# The Behavior Of A514 Steel Tension Members

Paper presented by G. L. KULAK (January 1971 issue)

Discussion by **John N. Macadam**

The standard tension coupon tests described in the beginning of the paper, were conducted in a rather nonstandard manner as far as many laboratories and producers are concerned. In the normal tension test procedure the machine is not stopped for some ten minute intervals to obtain a static yield stress level. Typical autographic load-strain curves for tension tests on A514 steel do not exhibit an upper and lower yield point nor any significant yield point elongation region as the author has noted. The writer wonders whether the type of stress-strain curve shown as typical by the author is due to a metallurgical effect or the method of testing.

The author's tension tests on small bars of A514 steel with different hole patterns pointedly demonstrated the overall tensile deformation capacity in terms of the net section-to-gross section ratio. If such members should be proportioned to achieve gross section yield prior to net section tensile failure as suggested, then $A_n/A_g \geqslant YS/_{TS}$ or 0.87 for A514.

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High strength steels in general have an inherently high $YS/_{TS}$ ratio. In addition to A514 steel, other steels included within the scope of the AISC Design Specification also have high $YS/TS$ ratios. Examples are cold-formed carbon steel structural tubing (0.87 for A500 Grade A Shaped Tubing) and the higher yield strength grades of A572. The author concludes that the spread between yield and tensile strengths of as-delivered A514 steel is even less than indicated by minimum specified properties. However, this would probably be the case for all common structural steels.

The author's point about previous bolted joint experiments being concerned only with joint behavior without including the full member is well taken. He refers to his tests as members with simulated joints, but in fact the specimens were simply single bars with holes in the central portion. In actual joints, such as double-shear butt joints for instance, several other effects are present which contribute to the total deformation of the member and joint. Slip in the bolted joint, fastener deformation, and bearing deformation, together with the basic member strain, add up to the total elongation. There is probably justification for experimental work on actual complete A514 tension members with joints.

Undoubtedly, it would be desirable to proportion a bolted connection such that gross section yielding would occur prior to failure in the joint itself, but it may not be a necessary design philosophy. Very often other considerations such as fatigue[1] may control, which would make gross section yielding impossible to attain.

Consider the design of A514 joint using the 1969 AISC Design Specification. Section 1.5.1.1 limits the allowable tension stress on the net section to 0.6 $F_y$ but not more than 0.5 time the minimum tensile strength of steel. Since the $YS/TS$ ratio of A514 steel is greater than 5/6, the latter provision applies. Furthermore, Section 1.14.3 limits the net section to no more than 85 percent of the corresponding gross section. These two criteria result in a gross section stress limit of:

$$\sigma_g \leqslant 0.85(0.5)\sigma_{TS}$$

$$\sigma_g \leqslant 48.9 \text{ ksi for A514}$$

Hence, there is a minimum safety factor of 2.05 against yield in the gross section and 2.0 against ultimate tensile strength of the net section. The writer feels that this design philosophy represents good engineering practice.

Research has shown[2] that the behavior of A514 joints can be predicted accurately on the same general basis as for lower strength structural steels. A current research investigation[3] includes bolted connection tests using steels with $YS/TS$ ratios very near unity. Although these materials are of a different class and thickness category, the bolted connection test results indicate that a high $YS/TS$ ratio has little effect on behavior in tension on the net section.

Use of constructional alloy steel naturally requires certain new and different design considerations than those associated with lower strength steels. Continuing research, such as reported by the author, is necessary and valuable to the engineering profession. However, A514 tension members are amenable to satisfactory design and offer attractive material savings in many cases.

## REFERENCES


1. *Birkemoe, P. C., Meinheit, D. F., and Munse, W. H.* Fatigue of A514 Steel in Bolted Connections *Journal of the Structural Division*, ASCE *Vol. 95*, No. *ST 10, Oct. 1969.*
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3. *Dhalla, A. K., Errera, S. J., and Winter, G.* Connections in Thin Low-Ductility Steels *Paper presented at ASCE Specialty Conference on Steel Structures, Columbia, Missouri, June, 1970.*