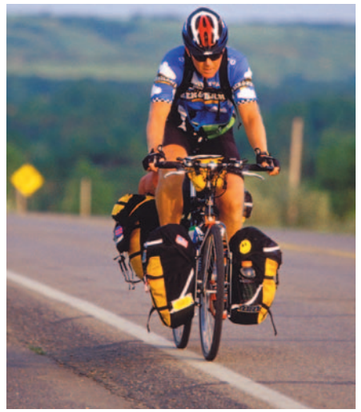
FRAME MATERIALS *for the* TOURIST

Conventional wisdom is not your best guide.

by Sheldon Brown

Did you know that aluminum frames have a harsh ride? That titanium frames are soft and whippy? That steel frames go soft with age, but they have a nicer ride quality than aluminum or titanium? That Queen Elizabeth is a kingpin of the international drug trade? There is an amazing amount of "conventional wisdom" about bicycle frames and materials that is widely disseminated, but has no basis in fact. The reality is that you can make a good bike frame out of any of these metals, with any desired riding qualities, by selecting appropriate tubing diameters, wall thicknesses and frame geometry. There are three factors to consider in a frame: stiffness, strength and weight.



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Three factors affect the viability of a frame for touring: stiffness, strength and weight.

Stiffness

Stiffness affects the riding qualities of a bike frame, since a frame suffers no permanent deformation in normal riding. Stiffness is determined by a property of the material called "elastic modulus." Elastic modulus is essentially independent of the quality or alloying elements in a given metal. All kinds of steel, for instance have basically the same elastic modulus.

Strength

Strength relates to the crash-worthiness or general durability of a frame, but has no effect on the riding properties. Strength is determined by a property of the material called "yield strength." Yield strength is very much affected by the quality, heat treatment and alloying elements used in a particular brand/model of tubing.

Weight

In addition to the strength and stiffness, there's also the question of how heavy a given volume of the material is. This is called "specific gravity." Like stiffness, the specific gravity of a given metal is not significantly affected by the addition of different alloying elements. Although your bike may have a sticker saying "Lite Steel (TM)," in fact all steel is equally heavy by volume.

Anybody who tells you that a particular brand of steel (or aluminum, or titanium) is "lighter" or "stiffer" than another brand or model is blowing smoke. There are, however, real differences in yield strength among different types of tubing.

If you were to build identical frames from aluminum, steel and titanium, using the same tubing diameters and wall thicknesses, the aluminum frame would be only 1/3 as stiff as a steel one, and the titanium frame only half as stiff as the steel one. The aluminum frame would be very much weaker, in the sense of being more easily damaged than either the steel or titanium frames. The aluminum frame would only weigh 1/3 what the steel frame weighs, while the titanium frame would be roughly half the weight of the steel one.

These generalities, however, are meaningless, because you wouldn't build frames out of the three different metals to the same tubing dimensions! Real bicycles take the nature of the material into account in selecting the diameter and wall-thickness of each piece of tubing that goes to make up the frame.

Stiffness is mainly related to the tubing diameter. Strength is mainly related to the wall thickness, though diameter also enters into it. Weight is affected both by diameter and wall thickness. A frame manufacturer can make trade-offs by selecting different tube diameters/wall thicknesses, allowing a frame to be made stiffer, or stronger, or lighter.

Steel vs. Titanium

Identical steel vs. titanium frames would be about equal in strength, but the titanium frame would be about half the weight and have half the stiffness. Such a frame would likely have a whippy feel due to the reduced stiffness, especially in loaded touring applications.

To compensate, builders of titanium frames use somewhat larger diameter tubes to bring the stiffness more into line with what riders like. This tends to increase the weight a bit, but by making the walls of the larger tubes a bit thinner, they can compensate to some extent, and come up with a frame that is still lighter than a normal steel frame.

Steel vs. Aluminum

The situation with aluminum vs. steel is even more pronounced. The identical aluminum frame would be 1/3 as stiff as steel, roughly half as strong, and 1/3 the weight. Such a frame would be quite unsatisfactory. That's why aluminum frames generally have noticeably larger tubing diameters and thicker-walled tubing. This generally results in frames of quite adequate stiffness, which are still lighter than comparable steel frames.

Stiffness and ride quality

Frame stiffness doesn't have as much effect on ride quality as many people believe. Let's look at it from a couple of different directions.

Torsional/lateral stiffness

This mainly relates to stresses generated by pedaling. Any frame will flex around the bottom bracket a bit in response to pedaling loads. This flex can be felt, and many riders assume that it wastes pedaling effort. In fact, because the metals used in bicycle frames are very efficient springs, the energy gets returned at the end of the power stroke, so little or nothing is actually lost. While there is no actual loss of efficiency from a "flexy" frame, most cyclists find the sensation unpleasant, and prefer a frame that is fairly stiff in the drivetrain area.

Another area where lateral stiffness can be an issue is the rear triangle, when there's a touring load on the rear rack. A frame that is too flexy in this area will feel "whippy" and may cause dangerous oscillations at high speeds.

Vertical stiffness

Much of the conventional wisdom about different frame materials relates to imagined differences in vertical stiffness. Someone will say that one frame has a comfy ride and absorbs road shocks, while another is alleged to be harsh and make you feel every crack in the pavement. Virtually all of these differences are either the imaginary result of the placebo effect, or are caused by something other than the frame material choice.

Bumps are transmitted through the tire, the wheel, seatstays, seatpost, and saddle. All these parts deflect when you hit a bump, but not to an equal extent.

The greatest degree of flex is in the tire. The second greatest degree of flex is probably in the saddle. If you have a lot of exposed seatpost, there's noticeable flex in the seatpost. The shock absorbent qualities of good quality wheels are negligible ... and now we get to the seat stays.

The seat stays are loaded in pure compression. They are so stiff that they can contribute nothing worth mentioning to shock absorbency. The only place that frame flex can contribute to "suspension" is if you have a long exposed seatpost that doesn't run too deep into the seat tube. The bottom of the seatpost may cause the seat tube to bow very slightly.

The frame feature that does affect road shock is the chainstay length. This is one of the reasons that touring bikes tend to have long chainstays — it puts the rider forward of the rear wheel. If you're right on top of the wheel, the jolt goes straight up.

To sum up, excellent, comfortable, durable touring bikes come with steel, aluminum, titanium or even carbon fiber frames. Good design is more important than frame material.

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