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INVESTIGATIONS
 OF
PORTLAND CEMENT STUCCO CONSTRUCTION

This is a digest in part of Circular No. 311, "Stucco Investigations at the Bureau of Standards with Recommendations for Portland Cement Stucco Construction", (December 13, 1926),¹ by Frank A. Hitchcock issued by the Bureau of Standards. The part selected deals with investigations only and will be followed by subsequent digests covering recommendations and finishes and maintenance.

As a result of the rapid and widespread growth in the use of stucco, the Bureau of Standards, cooperating with interested associations and manufacturers, conducted numerous exposure and laboratory tests to determine methods of improving such construction.

(1911) Investigations were begun in 1911 in cooperation with the Associated Metal Lath Manufacturers in an effort to determine what factors caused corrosion and consequent failure of metal lath embedded in stucco and plaster. Three hundred panels of various plastering materials such as cement, lime and gypsum applied to various metal bases were subjected to atmospheric exposure for two years.

General conclusions reached after examination of these panels and confirmed by subsequent observations were that oversanded mortar or the imperfect embedment of the metal lath had more to do with the development of rust than the nature of the cementitious materials. These panels were retained throughout the period of the entire series of tests and were still in excellent condition after 15 years exposure. The metal bases were listed according to merit as follows:

¹Available from Superintendent of Documents, Government Printing Office, Washington, D. C. (Price 15 cents)

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- (1) Lath galvanized after expansion
- (2) Lath cut from galvanized sheets
- (3) Painted ingot iron lath
- (4) Painted steel lath
- (5) Sherrardized steel lath
- (6) Plain ingot iron
- (7) Plain steel lath

(1915) These tests having aroused interest among manufacturers and users of stucco, the Bureau of Standards in 1915 undertook a larger and more varied series of tests covering all types of stucco construction.

Collaborating with those interested, a committee was set up to act in an advisory capacity, and inspect and be responsible for the satisfactory construction of the test panels.

A building 200' long, 26' wide and 25' high was erected consisting of 56 exterior panels of typical combinations whose construction and materials compared favorably with those used in good house construction. Most of the panels contained, at the center, a window 2'6" x 3'6". The lower story was largely of masonry construction while the second story was of frame.

The tests included a large variety of bases to which were applied stucco of various proportions. Observations and reports were made by the committee and conclusions of a general nature were reached. Summarizing, it may be said that monolithic concrete not coated with a bituminous compound was most satisfactory as a base, metal lath applied directly to the studs and back-plastered was second, brick and tile was third, metal lath over wood sheathing was fourth, wood lath was fifth, and gypsum block and plasterboard was last.

All the panels over diagonal sheathing developed large and prominent cracks which invariably first appeared near the corners of the windows and extended across the wall parallel to the sheathing. It was felt that these were brought into prominence, if not actually caused, by the shrinkage of the sheathing.

Stuccoes on gypsum block and monolithic concrete coated with bituminous waterproofing compounds were in poor condition, especially after the second winter. The results obtained did not indicate that the stucco was unsuitable, but that the combination of stucco and a base giving a weak bond gave poor results.

The sand-float finish used was, in a great majority of the panels, floated while the mortar was too soft. This resulted in bringing to the surface a rich mixture of cement or cement and lime which was subject to high shrinkage and upon drying, developed ex-

cessive crazing and map cracking. It was thought that the trouble was caused by the use of too much moisture, not necessarily mixing water, but too liberal soaking of the bases and undercoats.

Cement mortar panels to which small amounts of lime were added proved most satisfactory, as did the mixes leaner than those commonly specified at that time. The prominence which the smooth sand-float finish gave to fine cracks, unevenness of texture, blotches and other small defects suggested the advisability of finishing with rougher surfaces, such as "rough-cast" or pebble-dash finishes.

(1916) In 1916, it was decided to supplement the previous investigations with a series of tests in which more attention would be given to methods of application and it was also decided to investigate further the use of the leaner mixes.

Twenty-two new frame construction panels forming the walls of a penthouse were erected on the roof of the original test structure.

Deductions from these tests may be summarized as follows:

Diagonal sheathing of improperly seasoned wood or wood that has absorbed considerable moisture is apparently unsatisfactory for stucco backing. With only such wood available, horizontal sheathing appears to be the better construction, provided the wood frame is sufficiently braced.

Back-plastered construction for frame structures appears to be more desirable as far as the stability of the stucco is concerned. This type of construction demands consideration of the insulating qualities of a wall so constructed, as well as attention to the rigidity of the framing.

Lean mixtures produced better stucco when the necessary plasticity and density were maintained by grading the aggregate.

Changes in the method of finishing, partly by the use of less water in the undercoat, and partly by waiting for the stiffening of the finish coat to develop before final floating, produced improvement over the previous work by eliminating crazing. Large pattern map cracking was reduced, particularly in those panels where stucco was of a lean mix.

Previous indications of map crazing in cement stucco seemed to be the result of the over-wetting of undercoats. The desirability of studying the behavior of various stucco mixtures led to the making of further laboratory studies following the suspension of activities in this direction during the World War.

Measurements were made of shrinkage or expansion of mortar before,

during and after set. These extended over a period of more than two years and resulted in obtaining much valuable information which, when applied to the actual conditions prevailing in the stucco test panels, explained why some panels were good and others were poor. They also enabled the specifying of a procedure that would largely eliminate crazing and map cracking. It was found that the crazing and cracking, caused by excessive shrinkage, could be avoided by the proper control of moisture in the base or undercoats.

(1923) Through the generosity and cooperation of the National Lumber Manufacturers Association, the Portland Cement Association, the Associated Metal Lath Manufacturers and other interested individual manufacturers, a program was drawn up in 1923 which involved the replacing of 32 panels. These tests were conducted primarily to satisfy certain unanswered questions which were substantially as follows:

- (1) Is wood sheathing or open framing best for stucco?
- (2) Is the reinforcing value of the metal lath or fabric sufficiently important to warrant heavier lath and higher cost?
- (3) What method of attaching metal lath or fabric will most effectively minimize the transmission of strains to the stucco slab?
- (4) Is curing of stucco to be recommended and to what extent is it worth the additional cost?
- (5) Is it beneficial to delay the application of the finish coat for an interval of several days?

Conclusions and answers to the foregoing questions may be stated as follows:

(1) Back-plastered and possibly paper backed construction seemed preferable to sheathed construction. Insulation and proper bracing of the frame should be taken into consideration. If sheathing is to be used, it should be placed horizontally.

(2) Definite conclusions of the comparative merits of the four types of metal bases used, each having distinctive features not contained in any other, could not be drawn. However, indications show that heavier members have greater reinforcing value, but that further study of size and spacing of the members is required.

(3) There was no advantage of one type of furring over another. Some slight indications favored the loose tie. Further study is necessary before recommending any change in the present methods.

(4) A certain amount of curing is beneficial. If new stucco can be protected from too rapid drying, the ultimate shrinkage should be less and an early development of strength obtained.

(5) The tests indicated that delays in the application of the finish coat were not particularly beneficial and that as good, and possibly better, results would be obtained by applying the coats on successive days.