

## Adhered Veneer in Earthquake, Storm and Prefabrication

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A review of the use of Adhered Veneer in earthquake area, the basic method of UBC installation and the tests of bond made for variations of the method, especially for a correction to the ASTM Standard method for absorption test. Also this is a review of some of the aspects of panel connections and story drift in prefabricated panels.

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The subject of this discussion is Adhered Veneer. Veneer is basically a non-structural facing to add surface color texture etc. to something else and Adhered Veneer is one of the many types. One specific facing of Adhered Veneer has been applied to surfaces for centuries as mosaics and pavements, demonstrating the soundness and durability of such a surfacing.

The ICBO\* has added a consideration of seismic risk, recognizing that such masonry elements are frequently installed on surfaces above and overhanging public ways and areas occupied by people. Also that the supporting structures will be subject to movement and distortion. For many years the specification method listed in UBC (Uniform Building Code) has been a sure safe method as stated in the following quotes.

" (b) **Adhered Veneer.** Adhered veneer and its backing shall be designed to have a bond to the supporting element sufficient to withstand a shearing stress of 50 pounds per square inch. "

" (d) **Application.** In lieu of the design required by Section 3004 (a) adhered veneer may be applied by one of the methods specified in U.B.C. Standard No. 30-1. "

" **Adhered Veneer**

Sec. 30.103. One of the following application methods may be used:

1. A paste of neat portland cement shall be brushed on the backing and the back of the veneer unit. Type S mortar then shall be applied to the backing and the veneer unit. Sufficient mortar shall be used to create a slight excess to be forced out the edges of the units. The units shall be tapped into place so as to completely fill the space between the units and the backing. The resulting thickness of mortar in back of the units shall be not less than 1/2 inch nor more than 1 1/4 inches. "

This method is shown in the following drawings and consists of certain definite steps. The veneer may be applied over studs or solid backing such as concrete or masonry.

\*International Conference of Building Officials, which created and keeps up-to-date the UBC, (Uniform Building Code)

One of the common materials used for Adhered Veneer has been fired ceramic clay of from  $\frac{1}{2}$ " to  $1\frac{1}{2}$ " thick, either to provide colored textured area ornamentation or to simulate full brick walls. A specific example frequently installed is the "thin brick" unit approximately 1" thick with material and surface to match and simulate actual brick walls.

A close look at some of the factors pertinent to bond indicates the importance of the Initial Rate of Absorption. The relation has been shown in figures such as Figure 2, which is an excerpt reprinted from the textbook "Reinforced Masonry Design" by Robert R. Schneider and Walter L. Dickey, published in 1980 by Prentice-Hall, Englewood Cliffs, New Jersey. This indicates the result of tests made relating bond values developed to various rates of absorption, or suction. Tests indicate that the ideal initial rate of absorption to develop maximum bond strength falls above the 10 to 12 g/min. range with a preferable maximum of about 40 g/min. If for some reason the initial absorption rate does exceed 40 g/min., standard practice is to wet the units prior to laying in order to lower this excessive initial rate of absorption so it will be within a more desirable range. This wetting is most effective when done about 24 hours before the brick units are laid, so that the water will have adequately reduced the IRA (Initial Rate of Absorption) while not yet leaving the surface wet.

This particular IRA characteristic of brick is exceedingly important for several reasons:

1. If the absorption rate is too great the brick units will be more difficult to lay in the wall because water will be removed too rapidly from the mortar bed, causing it to lose workability before the brick units are laid on it.
2. Should the brick exhibit an excessively high absorption rate the bricklayer may have a tendency to tap the brick as he places it which has the effect of disturbing the bond between brick and mortar.
3. A brick with an extremely high IRA tends to dry the mortar so quickly that it will not retain the proper amount of water needed for hydration to develop strength

FIGURE 2-10. Brick suction, grams of water absorbed in one minute per 30 in.<sup>2</sup>.

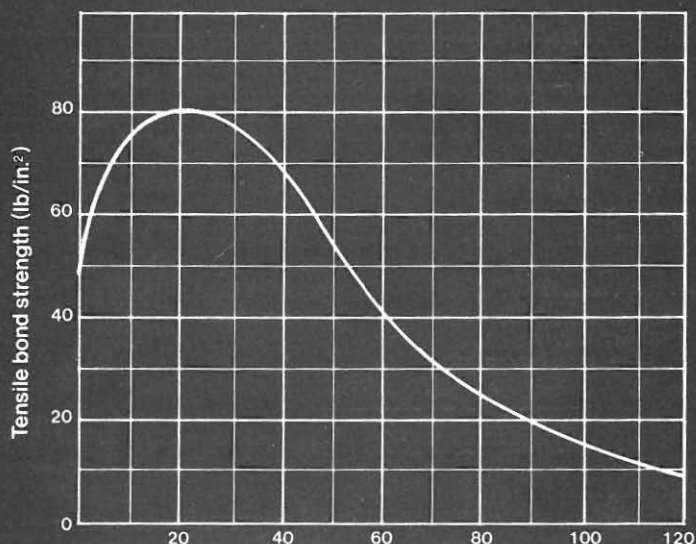
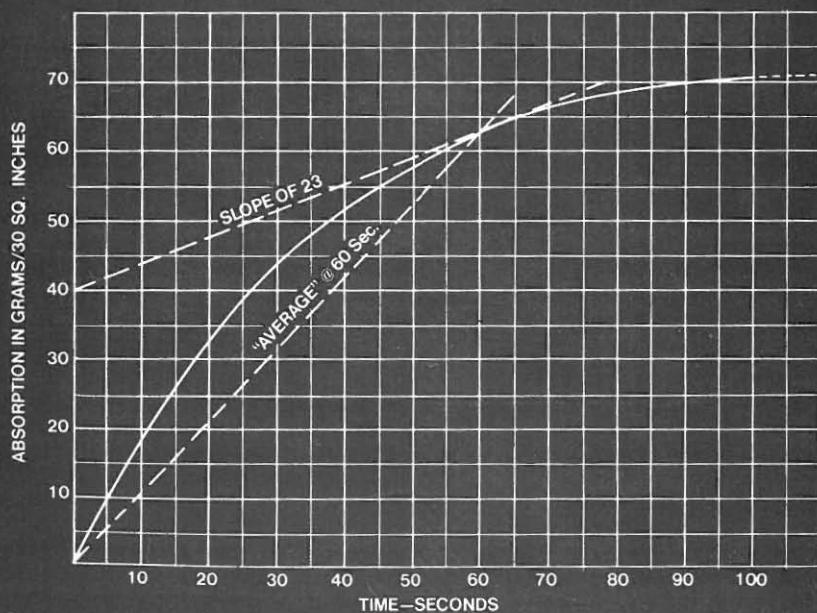


FIGURE 1



and bond.

4. Since suction has an influence upon the bond it also influences the water tightness and weather resistance or durability.

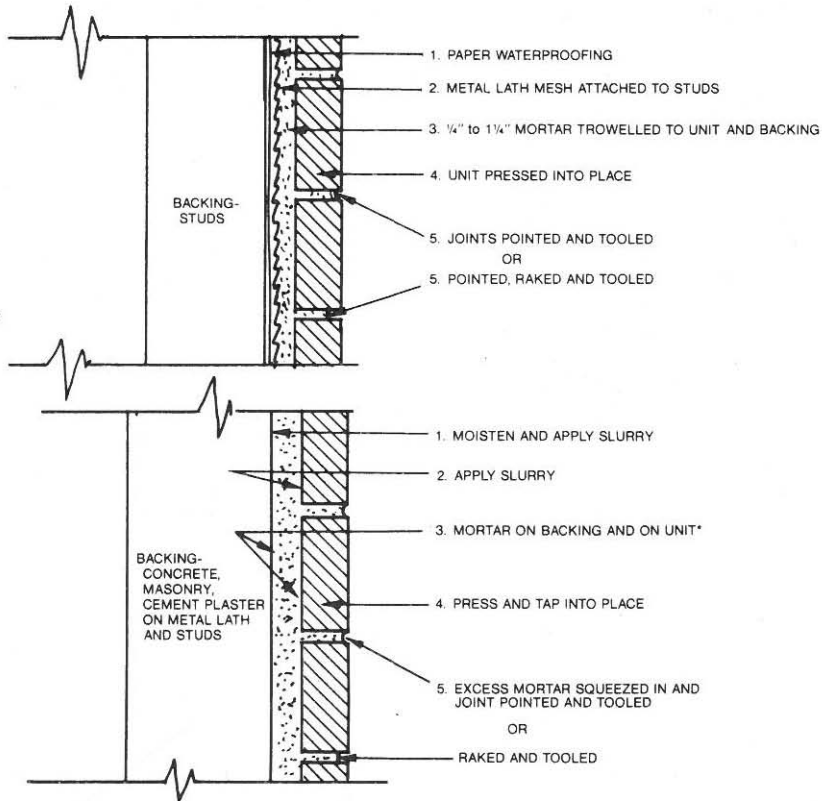
These factors are related to an item in which care must be exercised in determining the true IRA rather than the apparent rate that would be shown by strict adherence to ASTM procedure, that is, the placing of the face of a unit into water and measuring the amount absorbed by 30 square inches in one minute.

Many veneer units have a measured IRA which indicates it should be wetted in order to achieve highest bond. However, it must be recognized the units are thin with relatively low volume compared to the surface area. Therefore water can fill the pores of that volume quickly and the actual absorption rate near the end of the one minute standard exposure time of the ASTM procedure will be much less.

This change in the actual rate of absorption was evaluated by weighing a specimen at 20 second intervals up to 80 seconds. An additional exposure of another full minute showed only four grams of additional water absorbed. This change in the rate of absorption is shown in the plot of the accompanying chart.

In practice it is apparent that when a unit is checked by the standard ASTM IRA method used for thick units it would show an average IRA of 60 grams as shown by the slope of the line to the one minute exposure and this would indicate that the units should be wet considerably in order to reduce that rate. However, the actual rate of absorption at 60 seconds is about 23 grams as shown by the slope of the line tangent to the curve at that point. This rate of absorption is almost ideal for maximum bond. Further exposure to moisture would provide too much water content with the possibility of reducing the IRA and consequently reducing the bond. Hence it is obvious that the units should not be wetted. They will become wet enough from exposure to the water of the bonding mortar.

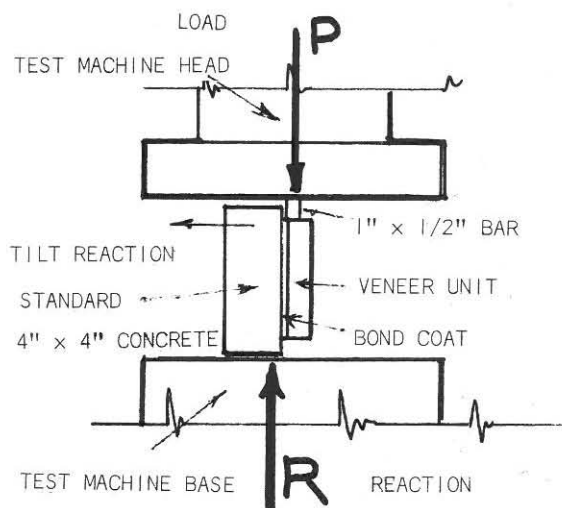
A drawing showing the installation of clay unit Adhered Veneer follows: This lists the various steps progressively followed for compliance with the basic UBC specification method.



1. Clean the surface of dust, dirt or other possible bond inhibitors, moisten and brush with slurry of cement or cement and equal parts of fine sand.
2. Apply slurry to back of units or dip into mortar to work juice onto back of unit.
3. Apply mortar to backing, and to units.
4. Press units into place tapping for proper alignment and spacing.
5. Mortar is pressed into or pointed into joints and tooled or may be raked and tooled.
6. See other details for supports, expansion joints etc.

A series of standard shear bond tests was made. This test consists of bonding a veneer unit to a standard 4 x 4 inch square elements. After curing, the surface is sheared. This will determine what the shear strength at the shear plane is. According to UBC it must exceed 50 psi. This is much greater than necessary but in practice it has been found that when workmanship is good the values will be far above 50 pound minimum. It has been felt essential to provide this considerable excess factor of safety because of the intangible forces of expansion and contraction that may be existent at the surfaces of wall masses.

The test program at the Smith-Emery Test Lab consisted of adhering veneer units to standard 4 x 4 concrete surface units, curing, and then shearing them off in a conventional compression testing machine as shown in the sketch below. Sets of 5 specimens of each variable were prepared to determine the shear capacity of bonding by the steps of the UBC method (which must meet 50 psi for acceptance) and then the effect and suitability of changes from that basic method, as follows.



<u>METHOD</u>	<u>SHEAR</u> (P.S.I.)
1. UBC requires	50
2. UBC (see excerpt & dwy	167
3. UBC, except with dry units	163
4. UBC but with no paste	118
5. UBC but dip in mortar	163
6. UBC, but dry, & dip in mortar	197
7. UBC but no tapping	139
8. UBC but dry, no paste, no tap	80
9. Thin-Set per Mfg. directions	320
10. Latex mortar, dry, no tap	187
11. Latex mortar, on backing	195
12. Latex mortar, on dry units,	69
no tap	
13. Mixture of Types & Thin-Set	201

Other methods were developed, as shown, by the test program that can provide adequate bond of the fired clay units. The materials are to be in compliance with ASTM and UBC standards and the mortar is to be Type M or S. These other methods are really merely slight modifications to the basic method and are shown in the drawings of alternates 1,2,3,4,5.

Alternate 1 provides that the backing and bond coat may be applied just prior to installation of the mortared units. The mortar must be stiff enough to resist the pressure due to the pressing of the units into place.

Alternate 2 provides that a Latex additive may be added to the mortar according to the manufacturers' instructions. This increases the bond capacity of the mortar and the Latex mortar may be applied to the units which are pressed into position, or may be applied to the backing and then the units pressed into the fresh mortar.

Alternate 3 provides that Thin set material may be used for bonding. The surface of the solid backing must be clean and must be a relatively true accurate surface plane. The Thin set is then troweled on and combed to provide ridges into which the units are pressed and tapped into place. The joints are then pointed and tooled or pointed, raked and tooled.

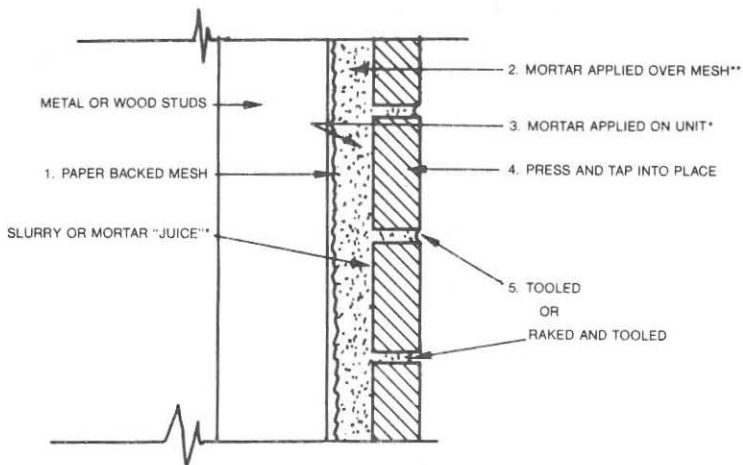
Alternate 4. A modification may be made when Adhered Veneer is to be applied to a sloping or soffit surface. The mortar to hold the units in place must be pasty, sticky, and stiff enough to hold the units in place without sagging or sliding while the initial set is developing. These physical properties depend on the mix proportions, the grading and type of aggregate, the moisture content and the type of backing surface and of masonry units. The actual proper mix and consistency may be checked by successive trials.

Alternate 5. This is a single coat method developed originally for tile installations. It consists essentially of attaching a paper backing over which wire mesh reinforcing is applied and then either plastering mortar on that surface and pressing the units into it or by putting mortar on the units and pressing them onto the mesh. In this case the real attachment of the veneer application to the wall is through the anchorage of the paper backed mesh.



# Installation Methods

## Alternate 1



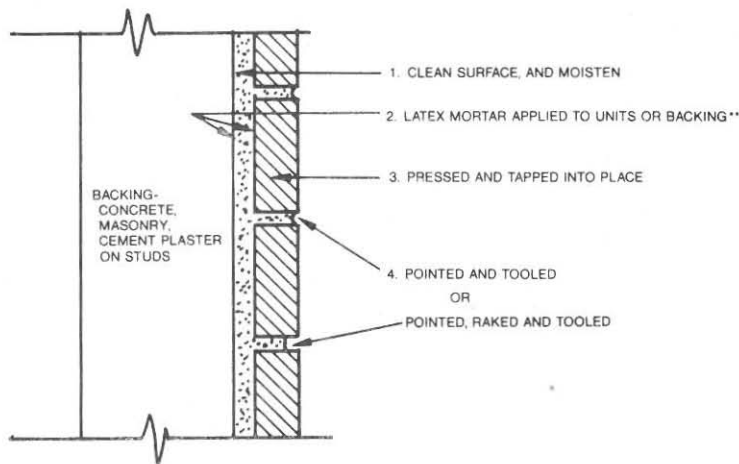
\*The back of the units may be coated by working or dipping onto mortar.

\*\*The mortar may be applied previously as a scratch coat or may be applied just prior to

installation of mortared units. It must be stiff enough to resist the pressure of placing the mortared units.

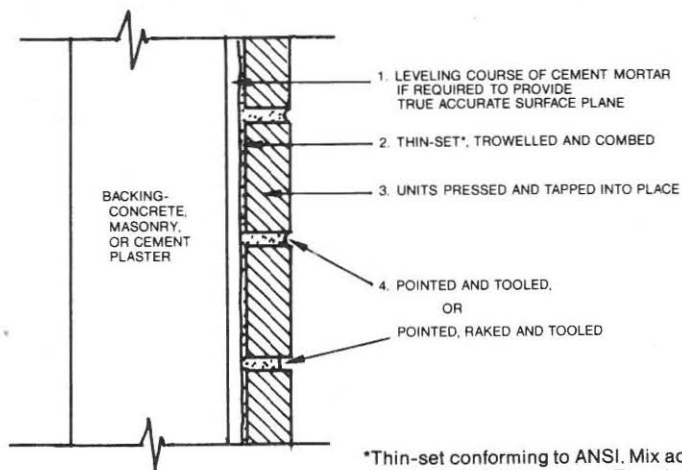
This method is illustrated in an article published in July 1980 Masonry Industry magazine.

## Alternate 2



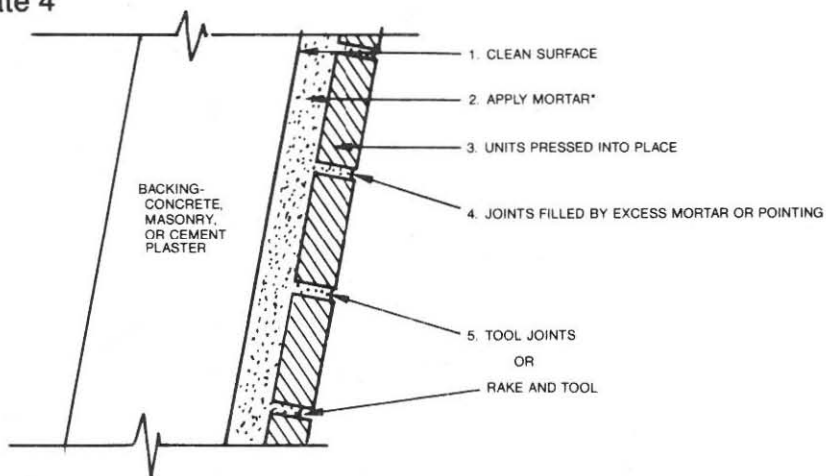
\*\*Latex additive to be added according to manufacturer's instructions

### Alternate 3

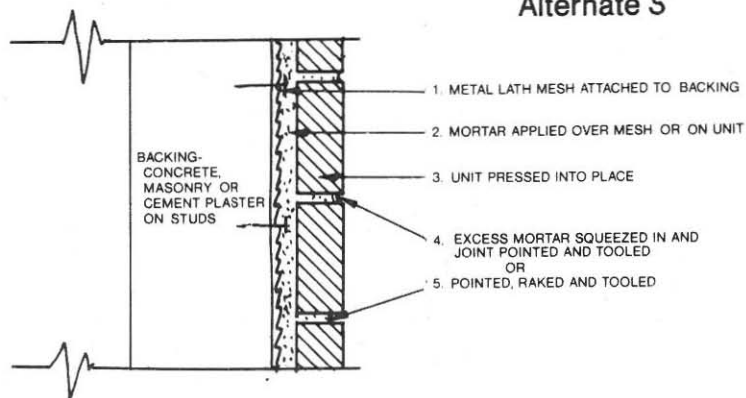


\*Thin-set conforming to ANSI. Mix according to manufacturer's instructions. Trowel onto limited area of backing, comb to provide ridges.

### Alternate 4



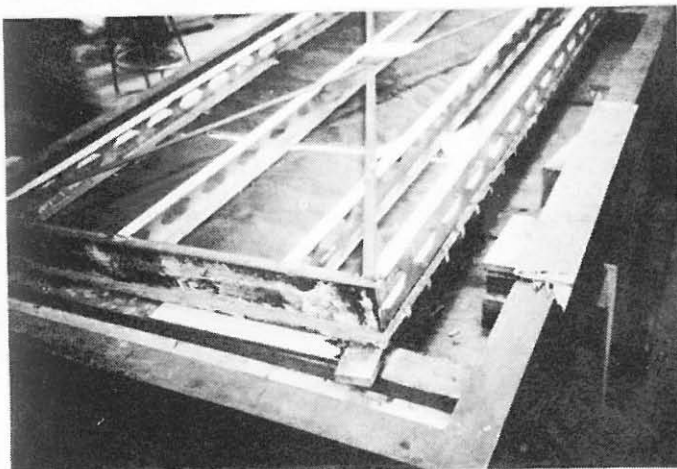
### Alternate 5



The use of Adhered Veneer applied to prefabricated steel stud framing can provide very effective large prefabricated wall areas and also prefabricated shapes that have the appearance of brick walls and shapes, but which might be very difficult to install as in-situ brickwork.

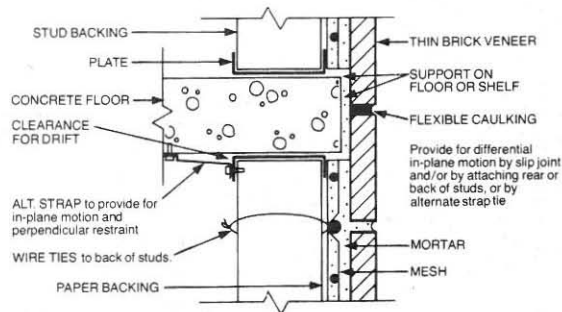
The connections of these prefabricated panels must provide for story drift where heavy wind and seismic motion is expected in the building. One method is to use straps or rods to support the top of the panels. This provides for support and resistance to forces perpendicular to the wall plane while yet permitting motion in the direction of the plane. This, of course, requires that there be carefully caulked weather resistant joints where such motion is anticipated.

There have been many tests made to verify the effectiveness of Adhered Veneer applied to light stud framing which results in weather resistant durable safe elements for exterior as well as interior applications particularly in prefabrication. Some of the tests were to note the safety and resistance to handling accidents. Panels with different installation methods were loaded to failure and it was observed that the panels were surprisingly strong and, more importantly, the panels held together without loss of fractured portions.



## CONCLUSIONS

1. Adhered Veneer may be used safely in seismic areas.
2. Adhered Veneer may be used effectively to resist heavy wind forces.
3. There are proven satisfactory alternates to the UBC basic Adhered Veneer method
4. Adhered Veneer may provide durable brick surfaces with a minimum of weight and thickness. This is especially important in reconstruction and in the adaptation of existing construction to new uses now so necessary in view of high construction costs and construction loan costs.
5. Adhered Veneer on studs can be used effectively on prefabricated panels with safe resistance to handling and to seismic stresses.



ADHERED VENEER