Mountain bike hub stiffness: Comparative testing

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Introduction

To make comparative measurements of rear hub stiffness, we developed a test rig to enable a range of rear hubs to be loaded and the resulting deflections measured. Using an industry standard Instron testing system the hubs were mounted in our custom fixture and a vertical load applied centrally with a force representative of that transmitted through the wheel. The fixture supported the hub in a manner that simulated the hub clamped in the dropouts of a bike frame, allowing the system to flex while maintaining the clamping action of the bolt through axle.

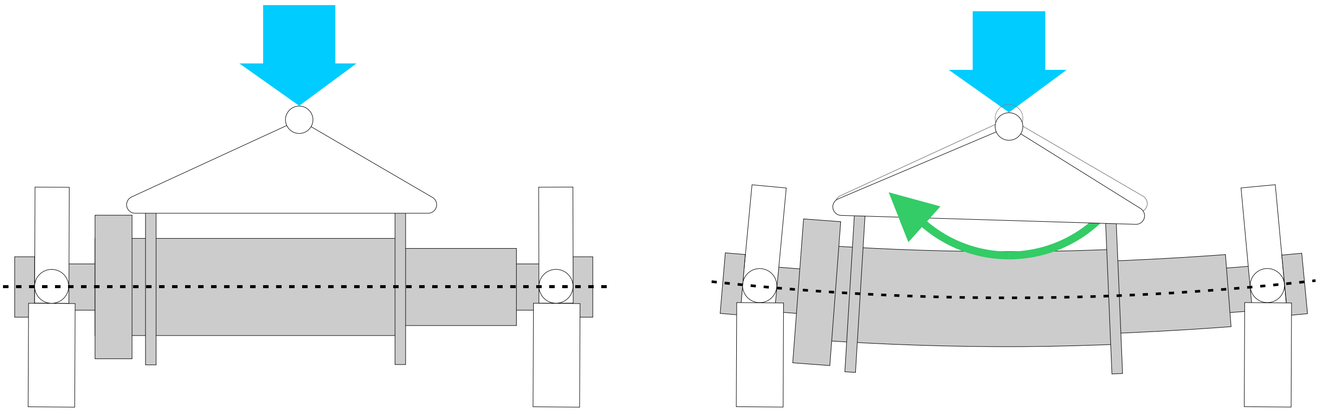

Figure 1 (Left a, Right b): The test fixture (white) was used to mount the hub (grey) in a compressive test bench to measure the flexion of the hub under load (blue arrow). (b) illustrates how the hub flexes under load with both a linear and rotatoinal component

Test method

A 4kN vertical load was gradually applied, shown by the blue arrow in figure 1, causing a vertical deflection of the hub which was measured at the point of force application. This deflection is illustrated in figure 1b as the change in position of the circular upper fulcrum. In some cases, the applied load resulted in an angular deflection of the hub which we measured across the spoke flanges, illustrated by the green arc in figure 1b. The support fixture was designed to permit this rotation. The maximum deflection of each cycle was measured with a linear dial gauge at a known distance from the fulcrum then the angular deflection was calculated.

Each new boost through axle rear hub, 148mm x 12mm as detailed in Table 1, was clamped into the fixture with a consistent torque, 8 Nm, then placed into the compressive test rig and aligned centrally with a reference laser. The load was ramped up from 0.1kN to 4kN and back down to 0.1kN and was repeated 6 times in total. The vertical deflection was measured throughout, and the angular deflection measured at maximum load. The mean and standard deviation of the maximum linear and rotational deflection over the six compressions was then calculated.

Test Hubs	Hope Pro 2	Hope Pro 4	DT Swiss EXP 240	E13 LG1 Race	KOM Xeno

Table 1 - Hubs tested. All rear 148x12mm boost

To measure the inherent stiffness of the fixture and measurement system, a reference measurement was taken. A solid bar with the same dimensions as a hub (length, flange diameter and bore diameter) was machined and subjected to the same test method. The deflection of the hub was then calculated by subtracting the fixture deflection.

Results

The stiffest hubs produce the smallest deflections under load. The maximum deflection results are tabulated below with the standard deviations indicating very consistent results over the 6 compressions.

Measure	Reference	HopePro2	HopePro4	DTSwissEXP	E13	KOM
Mean of maximum deflection - mm	0.21	0.96	0.96	1.23	0.81	0.57
St Dev /mm	0.0013	0.0013	0.0031	0.0019	0.0019	0.0017
Hub mean maximum deflection - mm		0.75	0.76	1.02	0.60	0.36
Mean angular deflection – degrees	0.00	0.24	0.23	0.23	0.22	0.02
St Dev - Degrees	0.0012	0.0004	0.0004	0.0005	0.0004	0.0012

Table 2 – Summary of comparative mean test results

The linear deflection of the hubs is represented graphically in Figure 2, comparing the range of performance across the selected hubs. The DT Swiss hub exhibited the greatest deflection with the KOM hub displaying the minimum delfection.

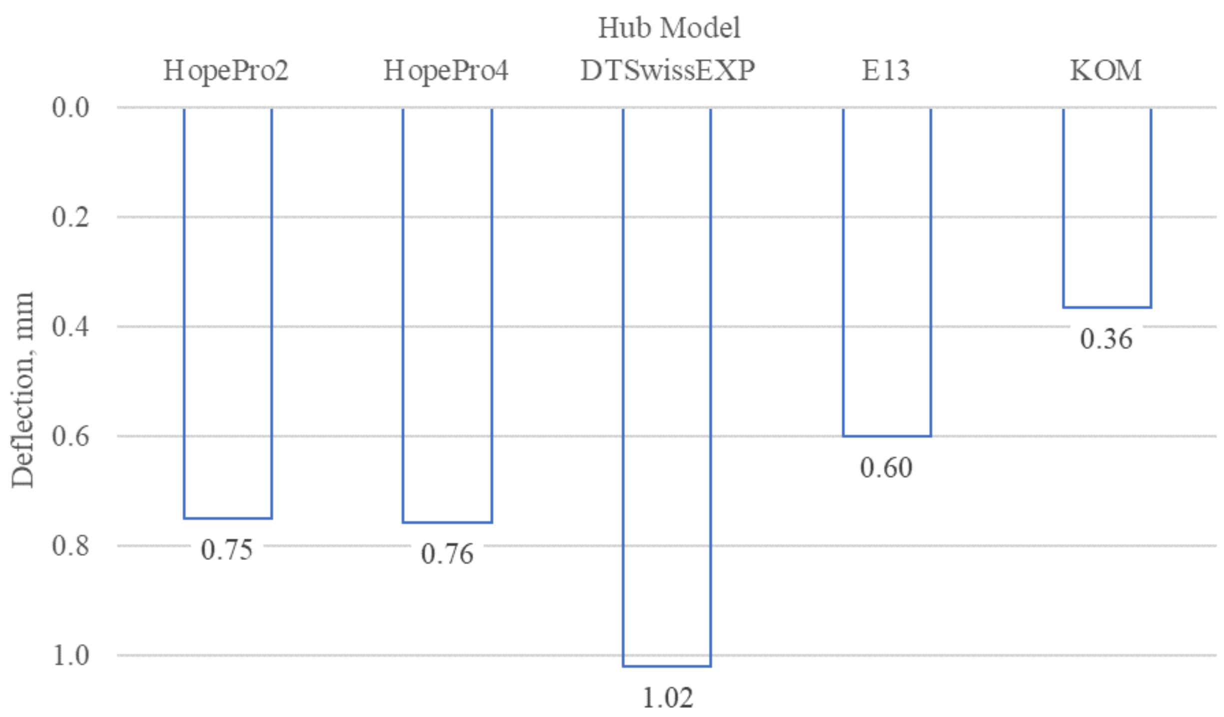

Figure 2 – Mean of the maximum deflection at 4kN calculated from each of the 6 load cycles. The measured reference deflection of the system has been subtracted from the total, giving only the contribution of the hub.

Similarly, Figure 3 graphically represents the angular deflection of the hubs at 4 kN, the KOM hub deflects a tenth of the magnitude of the other hubs.

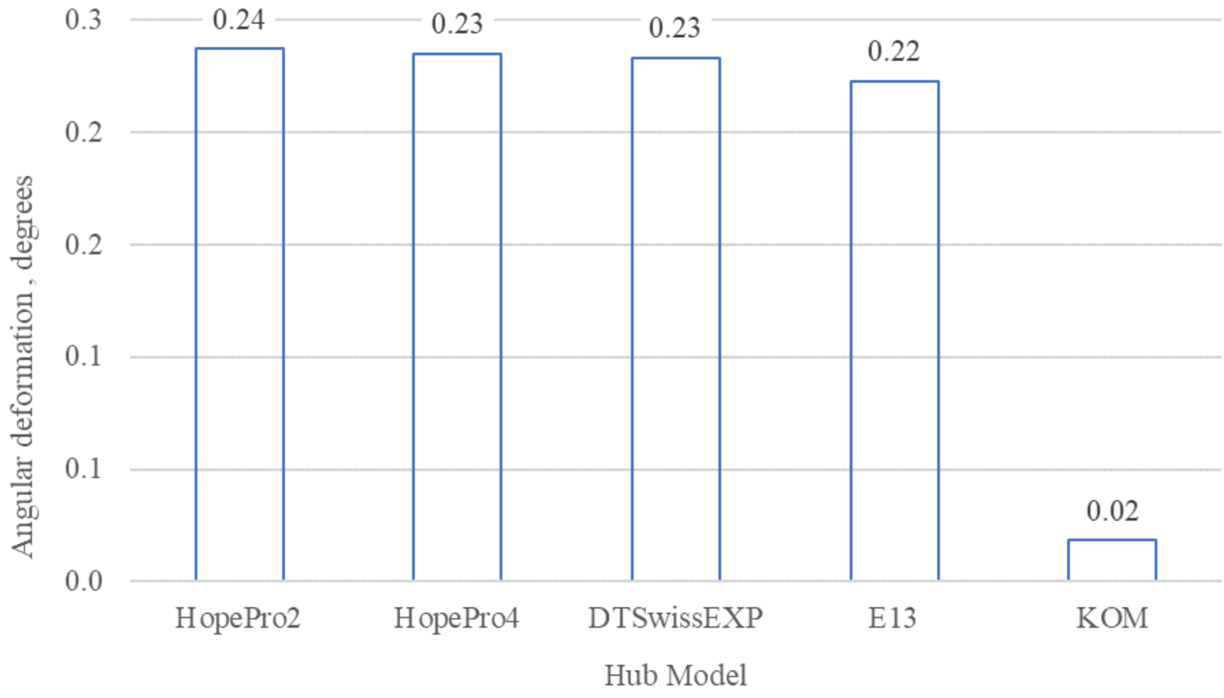

Figure 3 – Mean maximum angular hub deflection at 4kN measured across the spoke flanges.

As the linear deflection of the hubs was recorded throughout the application of load, we are able to plot the effect of that load on the hubs. Figure 4 graphically compares the linear stiffness of each hub model during the second compression cycle by subtracting the deformation of the reference. The steeper the curve, the stiffer the performance of the hub, and each model deforms near linearly throughout the range of load.

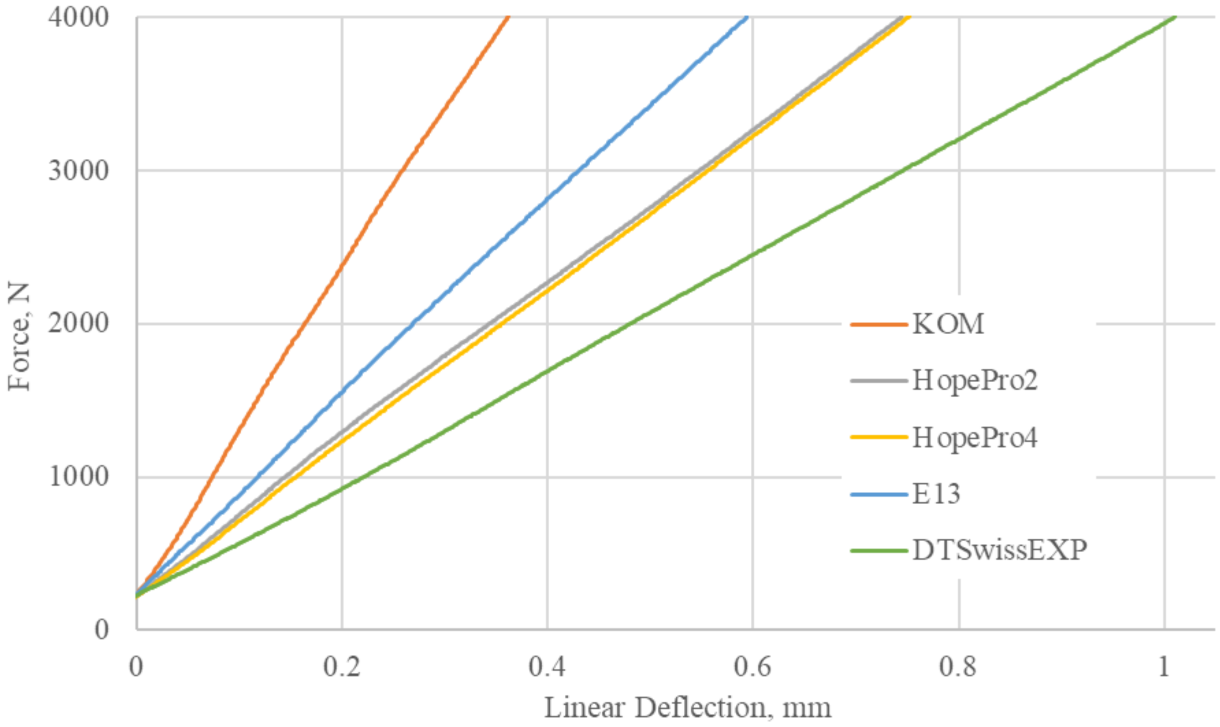

Figure 4 - The stiffness of each hub is measured as it deflects under loading. Here the stiffness of the hubs is plotted throughout the application of the force.

Conclusion

To differentiate the performance of a range of hubs under simulated riding loads we developed a test method to measure their linear and angular deflection. A custom fixture was created to allow the hubs to be held in a Instron test system which allowed the hubs to flex in an expected manner, as if supported within a frame. The load on each hub was cycled six times between 0.1 to 4kN measuring linear deflection continually and the angular at maximum load.

Stiffer hubs will deflect less under load and the results showed a range of performance of the hubs, from 1.02mm down to 0.36mm linearly, with the KOM hub deflecting the least. The largest differences were seen in the angular deflections with the KOM hub deflecting 0.02° and the others between 0.22° and 0.24°.