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Tech Hotline

No. 0714-C

Field Bond Strength Testing

Introduction

The quality of bond between two materials an important measure of the durability and potential performance of the materials involved. Measurement of the bond strength, or adhesion, in the field can verify compliance with project or code specifications, assess the quality of the surface preparation of the substrate, and provide a means to compare products for the purpose of selecting the best suited material for the job.

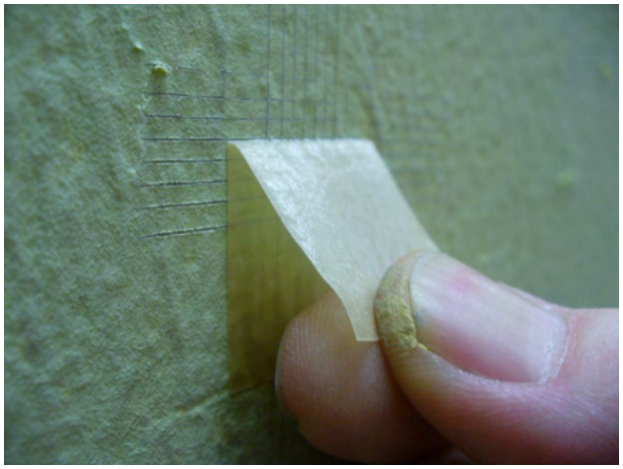
Bond strength testing can be performed on any set of materials that are applied in layers. It can be used to assess bond of a new coating to an existing coating, bond of a skim coat to existing construction, bond within a stucco or EIFS system, or bond between a repair mortar and substrate concrete. Each of these purposes has different considerations and even different methods of testing.

This Sto Tech Hotline will present basic information about common field bond strength testing methods that are generally employed for recoating a wall, either with paint or a skim coat. (Sto Level 2 reStore projects). See the actual ASTM standards for complete information about the ASTM methods.

Field testing for screening or general information can be performed by anyone with the basic knowledge of the test method and the equipment and materials that are required to perform the test. However, field quality control testing or testing to be used in dispute resolution must be performed by a *qualified independent* party using properly calibrated equipment.

ASTM D 3359 - *Standard Test Methods for Measuring Adhesion by Tape Test*

This simple method uses a standard adhesive tape to provide a visual indication of bond between a thin coating and substrate. The topcoat is scored with a knife or a cross-hatch tool. Tape is applied to the surface over the scored area and pressed firmly. The tape is then pulled from the surface and the degree to which the topcoat remains adhered to the substrate is compared to descriptions and figures presented in ASTM D 3359.



This method has limited value due to the relatively weak bond of the tape, but it is helpful to assess large areas with a minimum of disturbance to surrounding construction, and can be used to check quality of surface preparation. This method works best for smooth coatings applied to smooth substrates because it is difficult to get complete adhesion of the tape to a textured or rough surface. This method is not a good option for testing chalky or cementitious surfaces.

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Field Embedment Pull Test

This method is a nonstandard test which is similar to the ASTM “tape” test. For roller, brush or spray applied coating, a length of fabric is partially embedded in the topcoat as it is applied. The fabric is often cheesecloth, but any fabric that is thin and open enough to be saturated with the coating and strong enough to perform the test may be used. StoGuard Fabric is suitable for this type of test.

Typically a 6-inch length of fabric is embedded in the fresh coating and top-coated to fully encapsulate it. A 6-inch long “tab” of fabric is left. The coating is allowed to dry completely, and then the uncoated tab is grasped and pulled to provide an indication of the bond strength. The force required to complete the test combined with visual observation of the coating/substrate is the basis for conclusions about the test results. Some typical post-test observations and conclusions are:

Post-test Observation	Conclusion
Coating pulls clean from substrate with significant effort (no coating remains where fabric has been pulled).	Adhesion failure* between coating and substrate. Amount of force required to pull coating suggests the need to perform a quantitative test to actually measure the bond strength.
Coating pulls clean from substrate with ease (no coating remains where fabric has been pulled).	Adhesion failure between coating and substrate. Ease with which fabric is removed indicates need for additional surface preparation or potential incompatibility of the coating with the substrate.
Fabric and coating pull away from the wall with substrate material embedded in the coating that is removed.	Cohesive failure of the substrate. This indicates that the bond of the coating is stronger than the internal strength of the substrate. The design professional needs to verify that the substrate strength is sufficient before proceeding.
Fabric pulls from the coating leaving coating adhered to substrate (pictured above)	Cohesive failure of the coating. Satisfactory bond between materials. Coating is a candidate for use, provided it meets other performance requirements for the job.
Fabric tears with significant effort and remains embedded on the wall.	Fabric failure. If the effort required is significant, this indicates satisfactory bond. The judgment of how much effort was required is based on the experience of the person performing the test. This result may require a quantitative measurement of the bond strength.
Fabric tears easily	Fabric failure. Need to retest with sufficiently strong fabric to stress the coating.

*A ”failure” is the intended result of this test.

The field embedment pull test is beneficial for assessment of large areas, initial product selection screening tests, and assessment of the effectiveness of substrate preparation. The limitation of this test is that it does not produce a numerical result, so additional companion testing with actual bond strength measurement would be required to use this method as part of a field quality control protocol.

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The field embedment pull test can also be used to test adhesion of a skim coat to an existing surface. This is a common need during the scoping and performance of restorative projects where a new surface is to be applied to an existing wall that is cracked, needs to be leveled, or needs a new textured coating.

The test is run the same way as for coatings, except that EIFS reinforcing mesh is used in lieu of the fabric described above. A portion of a length of mesh is fully embedded in the skim coat, with a tab left exposed to pull. The mesh tab is pulled once the skim material has dried. If the mesh pulls through the skim coat or is torn during the pull, then the bond strength is sufficient. If the skim coat is pulled away from the substrate, further quantitative tests should be used to measure the actual bond strength.

ASTM D 4541, *Standard Methods for Pull-off Strength of Coatings Using Portable Adhesion Testers*

ASTM D 4541 measures the bond strength between materials and provides a numerical result which can be compared to code requirements and project specifications. This test is suitable for field quality control of application and use in resolution of disputes.

There are several different styles of testing devices that are designed to perform ASTM D 4541. All involve gluing a block to the surface of the coating, then using a consistent continuous application of force to remove the block from the wall. A gage captures the peak force that is applied or reports the strength directly in psi or N/mm^2. This test requires experience and training to be reliable.

In addition to recording the numerical results, the conditions of the break and the location of the failure plane should be documented. Similar to the field embedment pull test, the break can occur in any layer or interface of the construction. Examples are: cohesive failure of the substrate, adhesive failure between the coating and the substrate, cohesive failure of the coating, or adhesive failure between coating layers (where multiple layers of coating exist). In cases where an adhesive failure occurs, the numerical value must be sufficiently high to justify application. Else additional surface preparation is required or a different

coating should be used. If a cohesive failure occurs within the coating or the substrate, then the bond strength is satisfactory (i.e. the bond is better than the internal strength of the material that failed).

Standardized requirements for minimum bond strength are published by ICRI (International Concrete Repair Institute). The ICRI minimum bond strength for coatings applied to new concrete construction is 150 psi (1.03 MPa). The ICRI minimum bond strength for coatings applied to existing concrete construction is 100 psi (0.69 MPa). Sto suggests using these values for guidance only and giving the proper amount of consideration to the type of failure and location of the failure plane. For instance a cementitious base coat may only have an internal cohesive strength of 75 psi (0.5 MPa), but if the test results in failure of the base coat (not its bond to the substrate) then the bond is probably sufficient.

Multiple Coating Layers

The location of the failure plane can be very important in all of the test methods. For example, an existing building is to be recoated for aesthetic reasons. A filed adhesion test is performed with the intention of making sure the new coating will bond to the existing finish coating. The results of the test are poor adhesion, but the failure occurs between the original coating and the concrete substrate. What does this tell us about the bond of the new coating? Only that it is better than the bond of the old coating to its substrate. The design professional must determine if the bond of the existing finish is sufficient to complete the recoating project, or if the existing finish must be removed. This is a very common occurrence in restorative projects where multiple layers of paint have been applied or where an elastomeric coating has been applied directly to concrete and subjected to years of exposure.

Conclusion

Field bond strength testing is a valuable tool. However, like all testing, it should be performed by qualified and experience personnel as appropriate to the purpose of the test. In cases where a quick screening test is needed to compare products or check quality of surface preparation, the field embedment pull test is often sufficient. Where the test is a requirement for field quality control or dispute resolution, ASTM D 4541 is the best option and should be performed by someone who is independent of the contractor and material supplier and properly qualified, trained and equipped.