# Improved mold strongbacks

*By Tom Pawlak.*

Back in the 1980s, Gougeon Brothers was one of the largest producers of wind turbine blades in the US. The blades were built of wood veneer and epoxy, and varied in length from 10' to 70'. They were built in halves and vacuum laminated in female molds built with WEST SYSTEM® Brand Epoxy. Tolerances were tight, and every aspect of the tooling was critical, from molding to assembly. If something wasn't right when the two halves were glued together, there wasn't much you could do to make it right later.

The most difficult tolerances to maintain were span-wise straightness and twist. Early strongbacks for molds and assembly jigs were made of wood and were built like tall and skinny "I" beams. Initially, everything worked well. But as the seasons changed and the wood picked up moisture, and the summer temperatures in the shop went up, we were pushing the limits of the tolerances. The engineers figured it was a combination of forces caused by wood's volumetric change, with changes in moisture content and difference in coefficient of thermal expansion between the wood strongback and epoxy/fiberglass molds. Our short-term fix was to cut the mold free from the strongback and isolate it with plywood supports (⅜" thick) that were installed perpendicular to the length and located every 16" to 24" apart. They ranged from 4" tall at the root end to 12" tall at the tip end of the mold. The differences in height were due to the fact that the molds were tapered to mimic the blade half-geometry (thick at the root end and tapered to thin at the tip). The plywood supports were attached to the top of the strongback and to the backside of the mold with thickened epoxy fillets. Separating the mold from the strongback with the thin plywood supports meant slight changes in length between the two did not cause a problem. This is because the supports easily deflected to allow relative movement but had almost no effect on span-wise straightness. Luckily the problem was caught early, but we decided we needed a better strongback design that would be more stable.

**This box-beam strongback supports a female mold for a 70' Westinghouse wind turbine blade. (The plug that was used to build the mold is in the mold.)**

**The strongback is stiffened by ⅝" rebar glued into 1½"×1½" longitudinal stringers, one in each corner and one along the top and bottom surfaces.**

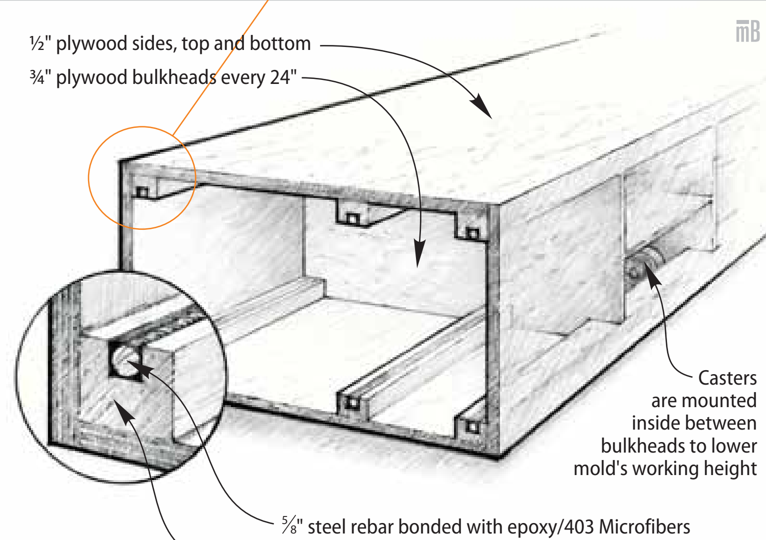


**Figure 1**

The solution was to make a box beam out of plywood and epoxy. This in itself provided significant improvement, but the engineers went one step further. They incorporated steel rebar originally designed for reinforcing concrete into the four corners of the box beam. The rebar, welded to full lengths, was glued into 2"×2" wood stringers that ran full length along the four corners of the box beam. To make room for the rebar, a slot was cut into the wood stringers that was wide enough and deep enough to accept the steel. Epoxy thickened slightly with 403 Microfibers was used to fill the gaps in the groove surrounding the rebar after it was in position *(Figure 1)*.

On molds up to 20' in length, we used ⅜" diameter rebar. On larger molds, we used ½" or ⅝" diameter. The 70' long mold strongbacks were reinforced with 6 stringers made of ⅝" diameter rebar, one in each of the four corners and an extra one in the middle between the corners of the top and bottom.

When the strongbacks were used for blade assembly jigs or for saw jigs, they were anchored to the floor to keep things stable. If the strongbacks were used to support molds, wheels were mounted inside the strongback (on the larger molds) to keep the center of gravity low and to keep the height of the mold reasonable. On smaller molds where the width of the strongback was too narrow for a caster to pivot inside the bow beam, the wheels were mounted on the outside of the structure.

Mounting wheels under molds with strongbacks can present some dilemmas. The wheels tend to get in the way of your feet. If you mount wheels under the mold strongback, you need to shorten the height of the strongback to make up for the wheel height. Otherwise, the mold gets too high for people to work on. Unfortunately, shortening the height makes the strongback less stiff, which can be a problem.

Mounting the wheels inside the strongback works best as long as you allow room for wheels to swivel without interference. Another option is triangular shaped strongbacks. We found this to be the best solution for 20' to 30' mold lengths. By positioning one of the three sides horizontally, wheels could be mounted under the mold on angled brackets *(Figure 2)*.

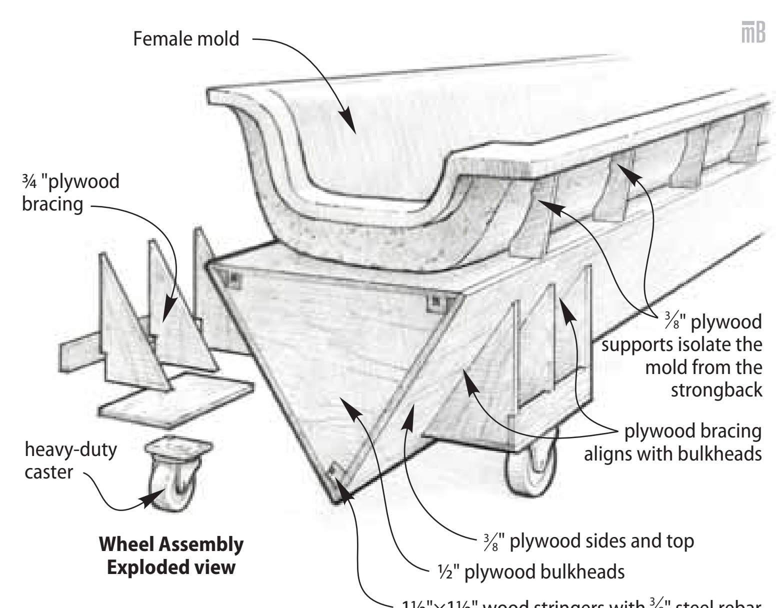


Figure 2

This allowed room for the wheels to pivot without getting in the way.

After the blade halves cured, they were pulled from the molds, positioned in saw jigs, and trimmed along the leading and trailing edges. From there, the blade halves were moved to glue jigs where a shear web was installed on the inside of the high-pressure side. Eventually, the two halves were glued together with thickened epoxy. ■

# Staudacher strongbacks

***By Brian L. Knight***

Jon Staudacher, of Staudacher Hydroplanes and Aircraft, has been using a long, very flat, work table/strongback that is mounted on casters. The table was originally 32' long, but because of space considerations, Jon has since shortened it to 20' *(Photo 1)*. Four rubber casters support it, one at each corner *(Photo 2)*.

Jon uses this table as a surface to assemble airplane wings, so it cannot have twist or sag. Because of its stiffness, the table is not dependent on having an extremely level floor. When the table is moved to a different location, it is easy to shim it level. It is stiff enough that it does not sag, and if there is a little twist, it is easily shimmed out. Since the tabletop is the reference point for all objects being built, the table does not have to be perfectly level, but it must

**1—This table is used to assemble airplane wings. It must not twist or sag. The table was originally 32' long, but has been shortened to 20'. Four rubber casters, one at each corner, support it. Built as a strongback, it spans 20' (previously 32') without sagging.**

**2— Four rubber casters, one at each corner, are mounted to brackets at the ends of the table to give it portability.**

**3—Access holes to storage spaces are centered between the top and bottom rails, and have oval ends.**

**4—The 1×4s that sandwich the top and bottom of the front and back panel are scarfed to improve straightness.**

have no twists. If Jon expects to use weights for clamp pressure, as he often does when building the frames for wings, he temporarily shims the bottom rail of the table so it cannot sag under the weight. The table doubles as a strongback with grid lines drawn on the top for locating frames.

A table like this has to be built carefully, but the materials that go into the construction are very light and readily available. The table is a long box beam made with plywood, and all pieces are glued together to make the table very rigid. There are plywood bulkheads every 4' to keep the front and back of the table from buckling. In turn, the front and back of the table keep the top flat, without twist. The top is supported on 16" centers to prevent any drooping of the plywood top between bulkheads. In order not to waste space, storage is built into the front of the table. The access holes are centered between the top and bottom rails, and have oval ends. These are important dimensions. If the access holes were sawn too close to the bottom or top surface, the table would lose its rigidity. Because square corners can cause stress concentrations, the holes have rounded ends *(Photo 3)*.

Full or half sheets of plywood are used where ever possible. Construction starts by sandwiching the top and bottom of the front and back panel between two 1×4s *(Photo 4)*, which were scarfed together to improve straightness. A ¼" plywood bottom panel was glued to the bottom rails. Then ¼" plywood bulkheads and supports for the top were installed. The top was glued to the top of the side rails, bulkheads, and supports. Finally, brackets of scrap OSB were bolted to the ends of the table to support casters *(Photo 2)*. ■

  