PAREXUSA

Cracking in Portland Cement Plaster Base Coats

Technical Bulletin

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All portland cement-based products, including stucco are susceptible to the occasional cracking. Fortunately, most cracks in a stucco assembly are hairline and present only a cosmetic concern. Most cracking ceases when the skeleton of the building is set in its final configuration / in a condition of equilibrium, as the building is occupied, loaded, stabilized and interior temperature brought to a fixed level. Such cracks may easily be filled when the exterior is redecorated.

CAUSES

Cracks in cement plaster are simply stress relief, the result of a material unable to tolerate the movements and stresses imposed upon it, however it is often difficult to identify the source of the stress when looking at cracks in a completed a stucco application. Determining the source of the stress can be simplified by placing all stresses into one of two categories: internal and external stress.

Internal stress: A normal change in volume of portland cement plaster intrinsic to the hydration and curing of the cement binder and / or the loss of the mix water required for workability but in excess of the moisture required for hydration.

External Stress: Stress transferred to the plaster membrane from external sources. Examples of transferred stresses are sonic resonance, seismic vibration, and deflections of supporting members, thermal shock, wind loads, settlement and/or subsidence. All structures are subjected to stress in various forms which are transferred to the stucco which will crack if transferred stress overcomes the plaster's ability to withstand it.

Outside sources, such as thermal changes, wind, lumber shrinkage, seismic events, structural loads, and racking present another kind of stress. Applying stucco before drywall and roofing are applied to framing exposes the stucco to stress from framing compression.

Outside stress relief cracks tend to be longer, often from one natural break to another.

Stucco is designed to carry and bind the aggregate, bond in place, and get hard. It should be hard, not weak, or soft. When a base coat is soft there is a cause for concern. It indicates a lack of moist curing. Without moist curing it will be weak in the time soon after application when external stresses can cause cracking.

Lack of Curing

Cement needs to set and harden, curing=hardening occurs through hydration. Excessive or fast evaporation of water from the cement plaster will cause shrinkage cracks (comma deleted) and also deprive the cement in the stucco of adequate hydration water. This is particularly true in the first day or two of application and with warm windy conditions. This can also happen to stucco applied over highly absorbent masonry-type surfaces that were not thoroughly wet prior to the stucco application.

Types of Cracks

Surface cracks are usually in the form of a craze or "map" pattern uniformly distributed extending in all directions and in hexagonal patterns, indicating surface restraints by the inner part of the plaster membrane or the substrate

Shrinkage cracking is a result of rapid loss of surface moisture that evaporates before the cement sets. Plaster shrinkage can result when high wind, low humidity, and high temperatures evaporate surface moisture faster than it can react with the portland cement

Settlement cracking starts to occur after application and the plaster continues to consolidate. Settlement may occur after initial placement and densification, as the plaster continues to consolidate on restrained plaster reinforcement and accessories.

The other main kind of crack is normally continuous and linear, which indicates restraint in the perpendicular direction. Often this cracking is a result of a complex combination of events. Observing a certain cracking pattern and relating it to its likely causes can be a challenging exercise.

Color Coat Stucco is not structural; it is a decorative finish. Cracks normally occur in the base coats and simply transfer through the finish.

Active versus Static Cracks

Both volume change and external stresses must be considered before one can take steps to design against portland cement plaster cracking. Volume change is almost always contraction or shrinkage. It has been observed the initial shrinkage-as portland cement plaster cures, will never be met (much less exceeded) by subsequent thermal expansion—these cracks are static. In the preparation of a cement plaster mix, the plaster applicator has the most influence over the finished product.

When portland cement and water make contact, the ratio of water to cement governs the manner in which the cement particles hydrate throughout the moist curing period. Low water content mixtures hydrate to form a strong, dense paste referred to as 'colloidal paste,' which bonds the individual aggregate particles together. The use of too much water in mixing the plaster diminishes this bond, resulting in a product with higher shrinkage and more cracking.

Movement Control

It is impossible to prevent cracking from all the various forces, but it can be partially controlled by way of unrestrained designs. Properly installed control and expansion joints can minimize cracking by providing some relief.

Although no matter how many control/expansion joints are installed and where they are placed, the act of predicting exactly where, how severe and/or the direction the stress will travel through the cement plaster is simply an educated guess.

Minor cracking at the corners of doors, windows and other high stress point areas is common and may be expected.

Control joints are not Expansion joints and the two should not be confused.

Control and Expansion Joints

Even properly mixed and installed stucco can crack if subjected to stress. Two-piece expansion joints or one-piece control joints should be designed into the installation.

Horizontal and vertical control joints are often specified but provide no relief at the perimeter of stucco walls and ceilings. Movement in all directions occurs due to a number of things such as shrinkage, thermal expansion, and substrate deflection.

Control Joints

A control joint is a one-piece trim accessory used to relieve "minimal" amounts of stress, provide architectural breaks or aesthetic appeal. Cement shrinkage, thermal expansion and contraction, minor lumber shrinkage, and other minimal building movement are functions, one-piece control joints are typically capable of handling. Control joints have been used in cement plaster for decades with great success, when their limitations are understood.

Control joints are made from steel, plastic or zinc and have varying degrees of flexibility. When a lath and plaster assembly is designed and installed to resist force, as opposed to allowing it to have some independence of movement, it is restrained. Developing a non-restrained plaster assembly is one of the most effective procedures in reducing cracks. This is aided by incorporating control joints in the stucco.

> ***ASTM C1063 Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster****: Expansion Joints shall be used to accommodate some degree of movement in the stucco membrane caused by movement of the building or its components to minimize damage to the stucco and weather resistive barrier.*

Control Joints shall be installed to minimize stress due to stucco curing and drying shrinkage and minor movement, and as a screed to aid in stucco thickness control.

> ***ASTM C926 Standard Specification for Application of Portland Cement-Based Plaster****: Control joints-control (expansion and contraction) joints shall be installed in walls to delineate areas not more than 144 ft2 (13.4 m2) and to delineate areas not more than 100 ft2 (9.30 m2) for all horizontal applications, that is, ceilings, curves, or angle type structures.* The distance between control joints shall not exceed 18 ft (5.5 m) in either direction or a length-to-width ratio of 2-1/2 to 1.
>
> *Control joint and expansion joint locations and their integration with the substrate and water resistive barrier shall be graphically depicted in the contract documents.*

Shop drawings are not contract drawings. Control and expansion joints locations are allowed on shop drawings, but they must be shown on the project designer's drawings.

Control Joint locations and installation

1. Where the ceiling framing or furring changes direction
2. Where an expansion joint occurs in the base exterior wall.

Shrinkage cracking is most common at the perimeter of stucco assemblies. It is crucial that attachment flanges have expanded wings or if solid be overlapped with lath. Some materials used in lathing accessories have expansion rates different from that of stucco and when exposed to heat, aluminum and zinc accessories expand more than stucco, developing a separation where they meet. During the curing process, the stucco can shrink and pull away from the accessory creating a small reveal. In cases, where a finish coat material is applied onto the surface of the accessory, the stucco material can still pull away, creating an impression that a crack has occurred. Additionally, spalling of the finish coat from the accessory can occur due to the plaster initially sticking, but not bonding permanently, to the accessory. Through the course of daily thermal expansion and contraction, these cracks may be visible or not. This type of cracking along the length of a given accessory, does not necessarily mean there is an installation defect. Cracking along stucco accessories does not necessarily indicate that there is water intrusion occurring.

Floor Line Deflection Joints

Sometimes metal framing is installed with a slip track at slab undersides along with an expansion joint to allow for floor deflection. The stucco must be separated by an expansion joint at the location of the slip track as well. If this is not done, deflection that should have been accommodated by the expansion joint now places stress on the stucco, resulting in cracks to relieve the pressure.

OTHER CAUSES OF CRACKING

Sheathing Spacing

Wood sheathing, such as plywood and OSB, needs to be gapped a minimum 1/8 inch where panels meet one another or meet other construction. This is the recommendation of the APA The Engineered Wood Association. Without the gap, when the sheathing naturally expands, it tends to buckle outward, cracking the stucco.

Lath Furring

Lath must be furred to allow the stucco to effectively key behind it. Failure to fur lath or over-fastening can lead to cracking.

> *ASTM C1063: Self-furring-a metal plaster base manufactured with evenly spaced indentations that hold the body of the lath approximately ¼ in. (6.4 mm) away from solid surfaces to which it is applied.*
>
> *ASTM C926: Portland cement-based plaster shall be applied on furred metal plaster base when the surface of solid backing consists of gypsum board, gypsum plaster, wood, or rigid foam board-type products.*

Lath Continuity

lath sheets must be properly lapped at their edges and asphalt paper of paper-backed lath must not be allowed between sheets of lath at their edges. Otherwise, the stucco will not have continuous reinforcement at the lath edges and will crack there**.**

Mixes

Excessive water used in mixing the plaster affects the cement's ability to bond and bind the aggregate; it also evaporates resulting in shrinkage. Plaster is a two-part composition, the two parts contract at different levels, with the cement shrinking more than the aggregate. Avoid cement rich mixes- stay within ASTM recommendations. Cement shrinks and sand does not. Some plasterers like a cement- rich mix because it is "stickier" and works easier. Unfortunately, it also shrinks more. Sand volumes must stay up to standard to minimize shrinkage.

Poor Sand Quality (Jobsite Mixed)

Sand with excessive fine materials, clay or too much dirt can all lead to volume loss of material (shrinkage stress). The clay absorbs excessive moisture and in turns shrinks more. Sand should have good gradation (variety of sizes) and be angular in shape. Example, round marbles don't grip as well as triangular shaped particles.

Variation in Thickness

Out of plane and out of plumb substrate walls can lead to excessive variations in stucco thickness as the outer face of the stucco is brought to a uniform, plumb plane. Where stucco thickness changes abruptly, stress concentrates and can cause cracks.

In Conclusion

Much like portland cement concrete, portland cement plaster (stucco) can develop cracks unless precautions are taken in the project's design stage as well as during the lathing / furring and plastering application. Although it is unknown how to make absolutely fissure-free portland cement plaster for ceilings and walls, design and construction professionals can employ numerous strategies to substantially minimize cracks. There is no simple or sure formula to this, as there are many causes for cracks and not all of them are subject to control.

Minimizing stucco cracking is accomplished by good design and construction practices that are not difficult but require conscientious adherence.

1. Interior wall board should be fastened in place prior to plastering.
2. Control and/or expansion joints should be installed per industry recommendations.
3. Buildings should be carrying at least 90% of its final load prior to plastering.
4. Sheathing installed correctly
5. Lath installed correctly
6. "Hard" float the brown coat to densify the plaster membrane.
7. Damp cure plaster base coats, scratch & brown.

8. Avoid pounding and other vibrations to the plaster membrane during the cure time.

Because of the nature of the material, some hairline cracking in portland cement plaster is very normal and should be expected and although stucco assemblies and is not a result of a product defect. Stucco installations sometimes crack however, it does not mean that the stucco assembly has failed, was installed, or designed incorrectly. Hairline surface cracking usually presents no leaking problems or other sub-standard performance of the plaster skin. It is usually a mere cosmetic or aesthetic consideration.

Additional information addressing cracking of stucco is available at the following Industry Association links

www.tsib.org/pdf/technical/60-101_CRACKS_IN_PORTLAND_CEMENT_PLASTER.pdf

www.flapb.com/uploads/5/6/2/5/56253453/tb-st-08-03.21_cracking_of_stucco_over_solid_substrates__edit_2021.03.18.pdf

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www.stuccomfgassoc.com/wp-content/uploads/2014/06/plastercouncil_tech4_crackr14.pdf

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