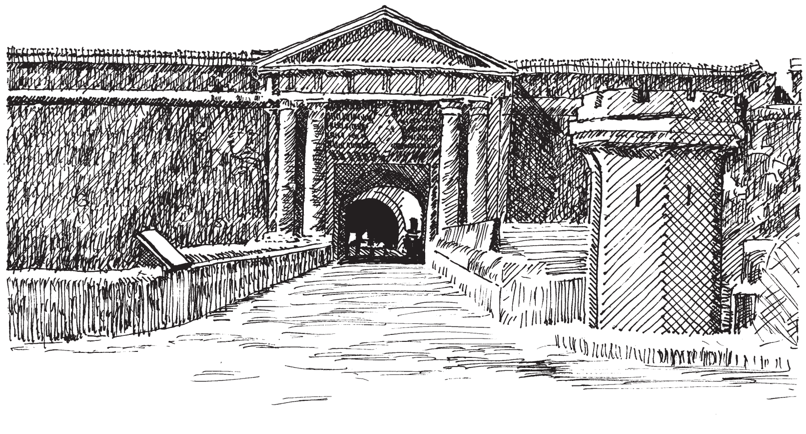
ARCHITECTURE
EHLINGER & ASSOCIATES THIRD QUARTER 2010



Castillo de San Felipe del Morro
San Juan, Puerto Rico
© 2010 Ladd P. Ehlinger

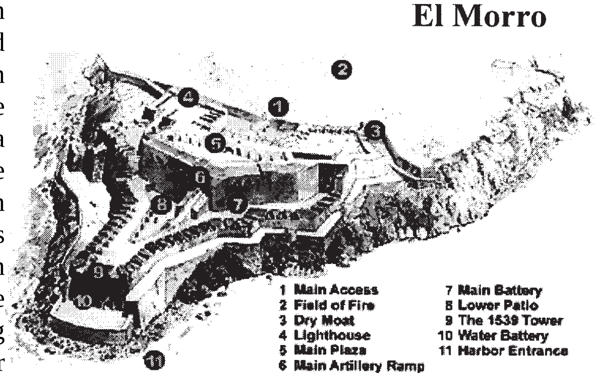
Castillo de San Felipe del Morro

Castillo de San Felipe del Morro is one of several forts that were built by the Spanish to defend the natural harbor of San Juan, Puerto Rico beginning in 1539. The other forts are: San Cristobal, which guards the land access to the rear (east) of San Felipe on the peninsula where they are located; la Fortaleza which guards the shore of the port; and el Cañuelo which is in the harbor and provides crossfire for San Felipe if an enemy makes it through the mouth of the harbor. King Carlos V of Spain ordered their construction to firmly establish the Spanish control of the island.

This issue's limited edition print by Ladd P. Ehlinger is of the main entrance from the land side, where one crosses over a dry moat on a bridge to the entry. Last edition was of the fort in Quebec City, and we may also do our own Fort Pike in a future edition as we are designing repairs there to correct Hurricane Katrina damage for the State of Louisiana, its owner.

A "morro" means promontory or headland, and in this case, it was exactly what the builders of the fort needed: a high location from which they would be shooting down on the enemy. In 1589, the engineers Juan de Tejada and Juan Bautista Antonelli designed and laid out the fortifications that we see today. The fort was extensively remodeled in 1765 by Alejandro O'Reilly and Royal Engineer Tomas O'Daly. The defenses were constantly being upgraded in response to advances in military technology and in response to the performance of the defenses during the wars they participated in.

El Morro



In 1589, Sir Francis Drake unsuccessfully attacked El Morro by sea. Drake gave up after El Morro gunners shot a cannonball through Drake's cabin on the ship. In 1589, George Clifford, Duke of Cumberland attacked El Morro from the land side (before the construction of San Cristobal) and was successful in taking El Morro - the only time this happened in its history. In 1625 the Dutch under the command of Boudewijn Hendricksz attacked and took San Juan captive from the land side, but El Morro held, even though the city was sacked and burned. The U. S. shelled El Morro in a day long bombardment on 12 May 1898. Six months later, Puerto Rico was ceded to the U.S. in the Treaty of Paris. In 1942, the U.S. added concrete bunkers and observation posts during Word War II. In 1949, the San Juan National Historic Site was established, and in 1961, the U.S. Army moved out of all the forts giving control to the U. S. National Park Service. In 1983, the site was declared a World Heritage Site by the United Nations.

I spent four months in 1961 working as a Student Assistant Architect for the National Park Service's Historic American Building Survey (HABS) documenting various aspects of several of the forts. In El Morro, I assisted an archeological team from the University of Florida by producing sketches of their digs and artifacts that they found, and at San Cristobal, I measured the 5 bay masonry barrel vaulted Officer's Quarters portion of the fort which was built atop a 5 bay barrel vaulted cistern. These drawings are in the U. S. Library of Congress.

Ladd P. Ehlinger

BRICK VENEER

About 40% of E&A's architectural practice is forensic, in that we investigate failures, ascribe responsibility therefor in reports, design repairs and/or replacements, and then testify and provide litigation support if litigation is involved also. In short, we fix failures. The failures are usually waterproofing or structural in nature, or both. One assembly of materials that is most frequently involved in waterproofing failures, and sometimes in structural failures and code violations regarding structural criteria is brick veneer. The usual composition of the failure is one of both design defect(s) and construction defect(s).

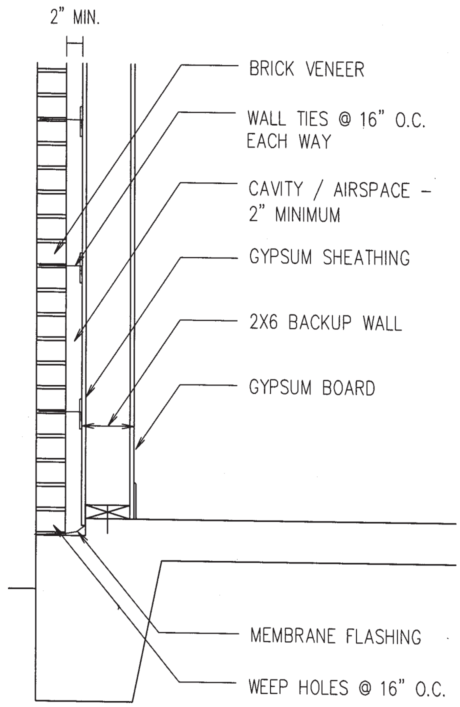
The brick units and the mortar that binds them together are not "waterproof". They are porous and thus absorb water

2200 Houma Blvd., Metairie, LA 70001-1399 (504) 455-8911 3109 Ivy Ave. SW, Huntsville, AL 35805-4698 (256) 534-1900

through capillary action and surface tension. If there are any "holidays" or defects in the mortar joints the amount of water entering increases. Brick veneer is an assembly of materials devised to deal with and overcome these porous properties of the brick masonry and with atmospheric effects generated by the wind.

When the wind blows on a building, the windward face or facade is positively pressured, the rear facade is negatively pressured, and the two side facades are negatively pressured. If the roof is flat it is also negatively pressured, and if sloped, depending upon the angle of the slope, either totally negatively pressured (low slope) or both positively and negatively pressured. The pressures are highest at the outside corners both vertical and horizontal. The net effect of these wind pressures is that the building may well "go negative", such that the internal air pressure is significantly less than the positive pressure on the windward facade, if there are sufficient holes in the envelope for the air exhaust to occur on the negatively pressured facades and in turn, enter on the positively pressured facade. The air that enters may well carry water with it in a rainstorm. This is why leaks in a building differ in location when the building is located in a variable wind zone. Leaks can also be exacerbated when the building's HVAC system is designed to be negative or is misoperated to be negative. The building can literally "suck" the water in.

A brick veneer assembly conforms to concepts developed in the "Rainscreen Principle". There is an outer "screen" (the brick, one wythe [one brick] wide) that absorbs the kinetic energy of the water from the rain, usually created by atmospheric pressure differentials generated by the wind interacting with the internal spaces of the assembly or the building itself, capillary action through the materials themselves (brick and mortar), gravity through holes and crevices, surface tension through holes and crevices, and by air currents through holes and crevices. This outer screen (the brick) allows the water to leak or seep into an inner space (the cavity or air-space) in a controlled manner that reduces the pressure differentials, blocks the air currents and collects the water through gravity drainage to a space where it is allowed to drain back or "weep" to the exterior through weepholes. This space is called a water-shelf or a "brick-shelf", and is lower than the top of the floor assembly of the building to separate the bottom of the watershelf vertically by gravity. There is usually a flexible membrane flashing, of vinyl or rubber that attaches and seals to the back-up wall above the floor level and then turns 90^{O} and lays on the bottom of



the watershelf under the first course of brick. This flashing is an "insurance policy" to protect against cracks in the vertical side and bottom of the watershelf that allow water to bypass the vertical separation and seep up under the flooring especially if it is a concrete slab.

Weepholes are usually created by omitting a head joint (the vertical joint at the end of a brick unit). The building code requires weepholes every 24" in the first course, or every three bricks if modular units are used. My observation has been that 16" OC (on center) is a better interval. Some architects use a greased sash cord (3/8" in diameter) equal in diameter to the joint and require that the cord be pulled out after the mortar has set. Some architects don't require that the sash cord be greased and allow it to be left in place. Some architects call for a corrugated plastic device to be placed in the head joint where the holes in the corrugation on its side are the drainage. These are aesthetic attempts to conceal the "tooth gap" look of the open head joint. I have observed that none of these contrivances work. The "left in place sash cord" has the same effect as impacted mortar, the greased sash cord removed and the corrugated plastic device provide perfect homes for insect and other critters, that clog them up once they are occupied.

I have seen brick veneer walls designed and constructed with no watershelf, on a high rise condominium balconies no less. I have seen where the design had a watershelf, but then placed a through wall membrane flashing at a level higher than the top of the floor inside and call for the space below the flashing to be filled with grout. Both of these types of defects are total disasters resulting in water intrusion.

The brick veneer is essentially unstable structurally by itself because it is only one wythe wide. The wall on the other side of the cavity or air-space, the back-up wall, provides lateral stability by tying the brick veneer to itself through use of wall ties. Wall ties are usually of two types: corrugated metal and wire. The corrugated wall ties are essentially used only on incorrectly designed low rise residential structures with a 1" wide air space, while the wire ties are used on correctly designed structures with a 2" or more cavity width. Testing of wall ties has determined a certain pattern for minimum support and a more frequent pattern for support in hurricane regions. Thus wall tie spacing is empirical, and there is no mathematical model for determining spacing/frequency of wall ties.

The corrugated anchors have been observed to fail in both compression (they buckled) and tension (they stretched) when the cavity is wider than 1". The brick veneer failed with the corrugated tie failure. Because of the indeterminate and empirical nature of the wall ties, the building code prohibits the use of brick veneer as a structural support for anything. The brick is intended to transfer all loads to the back-up wall (wind loads) by means of the wall ties and/or the supporting structure below which is either a slab or a support structural steel angle (gravity loads plus some wind load).

To Be Continued
Ladd P. Ehlinger