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G. MICHAEL STARKS
CGC, CDT, CCPR, LEED AP

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Stucco Bond – Investigating & Testing

Bonding of direct-applied stucco to solid bases is dependent upon several factors, all of which contribute to the ultimate bond strength. Solid bases are defined by ASTM C 926 as cast-in-place or precast concrete, concrete masonry (CMU), clay brick, stone, and tile. All other bases are considered "frame" for the purpose of plastering.

In this article, we will discuss the factors affecting bond, potential augmentation for bond, debonding or delamination, and the investigation and testing for disbonded (or debonded) areas.

ASTM C926, *Standard Specification for Application of Portland-Cement-Based Plaster,* governs the installation of stucco over all bases and includes some very specific language, in Section 6.2, regarding bond for direct-applied stucco.

FACTORS AFFECTING BOND

1. **Cleanliness** – All bases, including the lath or accessories, to which stucco shall be applied must "…be free of deleterious amounts of rust, oil or other foreign elements…" Form Release Agents, gypsum or mud, sand or other splatters, paint overspray, or any other material that is left in place during plastering will likely cause a bond failure in that location. For this reason, pressure washing is almost always recommended prior to plastering.

2. **Thickness** – Abnormally thick areas of stucco can exceed the carrying capacity of the bond. C 926 includes a Table (4) that expresses the "nominal" plaster thickness over different substrates. When the actual applied thickness exceeds that in the table for a specific substrate, the potential for disbanding increases. In a still wet condition, a 3:1 stucco mix (sand to cement ratio) can commonly weigh anywhere from approximately 90lbs/ft^3 to 94lbs/ft^3. It is this weight that affects initial bond in gravitational stress. Once cured, these weights drop approximately 10lbs/ft^3. The table below expresses stucco weight by thickness and wet or dry.

ESTIMATED PLASTER (STUCCO) WEIGHT 3:1 MIX RATIO (wet)						
Thickness (in.)	3/8"	1/2"	5/8"	3/4"	7/8"	7/8" w/2.5 metal lath
lbs/yd^2	25.38	33.84	42.30	50.76	59.31	60.57
lbs/ft^2	2.82	3.76	4.70	5.64	6.59	6.73
lbs/in^2	0.020	0.026	0.033	0.039	0.046	0.047

3. **Absorption** – For cement to bond to solid bases, the base material must absorb some of the water from the wet mix. This water carries with it the cement particles that will create a chemical bond where the cement particles interact. Because concrete and CMU are basically the same materials as stucco, they bond together extremely well.

   Absorption can also work against you. For this reason, solid-bases are required to be uniformly dampened just prior to plaster application. Highly absorptive bases can pull the moisture out of the plaster so quickly that the cement paste gets left behind. At the same time, the fresh plaster is being assaulted from both sides: absorption on the back side and evaporation on the exposed surface. Absorptive and evaporative forces acting upon the plaster at the same time can remove the moisture much too quickly and create a failure to bond initially. Dampening slows down the removal of moisture so that the plaster can begin to cure and lock together before the moisture is gone.

4. **Substrate Surface Characteristics** –Variances in the surface of the base also contributes to bond. A coarse-faced block, for example, will bond more easily than a smooth cast concrete or smooth-faced block. Cement grows a crystalline structure as it cures; the fingers of which lock into fissures and irregularities in the surface of the substrate. This is a mechanical bond as opposed to the chemical bond above.

5. **Application Pressure and Methodology** – Stucco is required to be applied with sufficient pressure to ensure bond through the mechanical keying as previously discussed. Pressure is a principal factor in ultimate bond strength. It is permissible to apply stucco by hand or by pump or spray. The former Should be done with a hawk and trowel. A “slicker” will not apply pressure evenly over the space. In reality, a “slicker” is a rod or darby improperly used to apply stucco over a wide area as much as 4 feet in one pass. There are two problems with this method. First, pressure is only applied opposite the hand-holds on the slicker; and secondly, it is usually a one-way pass. A one-way pass will leave some portion of the mechanical keys (fissures) unfilled. On the other hand, a trowel application is a two-directional pass that back-rolls the plaster into these fissures. Slickers, for the application of scratch or brown coats are prohibited by omission in the current published version of C 926. Application by pump or spray usually provides sufficient pressure which is then augmented by smoothing with a trowel. Rods or Darbies are intended for leveling out the coats and bringing them to a uniform plane, not for application of stucco.

AUGMENTING BOND

Augmenting bond, whether due to poor absorption or smooth texture, can be achieved by several methods which are specifically listed in Section 6.2 of C 926. They are:

i) Sandblasting, wire brushing, acid etching, chipping, or a combination of these. Obviously, these are labor intensive and may pose some environmental concerns.
ii) Application of a dash-bond coat.
iii) Application of a chemical bonding agent; either surface-applied or integrally mixed into the plaster.
iv) Application of lath & accessories but only after one or more of the methods above have been tried and failed. Lath application is intended to be a last resort measure. For more information on this issue see the article, *Lath Over Concrete Block – A Bad Idea,* at the In-Spex website.

It is the opinion of In-Spex, that the dash-bond coat is the most effective method; though it is becoming somewhat of a lost art here in Florida.

INVESTIGATING BOND

There are two common methods for investigating bond in hardened plasters: sounding and pull-testing. They should be performed sequentially.

Disbonding and delamination are not separately defined within the standards, but it is generally considered that disbonding involves the separation of scratch coat from the base (the entire plaster system) and delamination usually refers to the separation between coats of plaster such as the finish coat from the brown coat.

Sounding – Sounding involves careful listening for anomalies and an understanding of the potential causes of these anomalies. Lightly tapping the stucco over the surface is one way to do this. This is accomplished by tapping the surface with a small hammer or other tool around the area and listening for a hollow sound. It is effective in identifying potential disbonded or delaminated stucco areas but not good at defining the limits of a disbonded area. For this reason, those with more experience usually drag the same tool over an area. Again, a disbonded or delaminated area will cause a hollow sound; the limits of which are easily discerned. We have seen people use golf clubs, tack hammers, wrenches, rakes, any number of metal objects. All will work.

Sounding has its limitations as it requires a practiced ear. There are many anomalies created by conditions within the wall system. For example, the sound of stucco over cast-in place concrete will be different from that over hollow-core CMU. These areas are often identified as disbonded when, in fact, they are not. Hollow CMU is often identified as disbonded when the tool is first dragged over a grouted cell in the CMU. Areas around accessories are almost always incorrectly identified as disbonded. The unplastered areas behind the solid portions of the accessory flanges will intone as hollow areas. However, these areas should be limited to a few inches to either side of the accessory centerline and remain consistent throughout the length of the accessory. Though the path along an accessory is subject to disbonding, the anomaly will not be consistent in width or length.

During plaster application, there are often small air pockets left either behind the scratch coat or between coats. The plasterer will usually cut a pressure release in the bubble with his trowel edge and then re-trowel the area. Unfortunately, these air pockets are not always noticeable and can get missed even by the most experienced plasterers. These pockets will intone as potential debonded areas, and they are, but are usually less than three inches in diameter and pose little threat of falling out of the wall.

Other pockets can be created where the application of the brown coat over a scratched first coat inadvertently receives only a one-directional pass with a trowel. This can leave a hollow in the grooves of the scratch coat. These too, will intone as potentially debonded areas, and also, pose little threat.

The greatest limitation to sounding, however, is that it only *indicates potential* disbonded or delaminated areas. It is not definitive. It is, therefore, necessary to continue on to pull-testing.

Pull-Testing – Until recently, almost every engineering or testing agency used their own test-method for determining bond strength. Most were derived and adapted from standardized test methods for pulling concrete overlays or some other condition. The biggest problem with such testing is that there is no standardized pass/fail criterion other than to say this sample came off at “x” psi. There is no definitive, standardized quantity to which to apply the results. There are simply too many variables in plaster systems to arrive at a uniform data point. Here are a few items that will produce significantly different results even with all other factors being uniform.

Mix ratios of the plaster	Substrate absorption
Weather conditions	Surface characteristics
Mix ingredients	Applicator methods

Over the last few years, members of the ASTM Committee responsible for C926 have been developing a practical method that can be used for post construction testing of bond strength. Again, it is not a pass/fail test based upon a specific and uniform stress. It is a diagnostic to assist in evaluating questionable plaster coats.

We mentioned earlier that gravitational stress can be influenced by thickness due to weight increase. This is only one stress to be considered. The far greater stress that must be endured by the plaster is that of negative wind-loading on the exposed surface. For that reason, this new test method, ASTM C1860, *Standard Test Method for Measurement of Tensile Strength or Bond-Strength of Portland Cement-Based Plaster by Direct Tension,* should be adopted by anyone seeking to evaluate potential debonding of stucco. The results in this test method are compared to the calculated wind-loading for each specific sampling location on each specific job in any specific geographic location. Results of each sample can then be compared to the design wind-loading criteria (usually the minimum times a specified safety factor) set by the engineer in the project specifications.

It should be noted that the scope of ASTM C 1860 specifically calls for selection of suspected areas of concern. Sampling for the purpose of evaluating the entirety of the plaster application should include randomly selected test sites of a quantity that can be statistically shown to be relevant.

EVALUATING THE RESULTS

For years, most experts have agreed that suspected areas of debond that are less the 2-3 ft^2 in size ,without any intercepting cracks, should be left alone. The support for this is widespread and not without merit. However, it is a mostly subjective figure though derived from extensive historical experience rather than from a scientific analysis. It is true that plate mechanics can be expected to hold debonded areas in place without repercussion up to the point where the negative wind load (with applied safety factor) exceeds the tensile bond strength.

Those wishing to identify areas that may need to be removed can use the results obtained from the ASTM C1860 testing to determine the size of such areas by further analyzing and comparing the calculated bending stresses of a stucco sample to the allowable, in situ, stress for a specific sample for a specific location. The allowable, in situ, stress, as used herein, requires determination of the negative wind-loading for each specific test site. The methodology employed in such analysis is beyond the scope of this article. Further information on this methodology can be found in *Analysis of Areas of Unbonded Stucco Using Plate Mechanics,* P. Aguirre, and M. Innocenzi, 13th Canadian Masonry Symposium, Halifax, Canada, June 4-7, 2017.

REMEDIATION

There are several conditions to be considered as you plan a remediation protocol for disbonded areas:

1. Are there full-depth cracks traversing or defining the perimeter edges of the area?
2. Does this specific area's bond strength result fall outside of the safety factor as determined by ASTM C1860 testing?
3. Is the size of the suspect area greater than that determined to be allowable under the specific location wind load?

Copies of these standards can be purchased online at www.astm.org.

For further information, contact In-Spex, LLC at www.in-spexllc.com or (407) 709-9001.