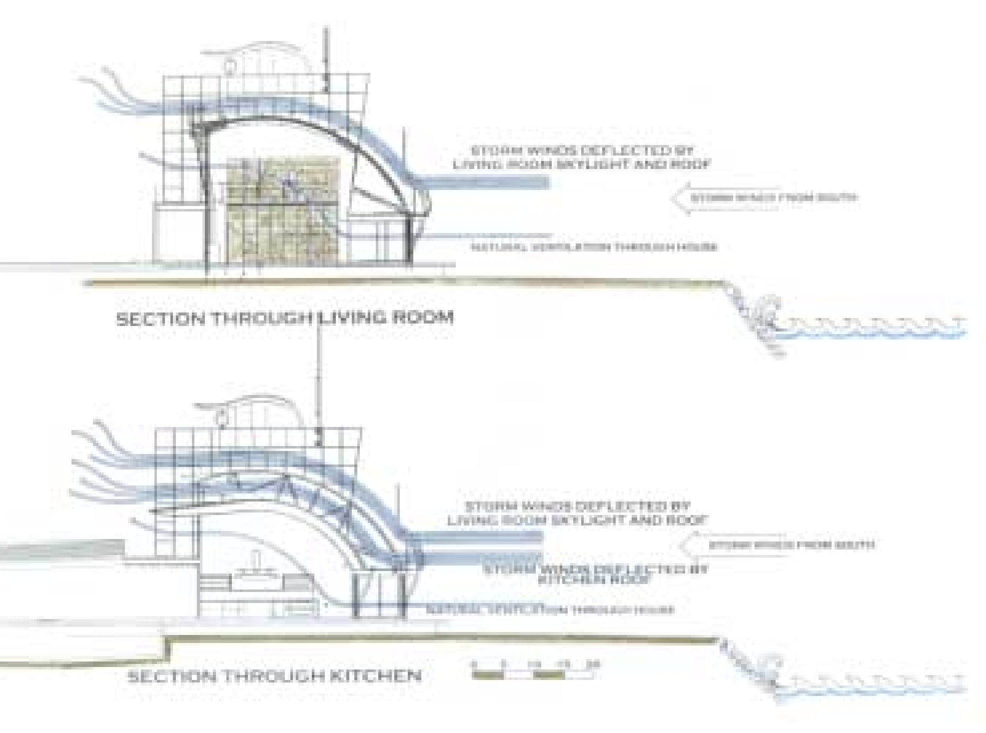
Natural Forces

Arthur Cotton Moore, FAIA

A steel-framed residence on Maryland's Lower Choptank River withstands hurricane-force winds with style.



Every year, the arrival of tornadoes, cyclones, hurricanes, tropical storms and windy conditions have devastating effects on buildings in their path. Most of the destruction is due to the effects of wind. Even when television cameras are not watching, the wind blows hard in many places, many times a year, causing damage.

Throughout history, architectural design has focused on one major force—gravity—and has been largely blind to lateral wind pressures. Modern engineering has long respected the power of wind, particularly since buildings have grown taller. Indeed, while lateral force is a major factor in steel skyscraper construction, it has received comparatively little attention in low buildings such as houses on waterfronts exposed to strong windstorms.

Inevitable storms near the coast can cause avoidable and costly damage. But for better or for worse, buildings are built on the coast, and always will be built there. Waterfront property sells for far more than inland property, and people enjoy living near the water.

The pattern of major destructive winds comes from one direction—the sea. It is a matter of physics that storm

The residence is located on Benoni Point, a point of land at the confluence of two major rivers leading to the Chesapeake Bay.

winds build up their strength over water and weaken over land, where their main punch occurs.

In the past, most aerodynamic design has been applied exclusively to moving vehicles, because their movement creates a predictable directional wind effect. Careful attention to wind effects allows designers to optimize the structural frame. The same principles can be applied to architectural design.

The steel-framed, steel-clad Benoni Point house is located on a storm-thrashed point of land with six-mile fetches on three sides, at the confluence of two major rivers leading into the Chesapeake Bay. It is designed to withstand a Category 5 hurricane with 150 mph winds, which, with global warming, is predicted to be a more frequent phenomenon. The building demonstrates that steel architectural forms can enable a project to stand up to ferocious force winds and the daily attack of corrosive salt spray. The form of the house curves in plan and elevation to deflect the incoming storm winds. These forms are created by three specially fabricated, steel curved beams, and by tilted bowstring curved steel trusses spanned by many standard steel purlins.

Channels and W-shapes formed into aerodynamic curves contribute strength, stiffness and architectural interest.

FRAMING SYSTEM

The steel framing begins with 12×26 wide-flange columns set so that their webs are parallel to the wind force. These stout columns support the custom-shaped beams and the bowstring trusses that give shape to the vaults. W16×26 beams laterally brace this major framing. Purlins spanning the vaults are W12×14s in the living room and W10×12s in the kitchen. These sizes, as well as the porch's 12×16 beams, and most of the other beams in the house, are simply determined by span.

The majority of the rest of the house is framed by W10×12 sections on 6' centers, supported by 3" nominal pipe columns. Columns for the tower wall are W12×19s, augmented by 12"-deep, 16-gage steel studs. An observation level is framed by W10×22s, which then support s-shaped custom beams at the top. A steel spiral stair is self-supporting, but its housing is formed around pipe columns. L3×3×$\frac{5}{16}$ shapes provide cross-bracing. The garage structure consists of four bowstring trusses on pipe columns.

The vaulted forms promote cooling breezes through the house. They are bolted together with high-strength bolts to form an integral frame buttressing each other, and then cross-braced with simple steel angles. Steel studs, steel decking, and stainless-steel roofing complete the envelope of the 4,000-sq.- ft house.

AGAINST THE WIND

To counter the aggressive salt spray, two types of steel were used. The silver-colored cladding components are Grade 316 stainless steel, which is resistant to the actively corrosive effect of salt water. Where the form is curved, as in the spiral stair to the observation tower, corrugated Grade 316 stainless steel was used. The flat surfaces were clad with a unique batten and panel system. Five-inch-wide strips of 316 stainless roofing steel (the battens) have been laid out in a grid over which thicker 3'- by-3' stainless steel panels with a textured finish have been mounted with grometted stainless steel screws. The surface steel stands up to the wind and spray. The grid pattern aesthetically contrasts with and sets off the curvilinear forms in a subtle way. The white steel elements are the basic structure fully exposed. However, because they had to be basic carbon steel, they were coated with an epoxy system (by Tnemec) that allowed the basic framing elements to be read separately from the skin of the building.

The project demonstrates the great malleability and plasticity of steel—the fabrication process allows steel to be curved, heated, bent, and shaped with great freedom. For example, there are three fixed sunshade devices which employ standard steel channels that have been rolled and cut to form sun-blocking amenities: outside the master bedroom, a horizontal curved channel interrupts the morning sun; on the west wall of the living room, a combination of curved pipes and curved sheathing shades a portion of the large glass; and on the large glass window on the west side of the kitchen, two curved channels replicate the curve of the roof and block sunrays. Other features are steel tubes on s-curved bracketed angles, which contain roll-out awnings that shade the sliding glass doors in the living room and the kitchen. The entrance canopy comprises two curved channels mounted on projecting steel pipes. Beyond their functional purposes, these steel elements comfortably complement the design of the house.

Ultimately, this project demonstrates that steel's inherent strength easily can be formed into a range of shapes, producing a building able to defy the destructive forces of an exposed waterfront location with precision and elegance. ★

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