Portland Cement Plaster Crack Analysis and Repair

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INTRODUCTION

This article originally appeared in the June 1993 issue of Walls and Ceilings *magazine and is reprinted with permission. Like so many other articles addressing cracking in portland cement plaster and portland cement concrete, this article attempts to review the acknowledged characteristics of portland cement plaster (stucco), the factors affecting its performance, and some of the recently developed methods and materials used to repair cracks. The author has made minor updates since the article's original publication.*

The views expressed here are those of the author and do not necessarily reflect the opinion or agreement of the International Conference of Building Officials.

Portland cement plaster (stucco) has become the preferred finish for exteriors of all kinds of structures, including single-family homes, apartments, schools, and low-rise and high-rise commercial structures. New materials, systems and application techniques have enabled cement plaster to be applied more quickly and in a variety of applications.

The cost of portland cement plastering is significantly less than what it was in past years. Unfortunately, as it so frequently happens with materials and methods which have become popular, there are a great number of people applying portland cement plaster who are untrained and inexperienced. They don't understand the proper proportioning, mixing, application and curing for the material. Consequently, too many unsatisfactory installations are being made.

Additionally, owners and general contractors try to speed up the installation process and insist that the plastering contractor take shortcuts the contractor often doesn't want to take. This includes applying plaster in an inadequate thickness and without sufficient moist curing.

When you add these factors to a plaster mix which has poor quality sand and/or too much water used in mixing the dry materials, is there any wonder why cracks result?

Proper Construction Techniques

Everyone familiar with construction materials realizes that concrete, mortar and plaster made with portland cement will shrink as the materials harden and gain strength. That is the reason score lines are placed in concrete walls and slabs and why stress relief joints are recommended to be placed in portland cement plaster. The spacing of joints in exterior plaster depends to a great degree on the texture of the finish plaster.

Fine or smooth finishes will obviously accentuate any cracks in the plaster while coarse, rough textures serve to conceal them. Joints in smoother finishes should be kept at a maximum of 10 feet (3048 mm) in any direction. Furthermore, the panels delineated by the joints should be kept to a shape in which the longest dimension is not greater than two and one-half times the shorter dimension. Stress relief joints in very coarse textures might be installed 16 feet to 18 feet (4877 mm to 5486 mm) apart with inconspicuous cracking.

The joints should be detailed to be installed as near as possible to points or lines of weakened structural planes such as the following:

- Corners of window, door and other openings in the plaster membrane
- Rim joists and other large dimension members in wood-frame construction which are likely to shrink
- Midpoints of maximum spacing of supports
- Over structural control joints in concrete, masonry steel or wood framing
- Over junctures of dissimilar bases

Most authorities and references agree that the metal lath and sheathing should be discontinued behind vertical joints but that the weather barrier paper must be maintained continuous behind vertical and horizontal joints. The most effective stress-relief joints are wire-tied to the edges of separate sheets of lath. Accessories with expanded flanges are easiest to wire-tie to the lath. When solid flanges to accessories are used, the lath should overlap the flanges to provide reinforcement for the plaster at this critical edge.

When plaster materials are properly proportioned, mixed, applied and moist cured, the finished product can be more crack resistant, less moisture permeable and able to withstand considerable abuse for many, many years with or without cracks.

Analysis of Cracking

Cracks in plaster are not necessarily indicative of substandard construction. They are always worthy of analysis, however, since cracks may disclose a construction oversight or unforeseen stress concentration. Cracks can also facilitate water intrusion through the plaster. Analysis of cracking usually consists of assembling the following information with photographs and drawings:

- Location of cracks on the building
- Pattern (horizontal, vertical, diagonal, random)
- Length
- Width (uniform or tapered; if tapered, note how)
- Depth (through finish coat, finish and brown, or all three coats)
- Kinetic (moving) or static

An assessment of this information can indicate to the investigator the likely cause of the cracking, how harmful it might be and how it might best be repaired.

Diagonal cracks are almost always found at corners of door and window openings in a plaster wall. Studies conducted at the Illinois Institute of Technology 30 to 40 years ago showed that sharp corners in openings in plaster walls are much more serious stress raisers than are filleted or rounded corners.

Bending of the lath and plaster matrix will result in cracks at the midpoint of the maximum span. Diagonal cracks most frequently result from racking of open-framed lath and plaster panels. Uneven settlement of the supports for open-frame panels produce tapered cracks in the portion of the panel in tension. The tapers are typically widest at the outside edge.

Acceptable Amounts of Cracking

What is an acceptable amount of cracking and how large must a crack be before it presents major problems?

The owner, architect, contractor and subcontractor all might have differing opinions as to how much cracking should be acceptable. This can be avoided with forthright communication in the development stages of a project. The architect must make the client (the owner) aware that portland cement plaster cannot duplicate architectural concrete or glass fiber-reinforced cement (GFRC). Plaster can reasonably approximate them, but plaster will always be plaster—a handcrafted material—whereas architectural concrete is cast and GFRC is molded.

Likewise, the honest subcontractor will concede the limits and capabilities of lath and portland cement plaster and will not contract to do something the materials can't do. In fact, if the subcontractor is instructed to proceed and tries to simulate cast concrete with lath and plaster, the subcontractor should go on record, in writing, that there is a limit as to what can be produced and warn that a certain amount of cracking must be expected.

According to the Portland Cement Association (PCA), a crack in concrete 0.010 inch to 0.015 inch (0.254 mm to 0.381 mm) wide neither hurts the surface appearance nor disturbs the viewer (PCA 1982). Because portland cement plaster is not as strong as portland cement concrete and is applied substantially less thick, some plaster cracks will be larger. The initial shrinkage cracks which occur as the plaster hardens are usually hairline in size [less than 0.010 inch (0.254 mm)] and occur in an overall cracked eggshell pattern. If they show up in the brown coat, a properly applied finish coat will usually conceal them. When they occur in the finish coat, it is usually the result of too rapid evaporation of the moisture or the finish coat applied too thick. They are usually so insignificant that they are better ignored.

If stress-relief joints aren't used to divide large plaster areas into smaller ones, the shrinkage stresses may magnify cracks enough to make them visually objectionable, particularly in smooth textured plaster surfaces. These larger cracks, ranging in width from 0.015 inch to 0.030 inch (0.381 mm to 0.762 mm), are hardly discernible from a distance of 10 feet (3048 mm) or more. In heavily textured finishes, they are difficult to locate at all.

Rainwater permeates plaster through capillarity and through cracks, holes and joints. The larger the crack or joint, the greater the moisture intrusion. A driving rain will force water through cracks and joints kinetically. Wind pressure will increase the capillary migration of moisture through the plaster cracks and air pressure differentials will cause moisture to flow from higher outside air pressures to lower interior air pressure. The weather-resistive moisture barrier between the lath and the framing will divert most of this moisture downward and out if the moisture barrier is installed without holes or tears.

Active or kinetic cracks can open, close and lengthen, but static cracks don't move. Active cracks must be filled with flexible sealants. If they are repaired with rigid plaster, they will only crack again. The most effective way to fill and conceal working cracks is with a material having good elongation and flexibility to compensate for the movement in the plaster. Elastomeric coatings have proved very successful in this application. There are a variety of brands on the market and one is probably as good as another if the mil thickness is the same.

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Crack Size and Possible Methods of Correction

Minuscule cracks measuring less than 0.0005 inch (0.127 mm) are to be found in the surface of every plaster, mortar or concrete made with portland cement and, in my opinion, don't require any treatment.

Hairline shrinkage cracks, 0.0005 inch to 0.010 inch (0.127 mm to 0.254 mm). These web-like cracks in the surface coating are sometimes referred to as crazing or checking cracks and will sometimes increase in width as temperature decreases. Cracks of this size can usually be obliterated by applying a 15 to 18 dry mil thickness of a good acrylic elastomeric coating over the entire wall surface.

0.030-inch to 0.125-inch (0.762 mm to 3.175 mm) cracks in smooth or fine plaster textures require treatment with brush-consistency elastomeric sealant applied to fill the cracks in a 2-inch-wide (51 mm) band over the cracks. This band should be crowned in the center and feathered at the edges to conceal the repair. In heavy or coarse textured plaster, the smoother texture of the repaired cracks might be too noticeable for this method to be used. The over coating 2-inch (51 mm) band would have to be deleted, but the effectiveness of the patch is then minimized.

0.125-inch to 0.250-inch cracks are typically structural in origin. They probably open, close and shear with movements in the structure and its finish. In smooth finishes, they can be repaired as described above, except that the crown at the center of the elastomeric sealant should be 63 mils [$^1/_{16}$ inch (1.59 mm)] thick to compensate for anticipated movement. It would also be advisable, on cracks close to $^1/_4$-inch (6.35 mm) wide, to be treated as described above (SWRI 1991).

0.250 inch to 0.500 inch (6.350 mm to 12.7 mm). Cracks measuring $^1/_4$ inch (6.35 mm) or more are serious movement cracks. They are subject to far more movement, and the use of elastomeric wall coatings alone may not be enough to provide a lasting solution. These cracks may first require filling with a urethane sealant or a high grade acrylic latex caulk.

Some authorities recommend filling the cracks with plaster, masonry or concrete patching material enhanced with emulsified acrylic admix in the mixing water. In my opinion, dynamic cracks cannot be effectively repaired with brittle materials such as those mentioned.

The Northridge earthquake, which created so much exterior plaster damage in January 1994, was an ideal proving ground for validating the observations set forth in this article. Alternate materials were tried and were found to do an excellent job of filling cracks and preventing their reappearance. Many of these materials were developed by the manufacturers of Exterior Insulation Finish Systems (EIFS) and are products of polymer research and technology. Most of the companies maintaining current ICBO Evaluation Service, Inc., evaluation reports on EIFS manufacture polymerized cement adhesives or polymer base sealants which are totally adaptable for use with portland cement-based plaster.

If the extent of the plaster damage is such that a new finish coat is warranted, consideration should be given to using a trowelable polymerized aggregated finish such as those which are part of the EIFS, rather than a conventional cement-based stucco finish. The polymerized aggregated finishes are more water and crack resistant and more uniform in color and shade, although they are more expensive.

After the cracks have been filled and allowed to dry, an elastomeric coating can be applied over them. After one day of drying, another 15 to 18 dry mil coat of acrylic elastomeric would then be applied to the entire surface. This procedure might not be as successful in coarse stucco textures as it is on smoother ones.

CONCLUSION

Proper crack repair covers all cracks which are visible. Painting cracks with conventional paint only gives you good looking cracks (SWRI 1991). For that reason, the elastomeric coating used must be of good quality and applied to the recommended thickness.

When repairing and redecorating an integrally colored stucco finish which has never been painted, a surface conditioner may be necessary to neutralize and free lime and to control absorption of the porous stucco membrane. Most coatings require a clean sound surface, free from dust, chalk, mildew, efflorescence, laitance, grease and other foreign contaminants.

By following the coating manufacturer's printed recommendations closely, the remedial work should be satisfactory both from an appearance and a waterproofing viewpoint. ■

REFERENCES

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