CRACKING IN PORTLAND CEMENT PLASTER – Original Draft by Jim Rose

Portland cement plaster, often referred to as stucco as a 2 or 3-coat system, is usually a 7/8” to 1” thick inflexible membrane, which most commonly provides the exterior skin for structures in Southern California and in some other parts the country.

Structural penetrations such as windows, doors, plumbing, electric accessory outlets, light boxes, wall refrigeration units, vents, etc. pierce the thin plaster membrane. Such penetrations function as focus points or lines for stresses inherent in the supportive skeleton of the building.

Cracking in plaster occurs when the forces or stresses acting on it exceed the tensile strength of the plaster itself. Since Portland cement plaster gains strength gradually, it is most susceptible to cracking during its early, weaker stage.

There are two and only two factors which produce all cracking in Portland cement plaster. One is that 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 in excess of the moisture required for hydration. This process causes internal stresses. The other factor is stress transferred to the plaster membrane from external sources. It is classed as an external stress. Examples of transferred stresses are sonic resonance, seismic vibration, deflection of supporting members, thermal shock, wind loads, settlement and/or subsidence.

Portland cement plaster, like concrete, must be mixed with sufficient water to render it plastic and workable. Part of the water chemically combines with the cement for hydration. A significant amount of water is lost either by evaporation or by absorption. Accompanying the setting of Portland cement plaster there is a natural shrinkage or loss of mass of its bulk. If the loss of moisture is not uniform throughout the thickness of the plaster, shrinkage will create internal stresses within the plaster membrane. Normally contraction occurs towards the center of the Portland cement area or panel. This is one of several possible factors which may affect shrinkage cracking.

Assuming that there are no deficiencies in either mix proportioning of the ingredients of the Portland cement plaster or in the ensuing curing, the plaster will gain its largest percentage of ultimate strength during the first 7 days following its placement. This is the same period during which most shrinkage of the plaster takes place. The two natural, but counteractive, processes develop during a period of time when Portland cement plaster should be expected to achieve its greatest gain in strength while at the same time, the greatest distortional stress from loss of volume occurs.

The second major factor in cracking, transferred stresses to the plaster membrane, is found in almost every structure built. The build-up of stresses is most pronounced in wood framed construction. When framing,
lumber loses the free moisture it contains, it is subject to volume change dimensionally through shrinkage, twisting, warping, bowing, bending, etc. Even kiln-dried lumber contains a considerable amount of water. Even when lumber is free of knots and is relatively straight-grained, it is subject to distortion to some degree.

In wood framing the natural deformation of supports and structural members may exert tremendous pressure perpendicularly to or in alignment with the plane of the plaster. Problems may be compounded if leaks occur and water is introduced into framing members after construction. Wet lumber swells and generates tremendous expansive forces.

In metal framing a significant degree of transferred stressing often is generated in thermally-induced expansion and contraction of wall framing metal elements and of steel structural elements. The problem is worsened where the wall systems are welded in a unitized without relief mechanisms.

Control joints in the lath-plaster areas should limit panel sizes. Construction expansion joints should separate structural components into reasonable areas.

Other examples of transferred stresses are thermal shock, temperature-induced expansion and contraction, sonic vibrations, seismic temblors, concrete creep and sag, foundation settlement, structural subsidence, wind loads, live loading of floors, mechanical vibrations or other stress-producing impingements on the plaster membranes. Such transferred stresses are usually well within the range of accommodation by the building structure and pose little threat to serviceability, structural performance, weather resistivity or safety. These stresses are normally minimal in measurement or hardly measurable at all. However, they can sometimes reach a magnitude which exceeds the resistive strength of the nominal 7/8" thickness of metal reinforced Portland cement plaster. While minimal in detection, such stresses may react on the hard, brittle plaster skin to such a degree as to find relief in fractures in the cement membrane.

Transferred stresses are of two types. One is a static force and the other a live or dynamic force. In the former the crack-induction potential is relieved once the stress has expended its energy in the fracture.

Some hairline cracking is almost always found in Portland cement plaster and should be expected as normal. Movements in the supporting building structure most commonly cause cracks at the header and sill corners of windows and doors, over concentrations of large dimension wood framing members, and at focus points of stress build-up.

The use of control joints or other properly designed and installed stress relief mechanisms may reduce or prevent the focusing and concentration of both internal and external stresses. The building's designer and/or engineer should determine lines and points at which stresses may be expected and make relief provisions.
Plaster panels should be limited in size to a maximum of 144 square feet and one dimension of the panel should not exceed 2 ½ times the other dimension.

Control joints which allow for some expansion and contraction movement are preferable to those which are rigid.

When unrelieved Portland cement plaster panels exceed the recommended spacing of relief mechanisms, cracking is almost certain to occur in the plaster. While the use of relief joints is not an absolute guarantee of crack prevention, it minimizes stress fracturing. Where control joints are omitted in the design of a structure, the designer and / or owner by default must shoulder the major responsibility for cracking.

Portland cement plaster over solid wood shear panels, such as plywood sheathing, is subject to tremendous stress action. Even minutia amounts of water may cause swelling and buckling of the plywood. This is particularly true when plywood sheets are placed without a minimum 1/8" spacing between joints. Industry practice and building requirements dictate a double layer of Grade D weather barrier paper or its equivalent in asphalt-saturated felt, be placed over wood sheathing when in direct contact with the back face of the plaster membrane.

If the plywood is wet at the time of installation of the lath, cracking of the plaster is almost assured.

An application of a moisture barrier coating over plywood prior to lathing may reduce cracking problems. Over wood shear paneling, control joints or other stress relief mechanisms are most urgently recommended.

Special relief provisions should be made at the juncture of dissimilar bases such as along the line of abutment of masonry and open framing construction. Relief should be designed at lines where wall membranes pass over concrete floors.

In some areas there is a strong opinion that the addition of short glass or polypropylene fibers added to Portland cementer during the last stage of mixing, provide considerable resistance to plaster fracture. Test results tend to confirm the theory that the plaster's ability to resist cracking is enhanced by the embedment of such reinforcing fibers in the plaster base coats.

Cracking is more apparent in certain stucco textures. Where the surface has been steel troweled to a dense, smooth finish, cracking is almost always present. Sand float and to a lesser degree light machine dash textures highlight cracks more than skip-trowel or other coarse texture patterns which tend to absorb or conceal the cracks.
A plastering expert can usually tell from the location, dimension, state of spalling and pattern if the fractures originate in the plaster membrane or were transferred to it.

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.

Most cracking ceases when the wooden skeleton of the building is in a configuration of equilibrium, with the lumber set in its final configuration, as the building is occupied, loaded, stabilized and interior temperature brought to a fixed level. Because of the nature of the material, some hairline cracking in Portland cement plaster is very normal and should and should be expected. Such cracks may easily be filled the first time the exterior is redecorated.