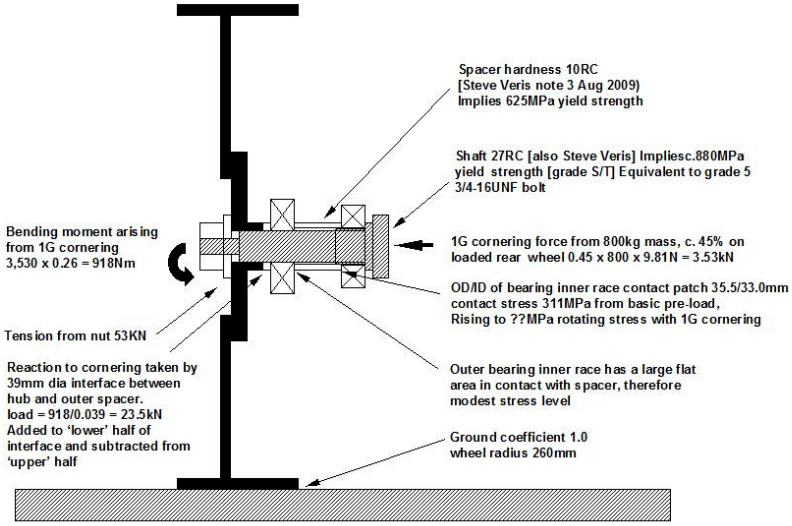

The basic tension from the hub nut tightened to 150ft-lbs translates to 311MPa surface stress at the inner bearing to spacer interface, duplicated at the inner bearing to axle face. This on its own isn't enough to cause material deformation.

Cornering force however generates a bending moment on the hub, a proportion of which will be passed on to other components. The BM will add to compressive stress in the 'lower half' of the spacers etc, and subtract stress from the 'upper half', but all the time rotating, known as rotating bending. This is repetitive on a once per wheel revolution basis and of course is also dependent on cornering force. Most of us don't take every corner on the door handles, hence peak loads such as shown in the schematic are a relatively rare event.

Consider what happens during 1G cornering. The bending moment generated by the cornering force exerts a load of 23.5KN at the diameter of the hub spacer, this must be reacted by the drive hub and its supporting spline, shaft, bearings etc. The load from cornering will add to the 53KN clamp force on the lower half of the hub-spacer interface, and subtract from the upper half. There is zero additive/subtractive load at the horizontal shaft plane and increasing load variation toward the OD of the interface above and below the centreline.

Calculating the potential load distribution using hollow tube bending theory yields c.+/- 450MPa rotating stress at the periphery of the hub. This rather dwarfs the hub to spacer stress arising from the clamp load of c.103MPa. It's not too difficult to imagine this rotating force travelling along the spacers and inner races to the axle abutment at the other end of the assembly where it literally rolls grooves into the spacer if not hardened, and the axle face via the substantially harder inner race.

It's good practice for a fastener system to have adequate stretch in the bolt to maintain clamping load, this is usually achieved by using the smallest diameter fastener that will achieve the desired clamp load. The axle diameter is large and stretch under 150ft-lb is small, hence this is sub-optimal. FEA showed the axle stretches by approx 0.045mm and the spacer assembly compresses by 0.03mm, a total of 0.085mm or 0.0033".

I've not measured the grooves in my spacer and axle but they seem to be of this order of magnitude. This will lead to a significant drop-off in clamp load and ultimately failure of the hub and spline due to fretting.

Axle threaded section failures

See also diagram following. Once the hub is free to move and the spline is worn the ever present rotating bending moment will be resisted only by the inner and outer faces of the hub. These reaction forces will act in a diagonal sense which will load the locally washer locally at a point that rotates around its periphery with the wheel motion. The hub nut will transfer this load to the ¾ UNF threaded section in the form of rotating bending. Those photos of failed axle threads that owners have posted show classic signs of fatigue in rotating bending.