Chapter 10
Seats, Rollover Structures, and Harness Installations

Seats

Seats seem to get the least amount of attention in the plans for experimental aircraft and it is often left to the builder to come up with a solution.

The seat is a single small point on a performance aircraft that must absorb and distribute a tremendous load. It may be compared to the engine mount in the concentration of stresses that it must disperse. See the paragraph on Aircraft Loads in Chapter 1.

In this discussion, the term seat is taken to mean the whole assembly or assemblies that make up the unit. The seat pan is the bottom part where the butt goes, and the seat back is where the back goes. The seat frame is what connects the seat back and/or seat pan to the fuselage. A composite seat (carbon/foam sandwich for example) may not have a seat frame because it alone may be strong and stiff enough to carry the loads of the pilot and distribute them to the airframe.

Much information about ergonomics and seat geometry are published elsewhere and more information may be had from the Tony Bingelis series on sport aircraft construction. The only purpose of this section is to provide ideas for the integration of the seat to the fuselage.

Design Considerations

The exact seat position and orientation of the whole seat is closely related to the geometry of the harness installation and must be considered simultaneously with the harness (see the section in this chapter on harness installations).

The seat must take the concentrated load of the pilots' weight and distribute it to the fuselage.

The seat frame should not impose excessive loads on, or cause bending of, the fuselage members to which it is attached.

The seat frame should be stiff enough that it won't deflect excessively under expected loading conditions, making it subject to fatigue failure.

Seat frames should attach to the fuselage at or close to existing clusters.

The seat must not be subject to failure in an accident, causing the body to change position in relation to the harness.

The seat frame must be strong and stiff enough so that it never interferes with controls that go under the seat.

If the pilot is mainly upright in the seat (not reclined back), most of the loads during maneuvering are on the seat pan and the seat back need only be strong enough to support lesser loads, excepting an accident where the seat should remain intact to maintain the proper pilot relationship to the harness.

The seat and harness geometry may be significantly altered by the use of parachutes. Detailed dimensions of available parachutes are given on the websites of the various parachute manufacturers.

The seat and/or seat back may be designed to fit one of the many parachutes available, so no padding is required on that part of the seat and best use of the available space is made.

The seat, seat back, and surrounding structure should allow an in-flight emergency egress without the possibility of the pilot or parachute snagging on something.

A reclined seat allows the pilot to sustain higher g forces and distributes the weight of the pilot over a larger area. It also allows a small fuselage frontal area.

The seat should be comfortable. Flat seats, even with padding tend to be uncomfortable after a short time.

The pilot should be able to manipulate all the important controls freely while solidly strapped into the seat.

A glass or carbon seat that breaks is going to create a lot of sharp edges.

Fuselage Attach Points

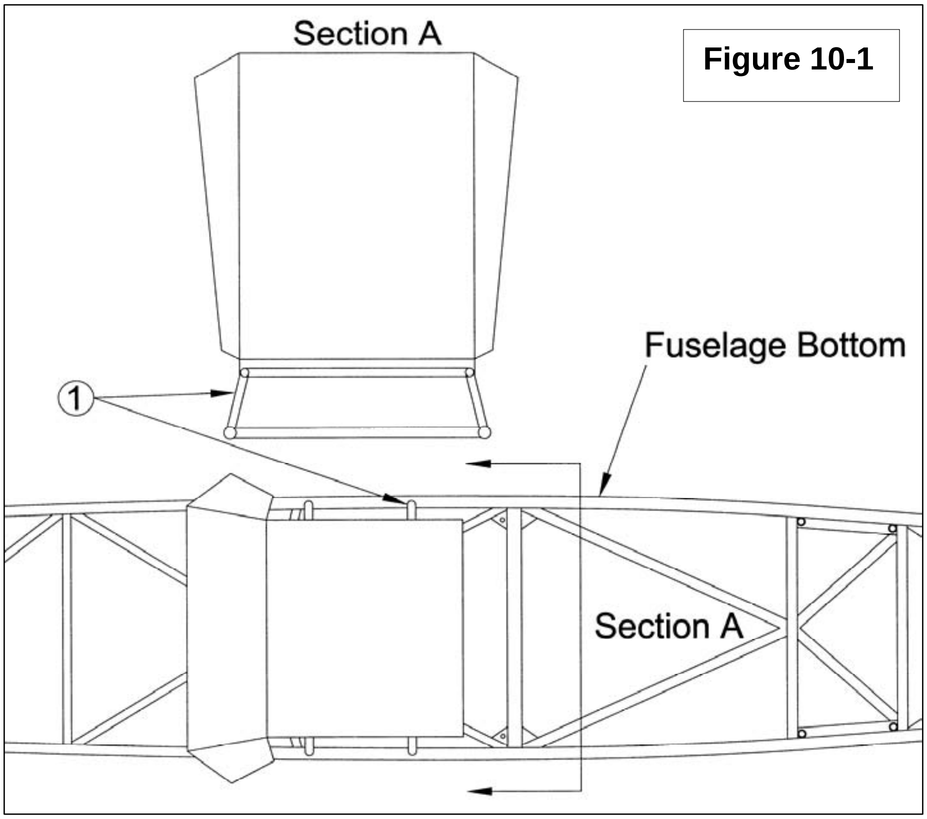

Figure 10-1

The individual round tubing members that make up the fuselage are easily bent or dented. For example, a seat with four fuselage attach points, at 6 g's and a 180 LB pilot, is going to put a load of about 270 LBS on each attach point. Refer to Figure 10-1. The 1/2" OD compression member (1) is putting a concentrated 270 LB load on the thin walled longeron (3/4 X .035). This may dent, bend, or collapse the longeron, making it useless as a structural member. The fuselage members already have a load when the aircraft is maneuvering, in addition to any loads imposed by the seat. In many loading conditions the attach points will not be equally divided in their load and any one point can receive more load than the others. Clusters tend to be better attach-points as they are stiffer and stronger due to the other members which are welded there. Seat attach points should distribute the loads as much as possible throughout the structure and not cause deflection of primary fuselage members (remember tubing is strong in compression until it bends it a little). This does not mean to imply that the whole seat frame must be absolutely stiff, only that that the way in which the fuselage reacts to it isn't going to cause excessive stresses on either the fuselage or seat frame.

In Figure 10-2, the example fuselage in this book has a large cluster of tubing directly under the pilot seat, but no plans were given for the seat or its' attach points. It would seem logical that this reinforced area would be a good place to mount part of the seat; however, just sitting on the cluster (180 LBS at 1 g) is enough to deflect the whole cluster downward by nearly an

1/8 inch. Knowing this, it's apparent that those members and their welds might not last long under the repeated stresses of hard maneuvering. In addition, the fuselage depends on that cluster to carry other loads, imposing additional stresses. That cluster is also the aft hinge point for the torque tube, and in this aircraft, a deflection of 1/8" of the torque tube downwards will deflect both ailerons more than a few degrees up.

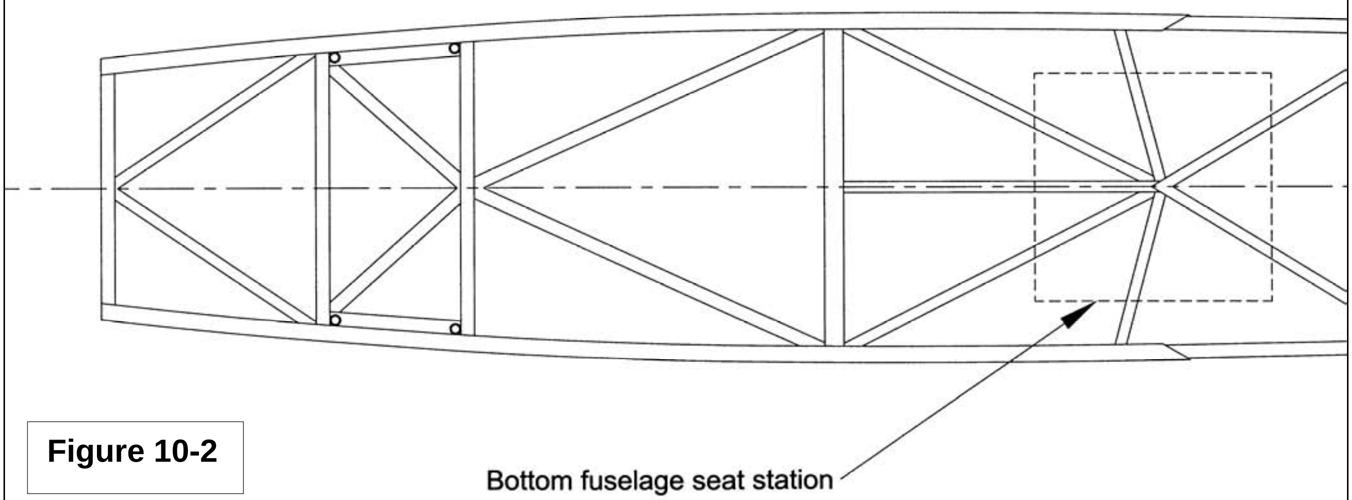

Figure 10-2

Seat Designs

Probably the most common type of seat design on a tubular steel fuselage is a seat frame of welded steel tubing with a seat pan and seat back made of aluminum sheet. Thin plywood is also frequently used for the pan and back.

A carbon or glass foam sandwich seat, made properly, will be stiff and strong enough to carry the pilot loads to the fuselage without an intermediate frame. This will be lighter than the conventional steel/aluminum seat but requires more work. It is most efficient for the reclined seat where there the pilot weight is more evenly distributed over the seat. An upright seat back requires less strength because it carries little load (rarely more than a few g's during hard maneuvering).

Other options include a hybrid of the above two designs, a minimal seat frame with a stiff foam sandwich pan and back that doesn't require reinforcement underneath. Those inclined towards sheet metal work may find that a semi-monocoque aluminum structure that bolts to fuselage attach points will be lighter than a welded steel seat frame.

Any type of seat pan or seat back should be contoured to fit comfortably by using carved foam covered with glass or carbon, followed by padding.

Rollover Structures

Low and mid-wing aircraft, and some other configurations, can be made safer with the installation of a small rollover structure. They are easy to design and install. Some competition organizations require a rollover structure on the aircraft.

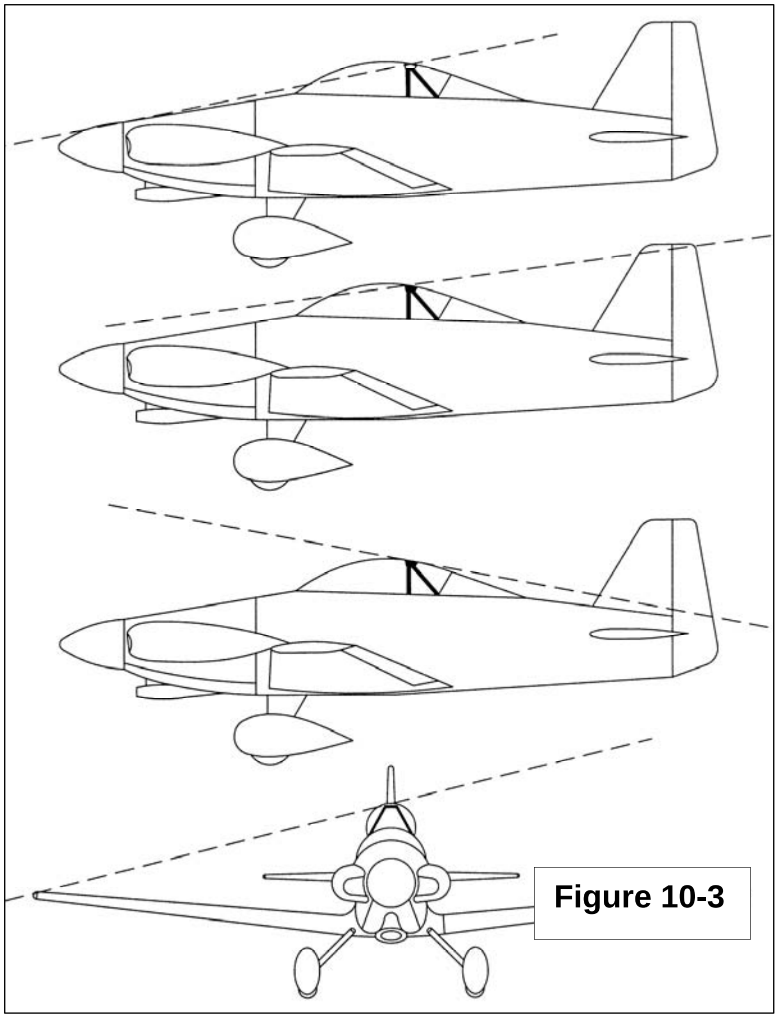

Figure 10-3

Design Considerations

It may be mounted in front of or behind the pilot, but consider how the aircraft will lay upside down. An unbroken airframe is likely to be contacting the ground at a bunch of different places about the airframe during the slide out, so some lines of action drawn between the major contact points and the top of the rollover structure should not intersect the pilots head (Figure 10-3). Don't depend on the vertical stabilizer as a support, but consider the possibility that it may break, or not.

The rollover structure should extend above the pilots head, taking into account seat padding, parachute, helmet, etc. A couple inches may be sufficient but in an accident there will be some burrowing into the ground that negates the lesser heights. This requirement directly opposes aerodynamic and aesthetic considerations.

The very top of the rollover structure should have a significant flat spot to help prevent it from burrowing into the earth.

A rear mounted rollover structure may be used to set the correct angle of the shoulder harness in relation to the body, allowing greater flexibility in the shoulder harness attach points (see the section on harness installations in this chapter).

The rollover structure should be designed to sustain loads no less than 7 G's or the rated strength of the airframe (whichever is greater), multiplied by the normal safety factor of 1.5. Rollover structures required by a competition organization may require that the structure be able to sustain loads given in that organizations rulebooks.

The rollover structure should be able to sustain significant side loads concentrated at the top of the rollover structure, from any angle.

The mounting points of the rollover structure, where it joins the fuselage, should be at or adjacent to existing fuselage clusters.

For aircraft without a bubble canopy (has a 'turtledeck' behind the pilots' head), the rollover structure may be used as mounting for the canopy and/or formers for the structural shape.

Give consideration to the possible requirement of extricating oneself from the inverted airframe on the ground, unassisted.

Planning a Rollover Structure

It will be remembered from Chapter 1 that the fuselage is composed of round tubular members because they are the most efficient in axial compression (compressed at the ends towards the middle). The loads are equally distributed in the material. This is in the direction that much of the load will be applied on a rollover structure in an accident. Long slender tubes however, are prone to buckling or collapse when compressed. In an actual accident it is likely that the tubing will be subject to sideward forces (causing bending) as well as compressive forces. This may be overcome by reinforcing a rollover structure so that the slender tubes of the rollover structure are not as easily bent. Some short pieces of tubing welded between the members of the rollover structure are usually sufficient. A piece of tubing used to orient the shoulder harnesses must be reinforced or fairly heavy-duty to withstand the bending forces imposed by the shoulder harness in an accident (see Figure 10-4 and the section on harness installations in this chapter).

Rather than do a lot of math to calculate how big the tubing should be, it's easier to say that a twenty inch long 3/4"-.035 tube will take about 3000 pounds in compression. Most rollover structures will have three or four tubes arranged in a triangular shape to provide stability so this tube size will do for a wide range of aircraft experiencing fairly severe upside down impacts. Again this doesn't take into account sideward loads which will cause the tubing to fail prematurely, so the tubes should be stiffened with some cross bracing. It is desirable that the rollover structure be triangular in shape as in Figure 10-4 and Figure 10-5. Triangles produce strong structures.

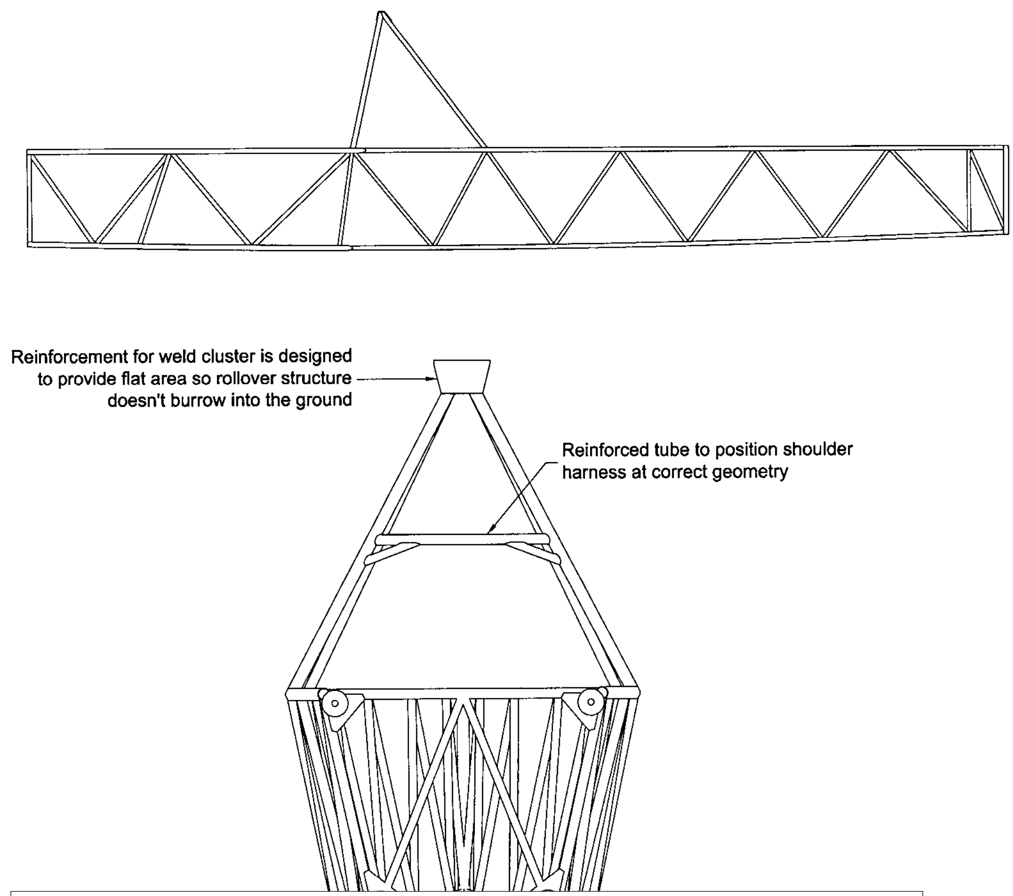

Figure 10-4: Rudder Post/Vertical Stab omitted for clarity

A 'U' shaped rollover structure is common as well (Figure 10-6). The bend should be kept close to the top of the rollover structure since bent tubing loses strength. To restore some of the strength and compensate for the small diameter tubing, it should have some interior bracing close to the bend tangent points so the bent tube doesn't distort in an impact. A second brace at a lower position may be needed for the shoulder harness. It should also be reinforced from the rear as in Figure 10-5.

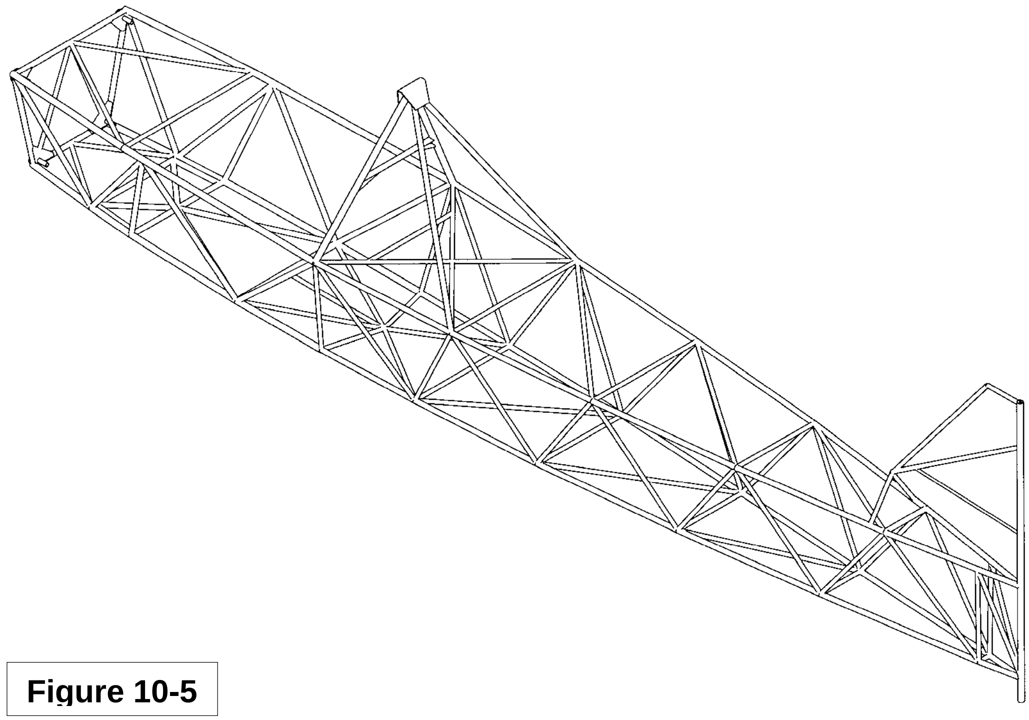

Figure 10-5

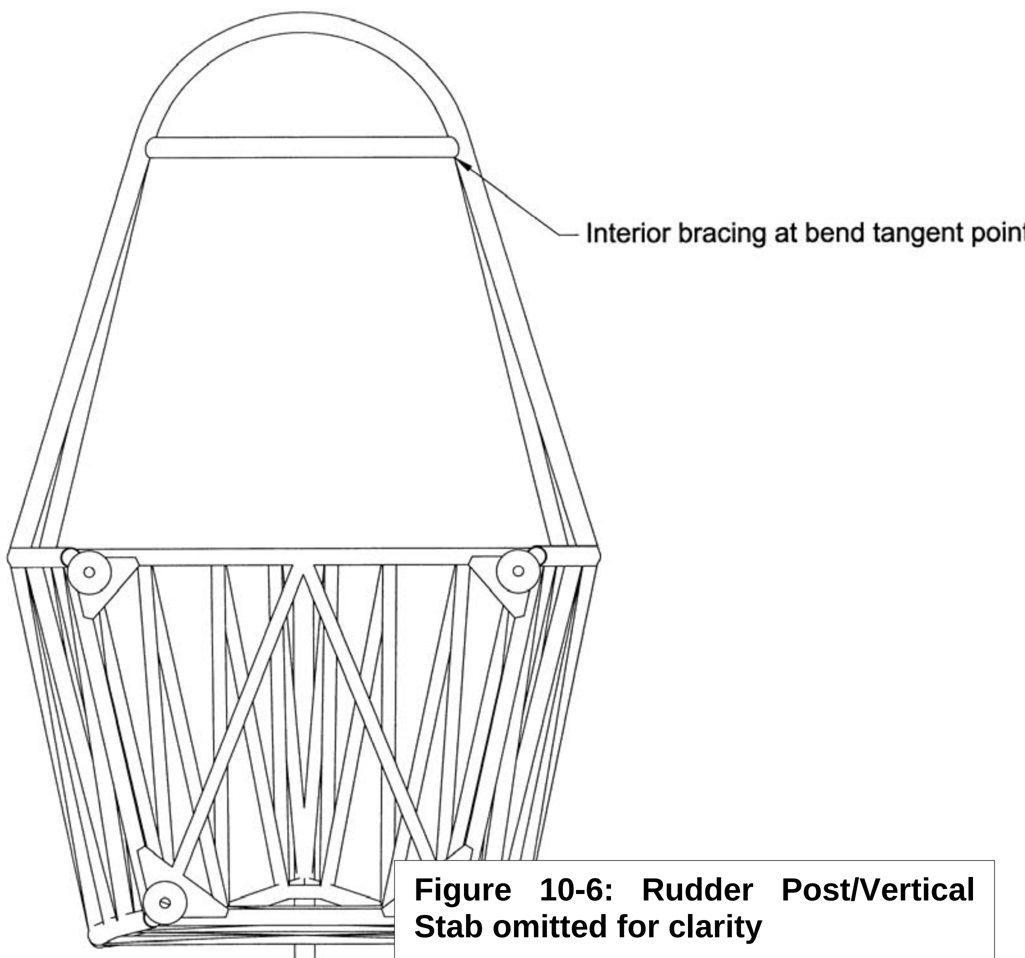

Figure 10-6: Rudder Post/Vertical Stab omitted for clarity