Collapse of Sloping Masonry Veneer

By Richard L. Hess, S.E., SECB

Collapse of a forty foot long section of a twelve foot high sloping granite veneer required a structural evaluation to determine the cause of the failure. Built in the 1970s, the collapsed wall is at the base of a mid-rise government office building located in southern California.

The granite blocks are approximately 8- x 8- x 3-inches thick, and are set in approximately 2½ inches of mortar. The granite blocks are attached by means of steel clips clamped to #9 wire in the mortar, and inserted into dovetail slots nailed to a wood nailer cast into the concrete support wall. Please refer to the details (copied from the original drawing) and the photographs included with this article.

The pavers on the concrete slab at the base of the wall had been removed in order to replace the horizontal waterproof membrane prior to the collapse of the sloped veneer.

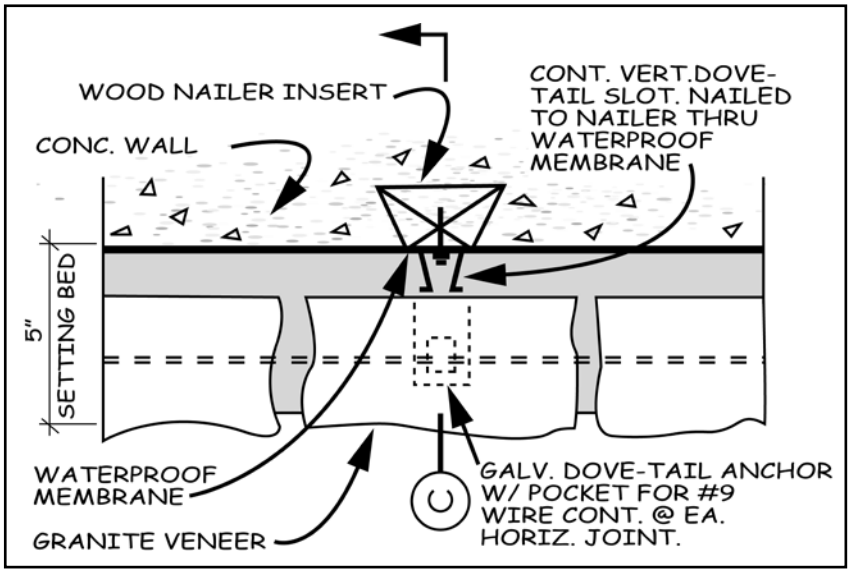
The fixings provided between the granite veneer and the concrete wall are designed for lateral restraint only. No provision was made to provide load-bearing fixings that could resist the vertical forces due to the weight of the veneer.

Edge of failed wall where adjacent granite has fallen off

The slope of the wall is three vertical units to one horizontal unit. In order for friction to be a significant factor to resist movement due to gravity, the slope would have to be reduced to approximately one vertical unit to four or five horizontal units, a much flatter slope.

Therefore, the primary vertical support for the veneer was the pavers at the base, which extended under the wall veneer. Once the paver at the base was removed to complete the waterproofing of the slab, the only thing resisting sliding was the six inches on center spaced nails from the vertical dovetail channel into the wood insert.

The vertical channels and dovetail straps are not designed to resist vertical forces, but do possess some small capacity to do so. However, all of the nails that were observed were completely rusted out within ⅛-inch of the back of the channel. A waterproof membrane was installed between the concrete wall and the mortar, which further prevented any bonding that might have occurred between the two cementitious surfaces. Any small shock could therefore detach the veneer and cause it to slide down. This shock could have been provided by any of the moderate earthquakes that occurred prior to the collapse.



Horizontal section through veneer

Conclusion

The attachments or fixings of veneer to its structural backing or support are of two types: load-bearing or for lateral restraint. All veneer that is not horizontal or nearly so (one vertical unit to at least five units horizontally) must have load-bearing fixings to resist gravity loads and restraint fixings to resist horizontal forces such as wind, earthquake, or impact. When load-bearing fixings are absent, any small lateral force, or simple expansion due to temperature change, will overcome the limited vertical support provided by the restraint fixings or by incidental friction. In this case, friction between the veneer mortar and the concrete substrate was negligible because of the moisture barrier.

The weak link in the restraint fixing was the small nails from channel to wood insert. These had completely rusted out. Failure was inevitable once the support from the slab paver, at the bottom, was removed. Furthermore, even if the pavers had not been removed, the veneer could have broken loose and buckled outward at any time due to a moderate earthquake.

Since there is no safe alternative to removing all of the granite veneer on the sloping and vertical wall sections, the granite had to be replaced. The new granite veneer must be attached with a design that incorporates the following features:

1. Load-bearing fixings consisting of corrosion protected structural steel angles anchored to the concrete wall with stainless steel concrete anchors.
2. These steel angles will run horizontally at a spacing that provides for properly designed horizontal expansion joints.
3. The bottom load-bearing fixing shall allow a space between it and the adjoining slab pavers. This joint will have a properly designed elastomeric joint filler.
4. Properly designed vertical running expansion joints. These expansion joints shall consist of a polypropylene rod or tape to prevent adhesion to the bottom of the joint, which shall have a depth no greater than its width, the space behind being filled with non-adhering joint filler.
5. Restraint type fixings shall be installed with positive connection from the granite into the concrete or stud wall by means of embedded steel slotted channels.
6. Waterproofing of the base structure shall provide for positive escape of moisture that penetrates behind the veneer. ▪

Southwest corner of failed granite wall; south face is sloped 1 horizontal to 3 vertical, while west face is vertical

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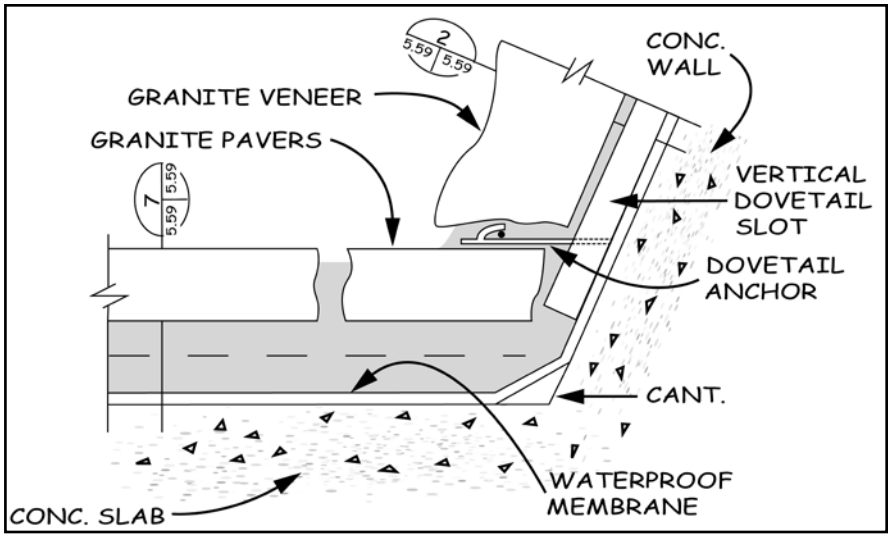

Vertical section at base of sloping veneer