Measuring the Flex of Fork Blades

by Alex Wetmore, Jan Heine and Mark Vande Kamp

Do fork blades flex?

Riding forks with different blades on otherwise similar bikes, we felt significant differences in comfort.[1] However, theoreticians have claimed that fork blades do not flex significantly and thus do not affect a bicycle's comfort.[2] The theoreticians reason that the long lever arm of the fork blades concentrates the forces on the fork crown and steerer tube, and significant flex is limited to this area. Could it be that our perceptions were due to a placebo effect – that we thought we noticed something, but which did not really exist?

A simple incident convinced one of us that fork blades do flex. After mounting fenders on a bike, Jan took it for a test ride. A rubbing noise emanated from the front fender. After putting the bike back in the workstand, the front wheel rotated freely, and the noise was gone. On the road, the noise reappeared. Finally, it was traced to the bolt attaching the light to the fender, which came within 3 mm of the tire. As the rider's weight flexed the fork blades, the bolt touched the tire. Filing the bolt shorter got rid of the noise.

In this article:

- Fork blades flex significantly under realistic loads.
- The amount of flex depends on a variety of factors, including fork blade diameter, wall thickness, and fork offset.

A simple experiment

To determine whether different fork blades provide significantly different amounts of shock absorption, we designed a simple test. We used two racks, one mounted at the top of the fork, the other one at the bottom, as indicators for fork blade deflection (Fig. 1). If fork flex occurred only above the fork crown, both racks would move in unison, and their distance from each other would remain constant. If the fork did not flex at all, the racks would not change position relative to each other, either. The lower rack only will move in relation to the upper rack if the fork blades flex between the dropouts and the lower attachment points of the upper rack (Fig. 2).[3] The amount of movement under a given load gives a rough indication to the amount of fork blade flex.

On each tested bike, we installed a handlebar bag support rack (Nitto M-12 on Bikes 1-3, custom Singer on Bike 4). The rack was attached firmly to the cantilever brake posts or nearby braze-ons. In addition, we installed a Bruce Gordon low-rider rack that was attached to eyelets on the dropouts and to the middle of the fork with rubberized clamps. The horizontal distance between the top bar of the low-riders and the front of the bag support rack (Fig. 2) was measured without a load, and with loads of 29 kg (64 lbs.) and 46 kg (101.5 lbs.).[4] The smaller load consisted of two large water canisters, which were hung on the drops of the handlebars. For the larger load, an additional canister was placed on top of the brake levers. The bike was held upright by a helper during the test.

Fig. 1: Weights on the handlebars simulated the loads fed into the fork by road irregularities (Fork 1 shown).

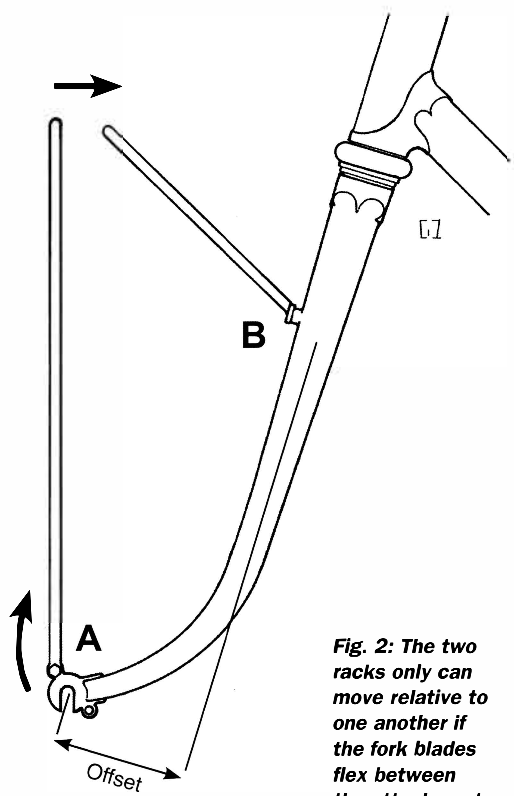


Fig. 2: The two racks only can move relative to one another if the fork blades flex between the attachment points A and B.

Fork	Head Angle	Offset
1 Kogswell P/R (heavy gauge)	73°	73 mm
2 Kogswell P/R (heavy gauge)	73°	58 mm
3 Kogswell P/R (lighter gauge)	73°	58 mm
4 1947 Alex Singer Special[5]	74°	80 mm

Table 1: The four forks we tested.

Four test forks

We tested several bikes to assess the influence of fork blade wall thickness, fork blade diameter, and fork offset (see Table 1): Forks 1 and 2 differ only in their offset. Forks 2 and 3 have identical offsets, but Fork 3 uses lighter-gauge blades and is bent closer to the dropouts, rather than in the middle of the blade. Fork 4 uses very thin blades, a large offset, and is bent very close to the dropouts (see p. 26). This should maximize its vertical compliance (flex).

Fork blades do flex!

The results clearly show that all fork blades in our test did deflect significantly under realistic loads (Chart 1). We measured only the horizontal component of the fork blade flex, so the measurements are relatively small, but the deflections were large enough to see as the two racks moved toward each other when the bike was loaded. Depending on where the fork blades flex, the vertical component of the fork blades' deflection can be significantly larger than the horizontal component we measured (Fig. 2).

The blades of Fork 1 with more offset deflected noticeably more than the same blades of Fork 2 with less offset, and thus a shorter lever-arm. However, the blades of Fork 3 deflected more than those of both Forks 1 and 2, indicating that the wall thickness of the blades and/or the location of the bend make a larger difference than the offset. The blades of Fork 4 combine a very thin diameter with generous offset and a bend concentrated near the front dropouts. They flexed almost four times as much as the blades of the stiffest fork, Fork 2. These measurements confirm our on-the-road experience, where we have found Bike 4 to be very comfortable.

Conclusion

Our tests have shown that fork blades do flex significantly in their lower portion. Wall thickness, diameter of the fork blades, and placement of the bend of fork blades greatly affects a fork's comfort and probably also the bike's speed (see p. 1). Furthermore, forks with more offset flex significantly more than those with less offset. We did not measure whether there also is significant flex at the fork crown and steerer tube of the fork. Fork failures are rare, but they usually occur at the fork crown. Good fork design should attempt to minimize the flex in these highly-stressed areas, and optimize it in the lower portions of the blades.

Notes:

1 Heine, J., 2005: Test: J. P. Weigle Randonneur. Bicycle Quarterly Vol. 4, No. 2, p. 37. The bicycle was tested with two different forks.

2 For example, http://groups.google.com/group/rec.bicycles.tech/browse_thread/thread/4f44cae1946e02dd/ae5f1d77c44837fd?&hl=en#, status 1/1/2008.

3 The lower rack and its attachments are too flexible to stiffen the fork significantly. Otherwise, the only flex measured would be in the few centimeters between the upper attachment of the lower rack and the lower attachment of the upper rack.

4 To check the consistency of our results, we once had two testers and once three testers measure the distances for the same setup in a blind test (without knowing each others' results.) The measured distances were within 0.06 mm in all cases.

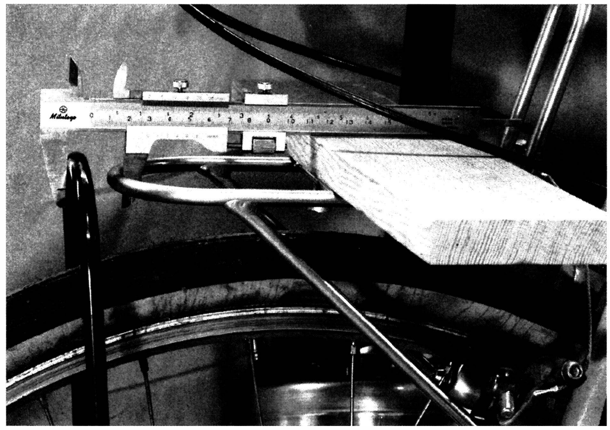


Fig. 3: The horizontal component of the fork blade deflection was measured.

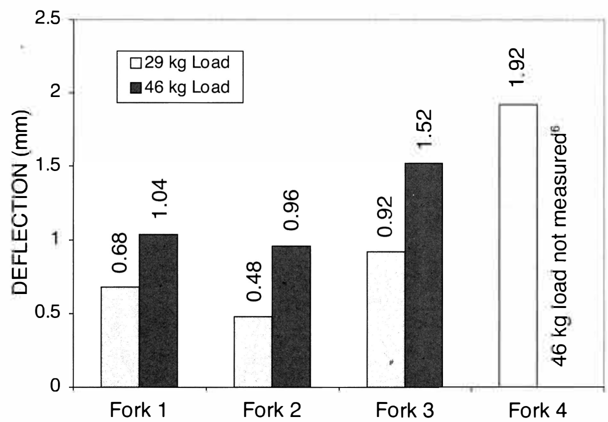


Chart 1: Different fork blades flex very differently under the same loads.

5 See p. 26.

6 Bike No. 4 has exposed brake cables, which do not allow placing the third water container on top of the handlebars. Thus, we measured deflection only with a load of 29 kg.

Thank You!

Matthew Grimm of **Kogswell Cycles** provided three frames and forks for this test. Kogswell's generous support made this research possible.

Fork Blades Optimized for Comfort and Speed

by Jan Heine

To provide shock absorption, fork blades should be designed to flex (see p. 24), yet provide strength in the areas of the highest stresses. The greatest stresses on a fork occur at the fork crown. Not only do forces act on the longest lever here, but there are stress risers at the bearing seats, and the fork blades are heated during brazing. On bikes with brazed-on pivots for centerpull or cantilever brakes, brake forces are fed into the fork crown as well. A well-designed fork blade should provide strength in this highly-stressed area, and flex in the lower part of the blades to dissipate vibrations. Fortunately, most fork blades do – that is why they taper from a relatively large cross-section at the fork crown to a much smaller section at the dropouts.

Alex Singer used special Reynolds 531 fork blades on many bikes. These blades appear to be particularly well-designed. Their cross-section at the fork crown uses the tall and narrow "Imperial Oval" rather than the rounder "Continental Oval" used by most modern bicycles.

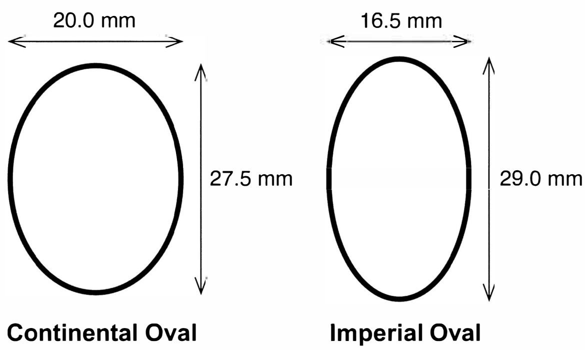


***Fig. 1:** In addition to its greater stiffness fore-aft plane, the thinner "Imperial Oval" improves tire clearance.*

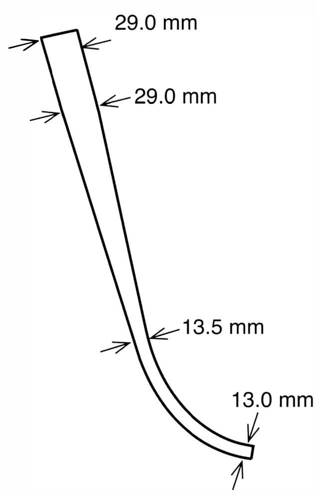


***Fig. 2:** The fork blades of this 1947 Alex Singer minimize flex at the highly stressed fork crown. The small diameter of the blades in the lower portion of the fork provides generous shock absorption.*

These "Alex Singer Special" fork blades continue with a constant diameter all the way to the cantilever posts to maximize stiffness there (Fig. 2). Then they taper relatively quickly to a round cross-section measuring 13 mm in diameter. The slender cross-section continues all the way to the dropouts. This design minimizes flex at the highly stressed fork crown interface, and maximizes flex in the lower portion of the fork blades.

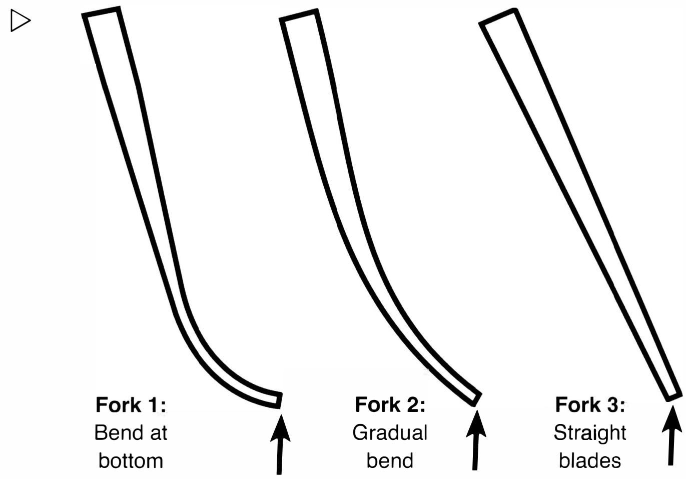
Modern fork makers often talk about the lateral stiffness of their forks, which is intended to provide better cornering. Clearly, the "A. Singer Special" fork blades lack lateral stiffness when compared to modern fork blades: At the crown, the "Imperial Oval" is narrower than the "Continental Oval." And the slender blades can flex in any direction. Will this make the bike track poorly in corners? The answer is no. Unlike a car's steering components, a bicycle's fork does not suffer significant side loads, since the bike is steered by leaning. If a bicycle's fork underwent significant side forces during cornering, the bike would not stay upright, and the rider would crash.

Side loads occur only when the lean is initiated or modified, and they are very small. Even when riding out of the saddle, the fork blades flex only insignificantly. Forks that are very flexible in the fore-aft direction may exacerbate problems with brake judder, but the obvious solution is to use brakes and pads that do not judder.

In practice, I have found that my best-handling and thus fastest-cornering bikes are equipped with the "A. Singer Special" fork blades. Riding otherwise similar Alex Singer bikes, one with standard and one with "A. Singer Special" fork blades, I found no difference in front wheel deflection even when riding out of the saddle. However, the shock absorption was noticeably different.

I consider the "A. Singer Special" fork blades an optimized design. They provide strength where it is needed, compliance where it is desirable, and generous tire clearance as well. Reynolds also offered a similar shape, but with a shorter constant diameter section at the top, for use with sidepull brakes. (With sidepull brakes, there is no

Fig. 3: Concentrating the bend near the dropouts (Fork 1) increases the angle of the fork tip in relation to road shocks, so the fork blade flexes more and absorbs shocks better. On a straight fork (Fork 3), road shocks act almost in the axis of the fork blade, and compressing rather than flexing the blade. Tubes are hard to compress, so there is little shock absorption. Modern forks also have less fork offset (rake), further steepening the angle of the fork blade.



need for the constant diameter all the way to the cantilever posts.) These were used by many British builders in the 1950s. Some Italian builders also used blades with a very small diameter for a long portion of the lower blades.

Like many classic bikes, the 1947 Alex Singer concentrates the bend near the dropouts (Fig. 3, Fork 1). This means that road shocks act almost perpendicularly on the fork blade, making the blade easier to flex than a gradual bend or a straight-bladed fork.

Unfortunately, the "A. Singer Special" fork blades and similar shapes today no longer are available. Most bikes today use relatively large-diameter fork blades that provide comparatively little shock absorption and concentrate stresses in the area of the fork crown. The current "Continental Oval" cross-section provides less strength in this area while also limiting tire clearance. The Japanese tubing maker Kasei still offers "Imperial Oval" fork blades, but the supply of matching fork crowns is dwindling. Perhaps it is time to resurrect the "A. Singer Special" fork blades and the associated fork crowns? ●