4 - Fasteners

Fasteners, quite simply, are materials that hold parts together. In FRC, they are most often rivets and bolts. Although fasteners are not always modelled in CAD, they are critical to effective design.

4.1 - Rivets

Rivets are small pieces of metal that hold two or more other pieces together by compression. Although other types exist and are used in other industries, we on Team 1732 exclusively use pop rivets, a type which works by having a piece break (or "pop") off to deform the metal and create a clamping force. This type of rivet is especially useful in FRC because it is light and easy to install.

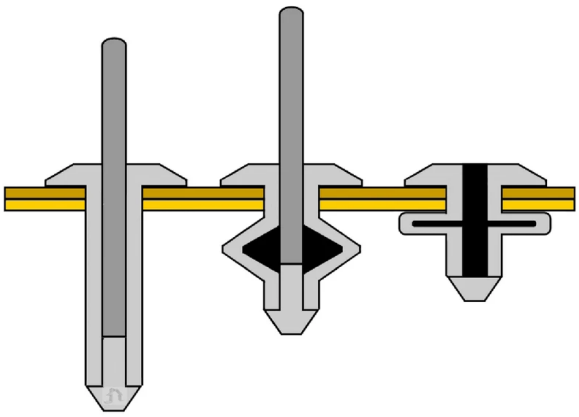

Figure 1: Diagram of pop rivet operation
(image from StageMotorSport.co.uk)

Pop rivets are specified by their diameter and their grip length, the thickness of material which they can effectively fasten. Different diameters are necessary in different applications, and examples of these are given in Table 1 below. Finally, most rivets used in FRC are aluminum, although steel ones are available for especially high-load applications.

Table 1: Common rivet sizes and applications

Size (diameter)	Application
1/8"	anywhere with a light load or where a 3/16" would be too large
5/32"	all VexPro gussets and mounts
3/16"	any ordinary custom plate or angle (standard size)

4.2 - Nuts & Bolts

Nuts and bolts are fasteners which turn on threads to create a clamping force. These are generally stronger than rivets, but they are also heavier because they are almost always made of steel. Dozens of types of each exist, but we use a few standard types.

For nuts, we use nylock nuts (also called nylon-insert lock nuts,) which have a small ring of nylon plastic in them to lock the threads of the nut onto the threads of a bolt. This prevents the threads from loosening under vibrations. Nuts are specified by their thread size.

For bolts, we use a combination of socket head (SHCS, socket head cap screw) button head (BHCS, button head cap screw) and occasionally hex head (HCS, hex cap screw) and countersunk or flat head (FHCS, flat head cap screw). Bolts are specified by their head shape, thread size, and length. Table 2 gives applications for the common head types.

Table 2: Common bolt head shapes and their applications

Head Shape	Image	Application
socket head		any ordinary connection (standard bolt)
button head		anywhere the bolt head needs to be low against the surface
countersunk		anywhere the bolt head needs to sit flush with or slightly below the surface

hex head		anywhere the bolt head cannot be accessed from above, so that an allen wrench cannot fit, but where a hex wrench can fit from the side.

Unlike rivets, which are defined by their diameter, bolts are defined by a thread size, which provides more information than just the diameter. The thread size is written with a two-part convention, such as 10-32 or 1/4-20. The first number is the nominal diameter of the bolt, and the second is the number of threads per inch of bolt length. For any bolt smaller than 1/4", however, the diameter is indicated by a number; a 10-24 or 10-32 bolt, for instance, has a diameter of 0.19".

Finally, the number of threads per inch indicates if it is a coarse or fine thread. For a #10 size, 10-24 is coarse, and 10-32 is fine. This distinction is important, as not only must the diameter of a nut and bolt match, but also the thread type (coarse or fine.) Table 3, below, shows some common bolt sizes and their applications.

Table 3: Bolt thread sizes and their applications

Thread Size	Application
6-32 (or smaller)	Small electronics and sensors
8-32	Anywhere a 10-32 is too large VexPro VersaHub components (wheels, pulleys, etc.)
10-32	Standard custom pieces (standard bolt)
1/4-20	Custom pieces where a 10-32 is too small or too weak
5/16-18 (or larger)	Large shoulder bolts or pneumatic components