing members. The building should be water tight and the framing reasonably dry before lathing and plastering.

   Settlement cracks usually result from an uneven settlement of the foundation walls or piers. They usually run diagonally across a wall or ceiling and if both sides of the partition are cracked in the same general direction they undoubtedly result from settlement.

Horizontal cracks, and sometimes diagonal cracks, may result from unusual racking of the building. Unless the frame is adequately braced against wind pressures and unusual vibrations, the accompanying distortion of the frame may create such cracks.

2. THIN PLASTER. Reduced plaster thickness invariably results in weak walls which may crack at vulnerable points. Full thickness plastering is essential. There is no remedy for thin plastering.
3. OVER AGGREGATING and the result of such practice, has already been described. This practice invariably results in weakened walls that are more susceptible to cracking due to minor framing movement, normal uses, vibrations, etc. There is no remedy for over-aggregating plaster.

THERMAL SHOCK:

During the process of construction many contractors use salamanders to provide heat against freezing and to dry the plaster after setting. Plaster does not attain its full strength until completely dried and whenever sudden heat or cold is applied to a wet wall or ceiling there is obviously an appreciable movement created in the frame supporting the plaster. This induced movement of the frame while the plaster is yet in a weak condition, often creates unsightly cracks. The temperature within the building should be raised gradually prior to plastering and sustained within reasonable limits until the plaster has become dry.

IMPROPER LATHING BASES:

Metal lath of the type and weight as recommended by the ASA provides a good lathing base. However, light weight lath is conducive to cracking of plaster because insufficient rigidity is provided between supports. This results in sagging of the lath and plaster that cannot be adequately corrected with succeeding plaster coats. Furthermore, failure to properly nail, staple, stretch, proper lapping of adjacent sheets, and tie-wiring together are all conducive to plaster cracking.

Gypsum lath properly applied resists plaster cracks. Insufficient nailing, improper bearing at lath ends, and failure to drive the nails home, contribute to an unstable base to receive plaster.

MASONRY BASES

BRICK AND TILE:

BOND: the masonry base must have sufficient suction to properly receive plaster. If the surface is glazed, or has insufficient suction, a satisfactory bond cannot be expected. Some manufacturers of waterproofing materials recommend the application of heavy asphalt products to the interior of exterior walls. These compounds reduce the suction to the danger point. The application of plaster under these conditions is not recommended and it is suggested that the exterior walls be furred and plastered.

Some brick and clay have extremely high porosity and suction which absorbs a considerable amount of the water in plaster. Such a condition in extremely hot weather may cause dry-out. Masonry of high porosity must be adequately sprayed with water to reduce suction before the application of plaster.

EFFLORESCENCE: many masonry walls contain soluble salt compounds, such as saltpeter, which are entirely harmless unless they come in contact with water. However, many masonry walls leak water and carry these salts in solution. As the water is carried to the surface it evaporates leaving the salts on the masonry or plaster surface. They are white chalklike deposits which are easily brushed away.

Efflorescence seldom causes bond failure of scratch or brown coats but is often responsible for finish coat failures. Stains, blisters, soft spots, and peeling of the finish coat or decorations, are most common with efflorescence deposits.

So long as these soluble salts remain in walls, and are subjected to moisture, the condition will continue. Walls should be made watertight and after the efflorescence has discontinued it should be thoroughly removed with a wire brush. This condition should be corrected before the scratch coat of plaster is applied, or the walls should be furred and plastered.

CHECK CRACKING: the term applied to a condition where a network of small cracks occur on the plaster surface. This condition is generally due to extremely high suction, which removes too much of the water from the plaster; or to insufficient aggregate in the basecoat plaster. If the check cracks are fine and small no damage will result to the finish coat. However, where the result is questionable, an additional base coat of plaster should be applied.

CONCRETE:

If plaster applied to concrete surfaces loosens and falls it is generally due to one of three circumstances.

First, the preparation of the concrete surface is highly important. If bond failure has resulted from lack of surface preparation, the loose plaster must be removed and the concrete properly conditioned before replastering.

Second, failure may have resulted from the use of a basecoat plaster other than bond plaster, or the total thickness of plaster may have exceeded the recommended maximum. Under no circumstances should the plaster on concrete ceilings be more than ⅜ in. thick, and on walls ⅝ in. thick.

Third, efflorescense, or moisture from the concrete, may spall, or force a separation of the first coat of plaster from the concrete. Efflorescence, its causes and remedy are described in this section under "Masonry Bases."

PLASTER FINISHES

GENERAL:

Since finish coat plasters are composed wholly, or in part, of gypsum they are subject to most of the conditions which have been enumerated for base coat plasters. Those unusual cases of quick-set, slow-set, sweat-out, and sometimes dry-outs, are detected and treated in the manner described for base coats. Likewise, many of the bonding discussions apply to finish coat plasters. Application under freezing weather, improper heat and ventilation as discussed for base coats apply to finish coats.

LIME-PUTTY FINISHES:

CHECK CRACKING: characterized by a multitude of interconnecting fine hairline cracks on the surface. In severe cases, the finish is easily removed from the base coat in dry brittle chips. Check cracking generally results from the following conditions:

1. Insufficient gauging plaster to prevent lime shrinkage.
2. Insufficient troweling.
3. Failure to screen openings in hot weather may subject the finish coat to hot dry winds.
4. Application in one thick coat should be avoided. This finish is applied with a tight scratch coat followed by a leveling coat, and under no circumstances should the total thickness exceed ⅛ in.
5. Overaggregated base coats or those having been subjected to dry-out, sweat-out, efflorescence, freezing, or retempering of the plaster before application, are improper bases for receiving finish coat plaster. Furthermore, the plaster base should be moderately dried, but not bone dry, before receiving the finish.

It should be noted that the small addition of white silica sand to the lime putty-gauging mix further reduces the possibilities of check cracking and is particularly recommended over lightweight aggregate basecoat plasters.

SOFT FINISH COATS: finish coats which are weak and easily abraded are generally due to insufficient gauging plaster, insufficient troweling, use of retempered plaster, or slow drying as a result of failure to provide ventilation.

LIME POPS: generally caused by insufficient blending of the gauging plaster with the lime, or the use of quicklime with insufficient slaking before use.

LIME BLISTERS: usually result from the application of the finish coat over a green base coat without sufficient suction.

PREPARED GYPSUM FINISHES:

These all-gypsum finishes are subjected to all of the unusual conditions which have been described for basecoat plaster and require only a few precautionary comments:

1. Streaks and surface imperfections are generally caused by the use of too much water in the troweling operation and sometimes by insufficient troweling. These finishes are extremely hard and require considerable troweling.
2. Soft spots are generally due to retempering, or manipulation of the plaster after the setting action has begun.
3. Joining marks are the result of failing to apply the finish in a continuous operation. Plastering operations should be timed to permit a continuous application, particularly where the finish is colored.
4. The condition of the base coat is important. The finish should be applied to a half-green base.
5. Lack of uniformity of finish may be due to improper floating, too heavy an application of the finish, or the use of excessive water in floating, resulting in scuffed areas and scoured spots.

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