The Hangar Gets Suspenders

Story and photos
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>> During the wartime effort of World War II, three temporary aircraft hangars were constructed at the Naval Air Station Brunswick, Maine. At the time, no one knew how long they would be needed — and by the same token, no one could have foretold how long the structures would remain in operation.

>> More than 50 years later, though, two of the "temporary" structures are still being used. The third was taken out of service in 2000.

>> One of the hangars still in operation, Hangar 1, was constructed with 26 trusses of California Douglas Fir that spanned four aircraft bays. In the intervening years since the structure were built, the wood has dried, connections have loosened, and the trusses haveundergone 58 years of cyclical loading and unloading due to the yearly snow and the wind loads.

>> The trusses were originally designed to accommodate a 40 psf live load. But according to recent structural studies, the trusses were only able to support a five to 10 psf live load. This equates to only three to six inches of snow — not a comfortable margin in Maine. The deterioration of the units' load-bearing capacity was due to creep, shrinkage, cracks and splits in the wood. In fact, a large snowfall in 1993 caused a por-

tion of Hangar 1's structural support system to fail. Luckily, no aircraft were damaged and no one was injured during this failure.

With the structural analysis in hand, Brunswick Public Works determined that truss repairs were necessary to maintain the structural integrity of the hangar. This would allow the two tenants, the "Minutemen" of Reserve Squadron VP-92 and "The Old Buzzards" of VPU-1, who operate P-3 Orion aircraft, to safely continue their maintenance operations. A task order under the BOS/JOC contract with J.A. Jones of Charlotte, N.C. was awarded to initiate the time-critical repairs before last winter's snowfall.

J.A. Jones recommended the installation of an exoskeleton structure on the roof of Hangar 1 that would tie into the existing trusses and support the inner building's roof, much like suspenders holding up a pair of pants. One of the earliest architectural examples of an exoskeleton structure is the Notre Dame cathedral in Paris, France, with its famous flying buttresses.

Contemporary examples are the *Centre Georges Pompidou*, also in Paris, with steel trusses spanning the width of the building, and the Hancock Tower in Chicago with its well-known exterior cross-bracing to stabilize the tower against wind loads. The Public Works/ROICC team accepted the Jones recommendation in March 2002 and a fast-track design and construction plan was quickly approved.

The exoskeleton structure consists of 24 steel trusses, each 12.5 feet tall, 120 feet long, and weighing 18,000 lbs each. The steel trusses span each hangar bay and share a common bearing point at the centerline of the hangar. Diagonal bracing interlaces the steel trusses. This forms a complete box truss system on the roof of the hangar, an area of 240 feet long by 300 feet wide. The steel trusses are supported by steel pedestals directly attached to the existing wooden columns, reinforced with additional diagonal bracing within the hangar bays. Lateral movement of the pedestals is allowed by a slip plate arrangement on the outside column lines.

Steel tie-rods spaced every 17.5 feet connect the existing wooden trusses to the exoskeleton structure and are tensioned so that 75 percent of the wood trusses' dead load is transferred to the exoskeleton structure. One of the best features off this solution was that it could be implemented with minimal impact to essential aircraft maintenance operations inside the hangar.

Cooperation among the ROICC-Brunswick office, the squadrons and the contractor was essential to ensuring minimum impact on critical work schedules. Aircraft maintenance work had to be continuously coordinated with the ongoing construction work and the ever-changing operational requirements of the wings. This coordination task, at times, was more challenging than the actual installation of the trusses. To the maximum extent practical, the goal was to maintain one maint bay per squadron for maintenance of P-3 airplanes.

In late September the trusses began arriving from South Carolina in 60-ft sections. J.A. Jones assembled the trusses on the ground by joining two sections using ASTM A490 bolts. The assembled trusses were stacked vertically in position for future crane placement. The project team, which included the regional safety office, finally determined it was prudent to vacate the hangar of all personnel during the final phase of actual truss placement. This safety-driven decision added complexity of the coordination effort.The original plans called for a crane to be placed at each of the four quadrants of the building. However, the team later determined that time could be saved by using a building centerline configuration with the crane located on north and south centerline projections of the building. This plan reduced the time required for crane disassembly, relocation and reassembly. Under this plan, the placement radius of the trusses in conjunction with their size and weight required a crane with a luffing boom configuration. The contractor used a 500-ton Demag rough-terrain crane furnished by Clark Rigging of Syracuse, N.Y., one of only a dozen in the entire country.

Just prior to crane operations for truss placement, an unforeseen condition arose that had the potential of bringing this project to a screeching halt: The ROICC didn't have enough funds to shore up the costs of the modifications. The truss project required immediate funding or the truss lift phase would be suspended. The financial need came to light after the start of the new fiscal year, and resolving it was further

complicated while the government operated under a continuing resolution.

Meanwhile, somewhere over the horizon, the team could almost feel the snow clouds building.

Suspending the project at that point would have prevented the work from being completed before the onset of snowfall. Not unlike a spacecraft in orbit maneuvering for a critical docking procedure, much work had gone into coordinating a four to six-day window for the truss installation. If it was missed, recovering the opportunity would be difficult to impossible.

The lift procedure demanded wind speeds lower than 24 mph, hard to forecast in the impending winter with its higher gusts. The highly specialized 500-ton crane would be lost to work elsewhere if demobilized. Finally, the squadrons had hard operational requirements. All three of these essential elements — weather, crane availability and operational schedules — had to be in perfect sync for that critical four to six day period. Then the money had to get here.

With the technical assistance of NAVFAC's Engineering Field Activity Northeast, Navy Region Northeast was able to fully communicate the critical funding need to receptive authorities at the Atlantic Fleet. Working overtime, the Fleet reprioritized this 11th-hour budget requirement and sent the critical infusion of funding just before project managers would have had to deliver a suspension-of-work order to the contractor.

Through the outstanding team effort expressed by all those involved, the project moved forward and avoided an enormous negative impact to key operational Naval forces. The trusses were very successfully installed, the project concluded, winter came and went, and all was right with the world.

Crane operators and riggers from W.O. Grubb, Richmond, Va., lift a cantilevered roof truss during construction of an aircraft maintenance hangar being built in the SP Area of Naval Station Norfolk. Each of the five trusses in the hangar is 155 ft long, weighs 110,000 pounds and is made of steel pipes ranging in size from 12 to 18 inches in diameter. The trusses cantilever the entire length of the hangar bay, approximately 85 ft, support the entire roof of the hangar as well as interior cranes and other items. To ensure each piece would fit in the field, the fabricator, Banker Steel of Lynchburg, Va., completely assembled each truss in its shop and then took it apart prior to shipping. The $11.6 million project, designed by TranSystems Corp. of Norfolk, is being built by American Bridge Company of Williamsburg, Va. The hangar is scheduled for completion in the spring of 2003. U.S. Navy photos by John E. Peters