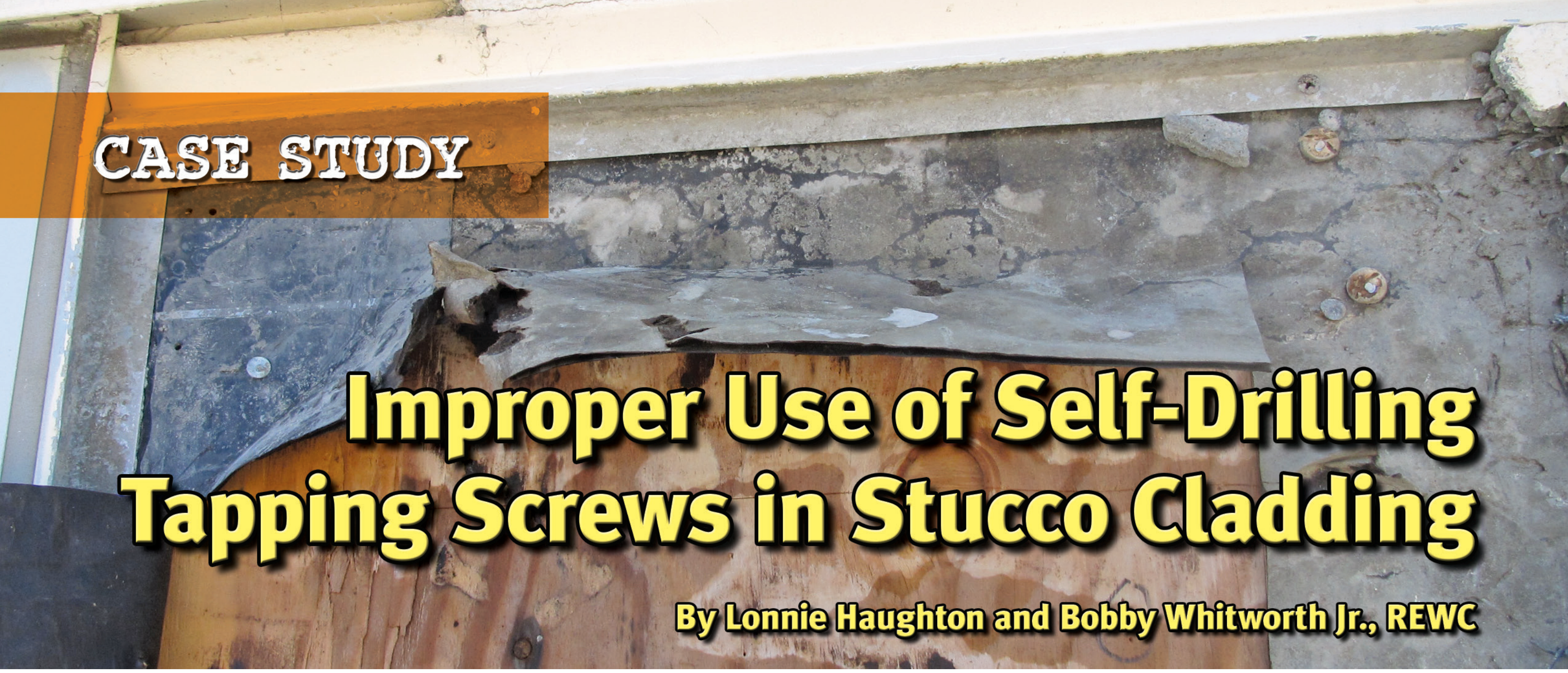

CASE STUDY

# Improper Use of Self-Drilling Tapping Screws in Stucco Cladding

**By Lonnie Haughton and Bobby Whitworth Jr., REWC**

## INTRODUCTION

Consider a large wood-framed, stucco-clad school building constructed circa-2009 in a small coastal town in Northern California. The structure is highly exposed to storm winds blowing in from the Pacific Ocean. As evidenced by *Photo 1*, building envelope failures have resulted in extensive deterioration and fungal growth within weather-exposed wall assemblies.

Presumably in response to concerns regarding potentially corrosive impacts of the harsh marine environment, metal accessories (including aesthetic "reveals") in the stucco cladding had been upgraded to stainless steel (see *Photo 2*). The narrow focus of this report is to examine the use of stainless steel "self-drilling tapping screws" to attach these components to the underlying plywood sheathing and wood framing.

## WHAT ARE TAPPING SCREWS?

Tapping screws comprise a wide range of threaded steel fasteners that form ("tap") their own mating threads when screwed through metal sheeting. A highly common use for tapping screws is the fabrication of ventilation ducts; for this purpose, traditional tapping screws often are simply called "sheet metal screws."

For typical metal-to-metal fabrication, the tapping screw installer first must provide a smaller pre-drilled pilot hole that serves to facilitate the fastener installation process. However, there are specialty fasteners (including "self-piercing tapping screws" and "self-drilling tapping screws") that have the ability to both drill their own holes and tap their own internal threads into metal sheeting without deforming their threads.

- **Self-piercing tapping screws,** commonly used with thin (e.g., 26-gauge) metallic sheeting, have sharp angled

*Photo 1 – Building envelope failures at this school building have resulted in extensive deterioration and fungal growth within weather-exposed wall assemblies.*

*Photo 2 – Bugle-head "self-drilling tapping screws" were used to secure the stucco accessories and trim to the underlying plywood sheathing and wood framing.*

*Photo 4 – The bugle-headed self-drilling tapping screws sit proud of the vertical reveal and the horizontal casing bead.*

*Photo 3 – Self-drilling tapping screws are equipped with hardened tips that resemble a drill bit. These 1¼-in. bugle-head fasteners had "the ability to drill their own hole" through the stainless steel components shown in Photo 2.*

points that provide: 1) "the ability to penetrate without benefit of a predrilled hole,"[1] and 2) "the ability to pierce metallic material 33 mils (0.84 mm) or less, form a sleeve by extruding metallic material, and 'tap' their own mating threads when driven."[2]

- **Self-drilling tapping screws,** most often used with thicker (up to ½-inch) steel sheets, have case-hardened tips (see *Photo 3*) that serve as a drill bit. In a single operation, self-drilling tapping screws have: "the ability to drill their own hole and form or cut their own internal mating threads without breaking."[3]

*Photo 5 – Water infiltration through the exposed fasteners exacerbates resulting damage at the stud framing and sheathing.*

In our experience, the most commonly encountered use for self-drilling tapping screws at construction projects is to attach a wide variety of materials (such as engineered wood sheathing, gypsum board panels, and metal flashings) to cold-formed steel-stud framing.

## ASTM STANDARDS FOR THE USE OF SELF-TAPPING SCREWS TO ATTACH METAL ACCESSORIES

Our review of key ASTM International industry standards for the use of self-tapping screws in stucco cladding systems revealed the following guidance:

- Section 5.1 of ASTM C926 requires: "Metal bases and accessories used to receive plaster shall be installed in conformance with Specification C1063, except as otherwise specified."[4]
- Section 6.7.2 of ASTM C1063: "Screws… shall be fabricated in accordance with either Specification C954 or C1002. …

Screws used for attachment to metal framing members shall be self-drilling and self-tapping. Screws used for attachment to wood framing members shall be sharp point."[5]

- Section 7.4.2 of ASTM C1002 requires: "Screw threads shall be adequate to pull a metal plaster base tightly...against the face of a wood or steel stud, without spin-out."[6]
- Section 8.2.2 of ASTM C1002 further advises: "The top of the screw shall be either flat or contoured. The underside of the head shall be flat or near flat. The threads shall extend to the underside of the head."
- Section 8.5.2 of ASTM C1002 additionally instructs: "Screws shall be long enough to penetrate wood members not less than ⅝ in. (15.9 mm)." (Also reference Section 7.10.2.5 of ASTM C1063.)

In brief, stucco industry standards for the use of tapping screws to secure metal bases and accessories to wood stud framing include the following instructions:

1. Only sharp-point fasteners (not self-drilling tapping screws) are accepted at metal-to-wood transitions.
2. Fastener heads should fit flat to the metal base.
3. The screws should have continuous threads from the tip to the underside of the head.
4. The fastener length should be sufficient that these continuous threads also extend at least ⅝ inch into the wood stud framing.
5. The screw-threaded structural bond within these wood studs should be sufficient to pull the metal accessory tightly against the face of the studs (or sheathing) without spin-out.

Further, if self-drilling tapping screws are being used in stucco cladding assemblies (whether at metal-to-wood or metal-to-metal transitions), great care must be taken to avoid damaging the building paper or wrap that serves as the code-required continuous weather-resistive barrier behind the plaster cement system.

## INITIAL ASSESSMENT OF AS-BUILT WALL CONDITIONS

It is informative to compare the above instructions with representative photographs of as-built conditions at this building. For example, per *Photo 3*, the stucco installer used self-drilling tapping screws (typically intended for use with metal stud framing) at all elevations of the wood-framed building. We found no sharp-pointed screws.

The installed self-drilling tapping screws have bugle heads (shaped like a trumpet) lacking continuous threads to the underside of the fastener head. (Bugle-headed screws most commonly are found at gypsum board panels, where the holes have been countersunk to accommodate the shape of the bugle head.[7]) As documented with *Photos 2* and *4*, bugle-headed fasteners simply cannot fit flat to metal bases and accessories.

Similarly, we found that these metal accessories often were not tightly fit to the plywood sheathing under the building paper. Therefore, because the drill point tips of self-drilling tapping screws are not threaded, these fasteners (with a total length of 1¼ in.) simply could not provide the required minimum ⅝-in. thread depth into the wood studs supporting the ½-in. plywood.

*Photo 6 – Wet, degraded (and fungal-contaminated) gypsum wallboard layers were exposed below an upper window.*

*Photo 7 – Removal of the degraded wallboard revealed severely damaged framing and sheathing.*

Further, as indicated by *Photos 3* through *5*, we saw that the exposed, poorly secured tapping screws provided direct routes for damaging water infiltration through the building paper into the wood sheathing and studs.

## AN EXAMPLE OF WEATHER-RESISTIVE PERFORMANCE ISSUES RELATED TO SELF-DRILLING TAPPING SCREWS

Note that our sole purpose for the following photographs is to focus on a specific example of rainwater infiltration conditions and resulting damage causally related to the stucco contractor's use of self-drilling tapping screws. While sharp-eyed *RCI Interface* readers may identify other construction deficiencies in these images, such concerns exceed the scope of this article.

A representative example, with annotated photographs, of our step-by-step diagnostic analysis[8] (carried out in general conformance with investigative protocols of ASTM E2128[9]) is outlined below:

1. Our destructive investigation below an upper floor window exposed wet, degraded gypsum wallboard (see *Photo 6*). Removal of these fungal-contaminated panels confirmed our preliminary assessment that the wood framing and sheathing at this jamb-sill corner would also be wet and decayed (per *Photo 7*).
2. Our first step toward tracking the origin of this leakage was to water-spray test the bottom two-thirds of this aluminum storefront window assembly. (Note in *Photo 8* the standard ASTM E1105[10] spray rack positioned below the awning framework.) No interior leakage was observed during this water test.
3. However, upon then spraying the upper right corner of this window (see *Photos 8* and *9*) with a pressure-calibrated nozzle (per test procedures established in industry stan-

*Photo 8 – AAMA nozzle testing at the upper right corner (see* Photo 9*) of this window produced interior leakage at the sill.*

*Photo 9 – Nozzle spray testing (see* Photo 8*) at this corner of the window frame rapidly caused interior leakage at the sill.*

dard AAMA 501.2[11]), we quickly were able to replicate a steady flow of interior leakage at the windowsill.

4. Our crew then removed stucco cladding below the exterior sill, revealing deteriorated plywood sheathing and free water (remnants from our water-spray testing) behind the building paper, per *Photo 10*. (The water-finding test paper[12] seen in this photograph turns red when in contact with free water.)
5. We then removed additional sections of stucco (*Photos 11* and *12*) in order to trace this water trail up the wall (behind the two layers of building paper) toward the window head. We discovered (per *Photos 13* and *14*) that the water trail continued under the horizontal stainless steel reveal, which was loosely set with self-drilling tapping screws and nails. (Note in these photographs the ripped and deteriorated building paper, which provides the infiltrated rainwater immediate access to the surface of the plywood sheathing.)
6. *Photos 15* and *16* conclusively established that the origin of the leakage, damage, and fungal growth seen in the preceding photographs was rainwater drainage off the ends of the horizontal head flashing and stucco casing bead (aka, "J mold") accessory positioned above this storefront window.

*Photo 10 – Water-finding test paper turns red when in contact with free water.*

*Photo 11 – We traced the water trail up the wall toward the window head (see Photo 12).*

*Photo 12 – We continued to trace the water trail up the wall toward the window head.*

7. Finally, *Photo 17* confirmed that rainwater drainage off the ends of the horizontal head flashing and stucco J mold had immediate access to the ripped/deteriorated building paper behind the loosely set stainless steel reveal.

In short: Our step-by-step investigation demonstrated that rainwater flow off these horizontal components at the window head (*Photo 16*) drained behind the stainless steel reveal (*Photo 15*), then migrated through the ripped/damaged building paper (*Photo 14*) and continued down the sheathing (*Photos 11* and *12*), eventually collecting at the jamb-sill corner (*Photo 10*), then migrating inward, leaving a swath of decay, deterioration, and fungal growth (per *Photos 6* and *7*) in its wake.

The linchpin of this entire deleterious water-intrusion process was the improperly installed self-drilling tapping screw projecting from the horizontal reveal in *Photo 16*.

## SUMMARY COMMENTS

As noted, the sole focus of our analysis is the contractor's use of self-drilling tapping screws to secure stucco accessories and trim to the wall sheathing and wood framing. Any other depicted deviation from any applicable standard exceeds the scope of this article.

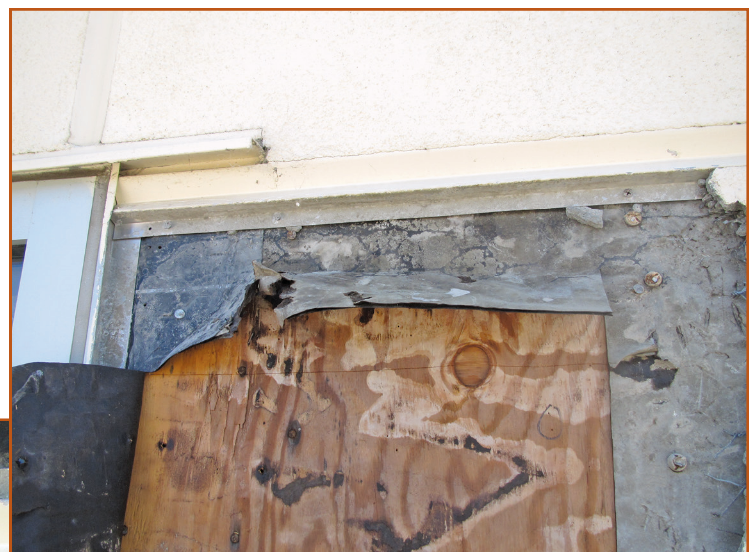

*Photo 13 – The trail of water damage led up (under the loosely set horizontal reveal) toward the head flashing above.*

*Photo 14 – The two layers of ripped and deteriorated building paper correspond to the corroded tapping screw above.*

*Photo 15 – The trail of water damage leads directly to the head flashing and J-mold accessory above the horizontal reveal.*

*Photo 16 – The linchpin of this entire deleterious water-intrusion process was the improperly installed self-drilling tapping screw projecting from the horizontal reveal.*

In our professional opinion, these 1¼-in. bugle-headed drill-pointed tapping screws:

1) Are not appropriate for use with wood stud framing
2) Are prone to improper "spin-out"
3) Fail to provide an adequate thread-mated structural bond with the wood studs
4) Generally tend to unduly damage the wood framing, sheathing, and asphaltic building paper
5) Fail to tightly interface with the stainless steel accessories
6) As evidenced by the stained/corroded screw threads seen in *Photo 3*, often are installed in a manner that pro-

*Photo 17 – Rainwater drainage off the head flashing and J-mold accessory had immediate access behind this loosely set reveal.*

vides a direct route and mechanism for damaging rainwater infiltration into and through the exterior wall assembly

Our forensic team members invested more than 30 days total to comprehensively investigate, evaluate, and document (including 8000+ photographs) the as-built construction and weather-resistive performance of the exterior wall assemblies at this school building. Upon final review, we concluded that the overall moisture intrusion conditions (and associated damage to the underlying plywood sheathing, wood framing, and interior wallboard) were so egregious, severe, and extensive that complete removal and replacement of the stucco cladding system were warranted. A key consideration was the many thousands of self-drilling tapping screws remaining at these walls.

## REFERENCES


1. ASTM C1002, *Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs*. ASTM International, West Conshohocken, PA (www.astm.org).
2. ASTM C1513, *Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections*.
3. *Ibid.*
4. ASTM C926, *Standard Specification for Application of Portland Cement-Based Plaster*.
5. ASTM C1063, *Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster*.
6. Section 3.2.11 of ASTM C1513 defines spin-out as: "the continued rotation of a screw without further penetration into the substrate."
7. Section 3.2.6.1 of ASTM C1513 defines a bugle head as: "bugle-shape countersinking head typically used for fastening gypsum panel products to wood and steel."
8. Lonnie Haughton and Colin Murphy. "Qualitative Sampling of the Building Envelope for Water Leakage." *Journal of ASTM International*, Vol. 4, No. 9, 2007 (www.astm.org/DIGITAL_LIBRARY/JOURNALS/JAI/PAGES/JAI100815.htm): "The goal of the skilled building professional is to produce findings of substantive significance that identify cause-and-effect relationships between building envelope characteristics and observed leakage and resulting damage."
9. ASTM E2128, *Standard Guide for Evaluating Water Leakage of Building Walls*.
10. ASTM E1105, *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference*.
11. AAMA 501.2, *Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems*. American Architectural Manufacturers Association, Schaumberg, IL (www.aamanet.org).
12. Micro Essential Laboratory: http://www.microessentiallab.com/ProductInfo/F30-SPLTY-WATERF-JUD.aspx.



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