How Strong Does It Have To Be?

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A STORY IN *SPORT AVIATION* last year by the author discussed static testing of light aircraft. We have been getting inquiries from homebuilders ever since indicating their interest in testing some of their structures, but they have no idea to what loads they should subject the assemblies or just what installations should be tested. It is impractical to try to compute loadings for everyone, or to try to outline a test program for everyone who contacts us. However, we can give homebuilders some idea of the things that should be tested, and also some idea of the loads that apply to an aircraft such as the Coot A/B light amphibian which was designed by the writer.

The Coot structure and installations have been designed to certain loads, and static tests to substantiate the Coot structures to these loads have been or are being conducted. The photos appearing in the December, 1970 *SPORT AVIATION* with another article showed some of the loadings applied to the tail structure of the Coot A as an example. Since the Coot A tail boom is made from a section (11 ft.) of 10-in. O.D. 6063-T3 commercial-grade aluminum tube (usually available through irrigation supply houses), it was essential that we determine the suitability of this particular material not only through analysis based on the manufacturer's specifications but also by actual static test of a representative specimen of tubing. To do this best it was desirable to test the entire tail structure of the Coot A design.

A test set-up was made from two new railroad ties using 3/4-in. thick plywood bulkheads between the ties to simulate the wood structure of the Coot hull. Thus, the tail boom with its supporting tie to the bulkheads was mounted exactly as it would be in the aircraft. The tail surfaces were built and installed exactly like the drawings, even to control cables, hinges, etc., so that the entire structure was exactly like the plans except that it was installed on the railroad tie mount. Since it was planned to load about 1000 lbs. of lead on the horizontal stabilizer and elevators, it looked like a good idea first to apply the load to the tail boom itself. This was accomplished by use of a Blackhawk Porta-Power pull jack and pump with a hydraulic gauge in the hose. The jack-ram area times the psi. on the gauge gives the load applied. The pull jack was first tied from the testbed up to the bottom of the aluminum boom at the bottom of the rudder post and application of the load showed that the boom actually bowed only 5/8 in. under the full deflection. This was actually less than calculations, and was far from the ultimate capability of the 0.063-in. wall and 10-in. tube.

Having determined that the tube itself would easily take the loads required (actually, the tube could have an 0.032-in. wall and be strong enough, but 0.063 in. is as thin as such big tubes come), and having no desire to have 1000 lbs. of lead come tumbling down as the last pig was laid on the horizontal tail, the struts supporting the horizontal tail were next tested by means of a whiffletree attached to the pull jack and two cables attached from the tree to the upper strut attachments. Application of the 1000-lb. pull load showed that the struts were not going to fail. Since the Coot A horizontal tail folds down on both sides for road towing of the aircraft with the wings folded, these tail struts are mounted in rod ends at their upper end and the lower ends incorporate quick-release pins so that folding the tail only takes a couple of seconds.

Having now proven that we were not going to end up with a pile of lead on the floor and a lot of sheet-metal damage to the tail surfaces, the elevator cables were secured to the test bed so that loading the lead pigs on the elevators and horizontal tail could be accomplished. This has to be done in two different patterns, as far as fore and aft loading is concerned, to satisfy the FAA requirements. The loadings are specified in Part 23 of the FAR and amounts to putting the pigs on the surface in a pattern so that the bulk of the load if first along the leading edge and then finally along the elevator hinge line. In addition, an assymetrical loading is accomplished, with full load of 500 lbs. on one side, and 350 lbs. on the other side. None of these loads caused any deformation or excessive deflections and it was determined that, despite the fact that the tail structure of the Coot A was built about as light as standard-thickness material would permit (0.016-in. 2024 aluminum), the tail obviously had more than ample strength and rigidity.

The test rig was then laid on its side and the vertical fin and rudder were tested in two loadings, along the leading edge of the fin and then on the rudder hinge line. While the bulk of the loads are along these lines, they are actually tapered out from these concentration areas fore and aft to

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The Coot A fiberglas hull shell is to be offered to the builder in the near future. Stiffeners and frames would have to be installed according to the drawings. Neither the Coot A nor the Coot B will lend themselves to a four-place arrangement.

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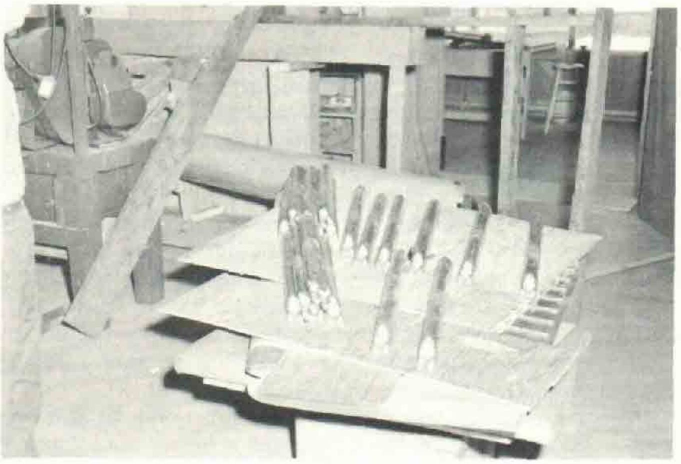
the leading edge and the trailing edge in semi-triangular patterns as far as weight is concerned. Anyone interested in loading should get a copy of Part 23 of the FAR, and the patterns are all drawn out for you. While the tail structure was on the test support, the control-surface static loads were also applied although these loads were in actuality not as high as the loads imposed during the vertical-tail and horizontal-tail loadings. The whole operation of static-testing the tail of the Coot A took about half a day after the test set-up was completed.



Side loads are being applied to the vertical tail of the **Coot A. The boom and tail are rotated 90 degrees for this static test.**

Similar simple test set-ups can be arranged to test any of the structure of a homebuilt lightplane and, while FAA certification testing is much more involved, the average homebuilder should have no difficulty in completely substantiating his whole aircraft without too much trouble. Testing should be accomplished in such a way that loadings can be applied in stages. The structure being tested should be placed in such a way that if failure does occur the whole thing will not come tumbling down in a heap. This can be done by providing simple scaffolding of wood under or in front of the structure so that if failure does occur the structure will merely come up against the restraining scaffold before catastrophic failure occurs. This way, you can determine where weak points are located remove the loads, reinforce the weak spot, and resume testing without having to rebuild the whole works. The FAA looks with disfavor on the use of structures that have been tested to ultimate loads in operational aircraft after they have been tested, and where the static-test program for a homebuilt has resulted in deformation or permanent set of any part, the tested parts should be discarded and new parts installed in the final flying article.

While it is not necessary for the homebuilder to test everything in his machine as must be done in an FAA-certification program, the following items should be investigated. The loads listed apply to the Coot A/B aircraft, and are based on an all-up gross weight of 1950 lbs. It should be pointed out that the loads indicated are **ultimate** loads and not **limit** loads. **Ultimate** load is 1-1/2 times **limit**, and is the load at which the structure must be tested without total failure. The structure can bend, sag, or deform, but it must hold together at least ten seconds at these loads. The **ultimate** load is considered to be 1-1/2 times the **maximum** (limit) loading to which the aircraft would be subjected during any normal operations. Thus, **limit load** is considered to be 4G and **ultimate load** is considered to be 6G. These are **ultimate loads**.

Two tail units for the Coot A are seen here, along with the prototype fiberglas hull shell for the Coot A.

The following basic loads apply to either the Coot A or Coot B:

1. Down load on the horizontal tail (stabilizer and elevators) — 500 lbs. applied to each side. The loading is distributed in two conditions: (A) Basically on the hinge line; (B) On the leading edge. The loadings are distributed as required by the FAA for certification.
2. Assymetrical load on the horizontal tail — 500 lbs. applied on one side, and 350 lbs. on the other.
3. Side load on the fin and rudder applied on hinge line — 350 lbs. distributed as per FAA requirements.
4. Side load on the fin and rudder applied along the leading edge — 350 lbs. distributed as per FAA requirements.
5. Down load on the tail boom — 1000 lbs. applied at the bottom of the rudder hinge line.
6. Side load on the tail boom — 350 lbs. applied at the strut attachments.
7. Control-surface loads distributed as per FAA requirements: Aileron, 180 lbs.; elevator, 110 lbs. (Coot A), 160 lbs. (Coot B); rudder, 150 lbs. (Coot A), 100 lbs. (Coot B).
8. Control-system operational loads — surfaces restrained and the following loads applied to the flight controls: Ailerons, 60 lbs. L&R; elevator, 170 lbs. U&D; rudder, 200 lbs. L&R.
9. Engine-mount loads applied at the engine mounts to the structure — side, 500 lbs.
10. Engine-mount forward load — 2700 lbs.
11. Engine-mount down load — 1800 lbs.
12. Landing-gear side load (loads applied at the wheel axle) — 1000 lbs. inboard, 700 lbs. outboard.
13. Landing-gear vertical load — 4000 lbs. vertical, 1000 lbs. aft.
14. Safety-belt attachment loads — 1000 lbs. applied to each attachment in direction of belt.
15. Fuel-tank attachment load — 1400 lbs. on the support and attachments.
16. Fuel-tank pressure test — 3.5 lbs. psi. without major distortion.
17. Baggage-compartment down load (if applicable) — nine times baggage capacity (900 lbs. on the floor).

ONE OUT OF THE BOX

(Courtesy of "Aviation News" of Australia)

Shoulder harness and crashproof cockpit design combined to provide one of the happier stories last year in Australian aviation.

Early last fall, the tangle shown here was a Piper "Pawnee," VH-SFT, owned by Sky Farmers of Leongatha, Victoria, Australia.

The 28-year-old pilot, Ray Teicher, was spraying weedkiller when a wing is believed to have caught a hard-to-see power line.

The "Pawnee" flipped over on its back, and crashed upside down. Teicher said: "I thought I was a goner for sure, but I found myself hanging upside down in the harness.

"My first thought then was fire, and I think I cleared the wreckage in about three jumps."

Even the engine castings were shattered by the impact. Old hands said they had not before seen a live pilot leave such a badly mangled airplane.

Piper's superbly strong cockpit capsule and the inertial shoulder harness must take much of the credit. But luck also played a part.

As the airplane fell to the ground it is believed to have struck a bank of telephone wires which decelerated its 100-mph air speed. And, on impact, the tank of weedkiller ruptured and sprayed over the aircraft. It is thought that the fuel did ignite for a few seconds, but it was thoroughly doused by the weedkiller.

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18. Wing attachment down load @ PHAA (Positive High Angle of Attack Attitude) (15 degrees) — 4000 lbs. applied six feet from the attachment of the wing spar (main) to the sponson. Load applied to the front spar upward.
19. Wing torsion load — 600 lbs. applied vertically at rear spar attachment.
20. Tail-boom torsion loading — load developed by static loading of vertical surfaces mounted on the tail boom during loading of those surfaces with the boom normally supported on its side in the test fixture.
21. Nose-gear loads — 500 lbs. vertical, 400 lbs. aft, 350 lbs. side L&R.
22. Seat loads — 2250 lbs. down on the seat cushions, load uniformly distributed.

The above loads are not exact loads as required for FAA certification at 1950 lbs. gross but are, for the most part, loads near enough (usually more) to certification requirements to assure you that the design is amply strong in these areas. These loads should be considered as being **minimum** permissable capabilities of the structures. Greater strength is always permissable if weight is not compromised. If gross weight is greater, then of course strength must be greater. We should point out that the Coot A design has been tested to the loads listed, but in no case has permanent set or deformation occurred in the structures when loaded to the values indicated. As we said, these are considered to be **minimum** satisfactory load-carrying capabilities. Actual loads that might apply to your own design can be fairly easy to calculate by using FAR Part 23 as a guide. Actual loads depend on expected performance, operations, wing area, and operational weights. Thus, an aircraft can be certificated by the FAA as non-aerobatic at a high gross weight, and be certificated as aerobatic at some reduced gross. The so-called "red-line" speed that applies to certificated aircraft is determined by these same considerations. If the aircraft is to be dived at high speeds, the weight may have to be reduced to be within approved limits. It is well to remember these things when you get the temptation to roll your "jewel" over on its back at 5000 ft. and dive out of the "split-S."