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Shear resistance of high strength bolts, Lehigh University, (1958)

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SHEAR RESISTANCE OF HIGH STRENGTH BOLTS

I. Introduction

In order to gage the performance of the high strength bolts used in the Large Bolted Joints project at Lehigh University it was necessary to establish the resistance to shearing loads provided by a single bolt. In April, 1958, the advisory subgroup for the project approved a program in which the main variable was the amount of initial tension in the bolt. A complete report on this study is being prepared but in the meantime the following simplified summary may be useful in connection with the Fritz Engineering Laboratory Report No. 271.1, "Static Tension Tests of Bolted Joints."

II. Description of Test Specimens

See Fig 1.

III. Material Properties

See Tables 1 and 2.

IV. Scope of Tests

The resistance of a high strength bolt assembly to shearing loads depends on the friction between the faying surfaces as well as the true shearing strength of the bolt shank. The friction in turn depends on the clamping force (bolt tension) and the coefficient of friction. Because of this, single bolts were tested with various degrees of initial tension and the faying surfaces were either mill scale or mill scale lubricated with molycote.

Thus in addition to providing a "standard" of performance, one of the important purposes of these tests was to determine the influence of initial clamping force upon the shear resistance of individual fasteners.

Connections were assembled in the "slipped" position.

V. Results of Tests

Figure 2 shows that the ultimate double shear resistance of the high strength bolt is not affected by the amount of initial tension in the bolt. Figures 3 and 4, plotted to larger scale, show this in more detail. The fact that bolts joining plates with mill scale surfaces showed higher resistance indicates that there is still some bolt tension, and thus friction, even at high shearing loads but that it is relatively unimportant.

For relating the behavior of the 7/8" and 1" bolts which were of different strengths it is useful to think in terms of an effective ultimate shear stress ($\tau_{eff} = R/2A_s$) as a percentage of the ultimate tensile stress. Table 3 indicates that the effective shear stress is about 68% of the ultimate tensile stress. Shear tests of 5 - 7/8" rivets (similar to those in Joint BR2) showed an average shearing force of 59.9^k or an effective shear stress of 49.9 ksi.

Figure 5 shows typical load-deflection curves for 7/8", 1" and 1 1/8" bolts and for 7/8" A141 hot driven rivets. Note that the bolt deflection at ultimate load is about the same as that of the rivet.

TABLE 1

RESULTS OF COUPON TESTS OF SHEAR JIG PLATE MATERIAL

Coupon Number	Static Yield Level psi	Yield Stress .2% Offset psi	Ultimate Tensile Strength psi	Percent Elongation (in 8")	Percent Reduction in Area
J1 (7/8" Bolts)	37,800	39,900	67,200	32.5	57.4
J2 (1" Bolts)	38,000	40,100	66,800	28.5	56.7
J3 (7/8" Rivets	38,600	41,200	67,700	28.0	56.3
J4* (1 1/8" Bolts)	34,400	36,500	64,100	30.7	57.1

* Cut from surplus material of B Joints (B4, B5, B6)

TABLE 2

PROPERTIES OF BOLTS

Use	Bolt Lot	Dia. in.	Avg. Ult. Tensile Strength kips	Spec. Min Ult. Tens. Strength kips	% of Min Ult.	Tensile * Stress on Stress Area ksi	Spec. Ult. Tens. Stress ksi
Shear Jigs J1	Z	7/8	60.4	53.15	113.6	130.7	115.0
B Joints	B	7/8	54.3	53.15	102.2	117.5	115.0
Shear Jigs J2	Y	1"	73.1	69.70	104.9	120.6	115.0
A Joints	A	1"	74.1	69.70	106.3	122.3	115.0
Shear Jigs J4 and G1 Joint	G	1 1/8"	91.2	80.10	113.9	119.5	105.0

Note: All bolts satisfied min proof load requirement of specification

* Area calculated from the mean root and pitch diameter of class 3 external threads:
$A = \pi$ (1/2 Pitch Dia. $-$ 3/16 Height of V Thread)^2

TABLE 3

Bolts	Faying Surface	τ, Eff. Shear Stress ksi	σ, Tensile Stress on Stress Area ksi	$\frac{\tau}{\sigma}$
7/8" Lot Z	Mill Scale	93.2	130.7	0.714
7/8" Lot Z	with Moly	88.2	130.7	0.675
1" Lot Y	Mill Scale	81.6	120.6	0.676
1" Lot Y	with Moly	79.4	120.6	0.659
1 1/8" Lot G	Mill Scale	84.0	119.5	0.703

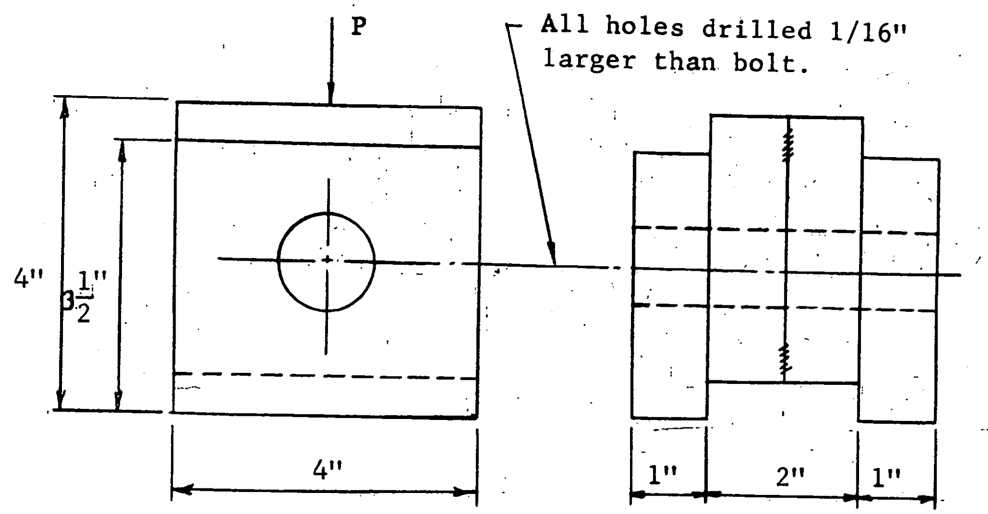

FIG 1 - SHEAR JIGS (J1, 2, 3, 4)

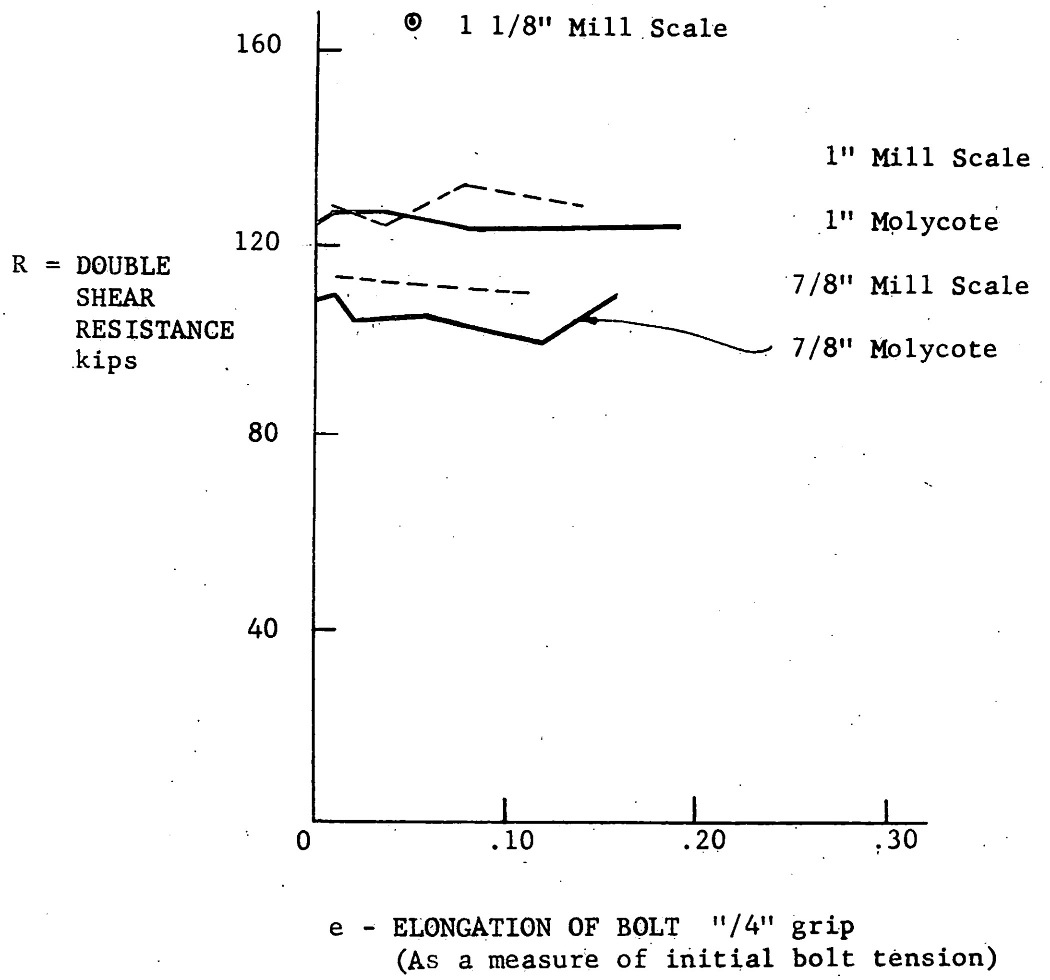

FIG 2 - ULTIMATE DOUBLE SHEAR RESISTANCE OF H. S. BOLTS

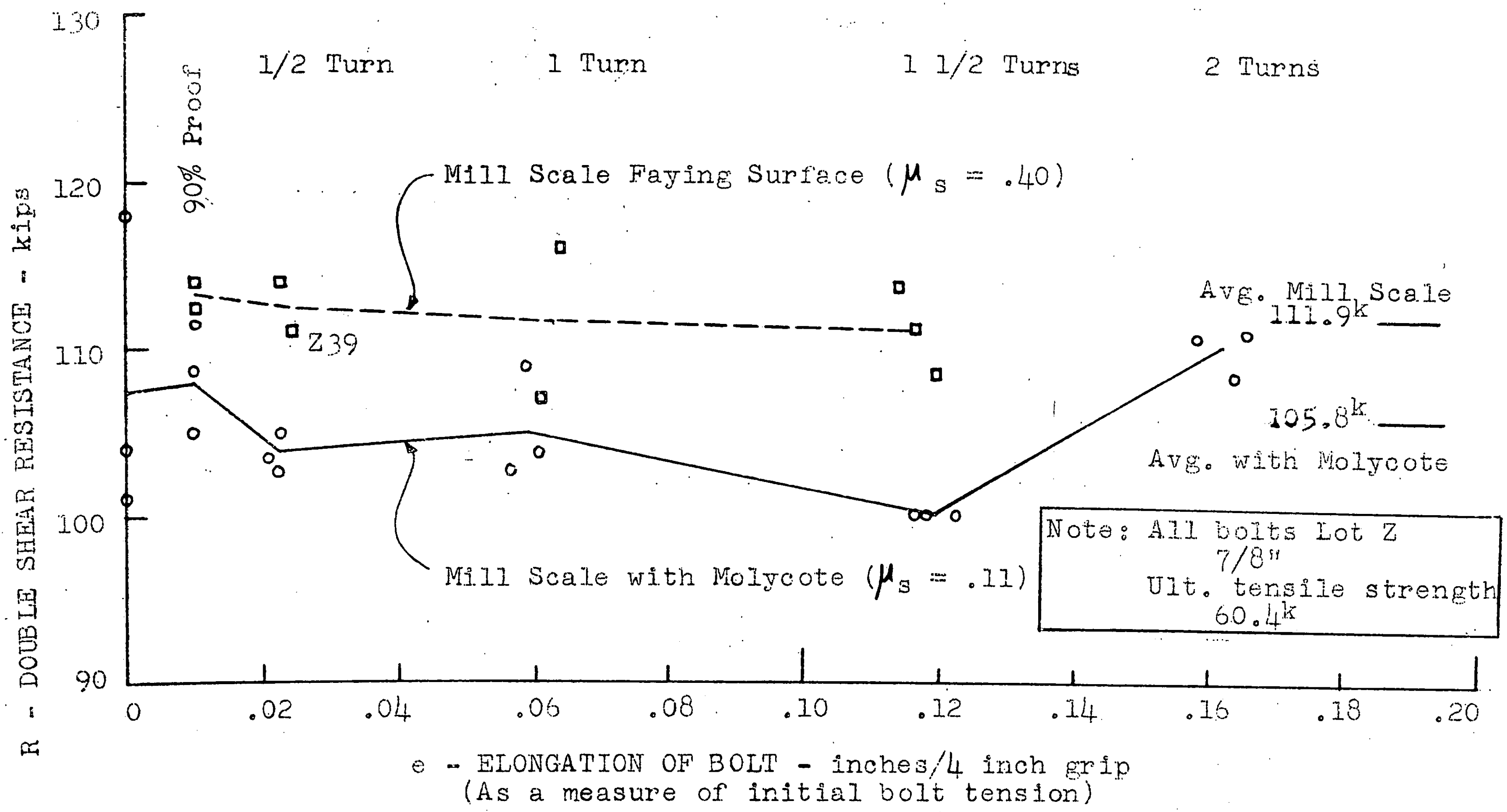

FIG 3 **ULTIMATE DOUBLE** SHEAR RESISTANCE OF A 7/8" H. S. BOLT

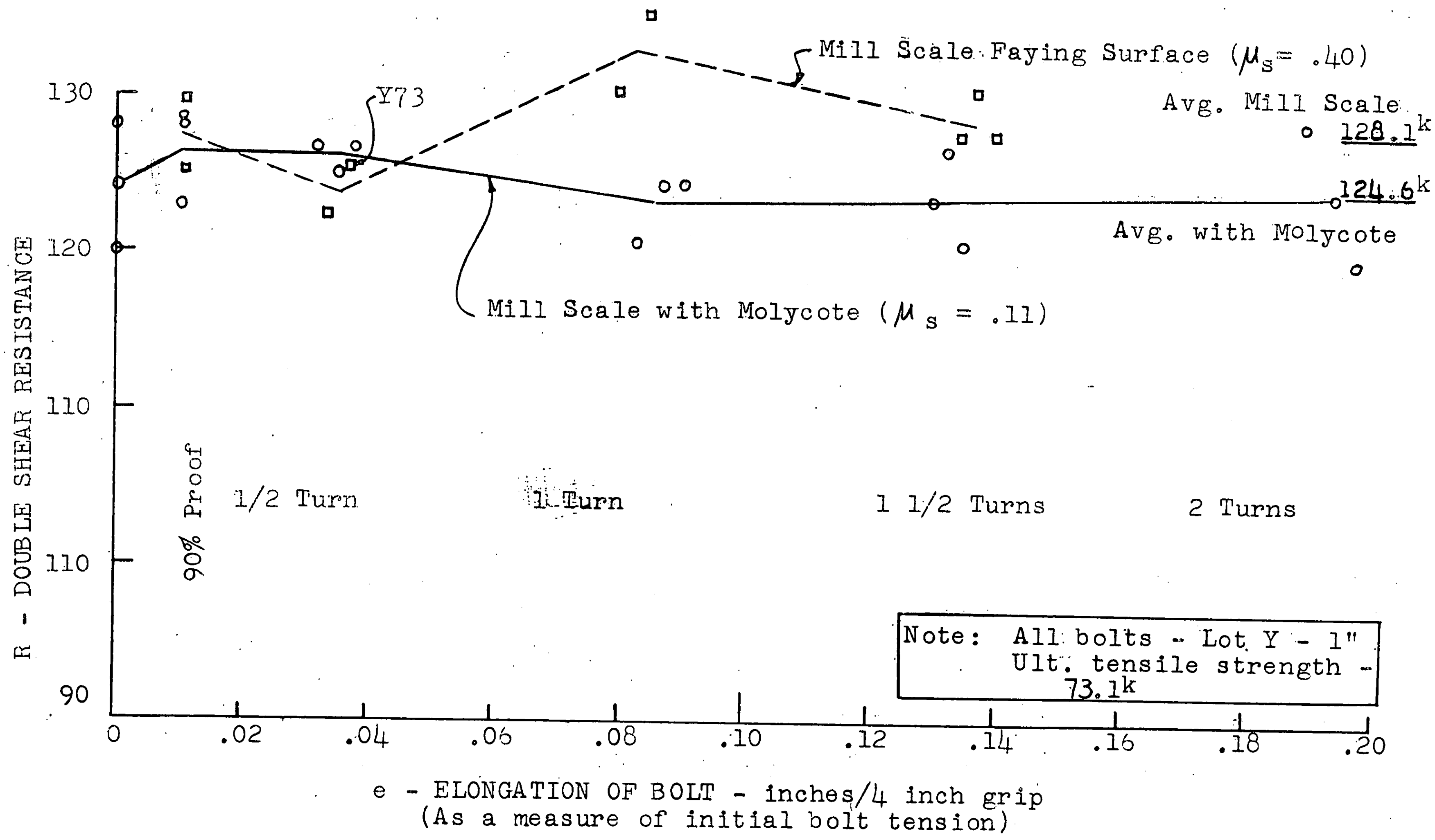

FIG 4 ULTIMATE DOUBLE SHEAR RESISTANCE OF A 1" H. S. BOLT

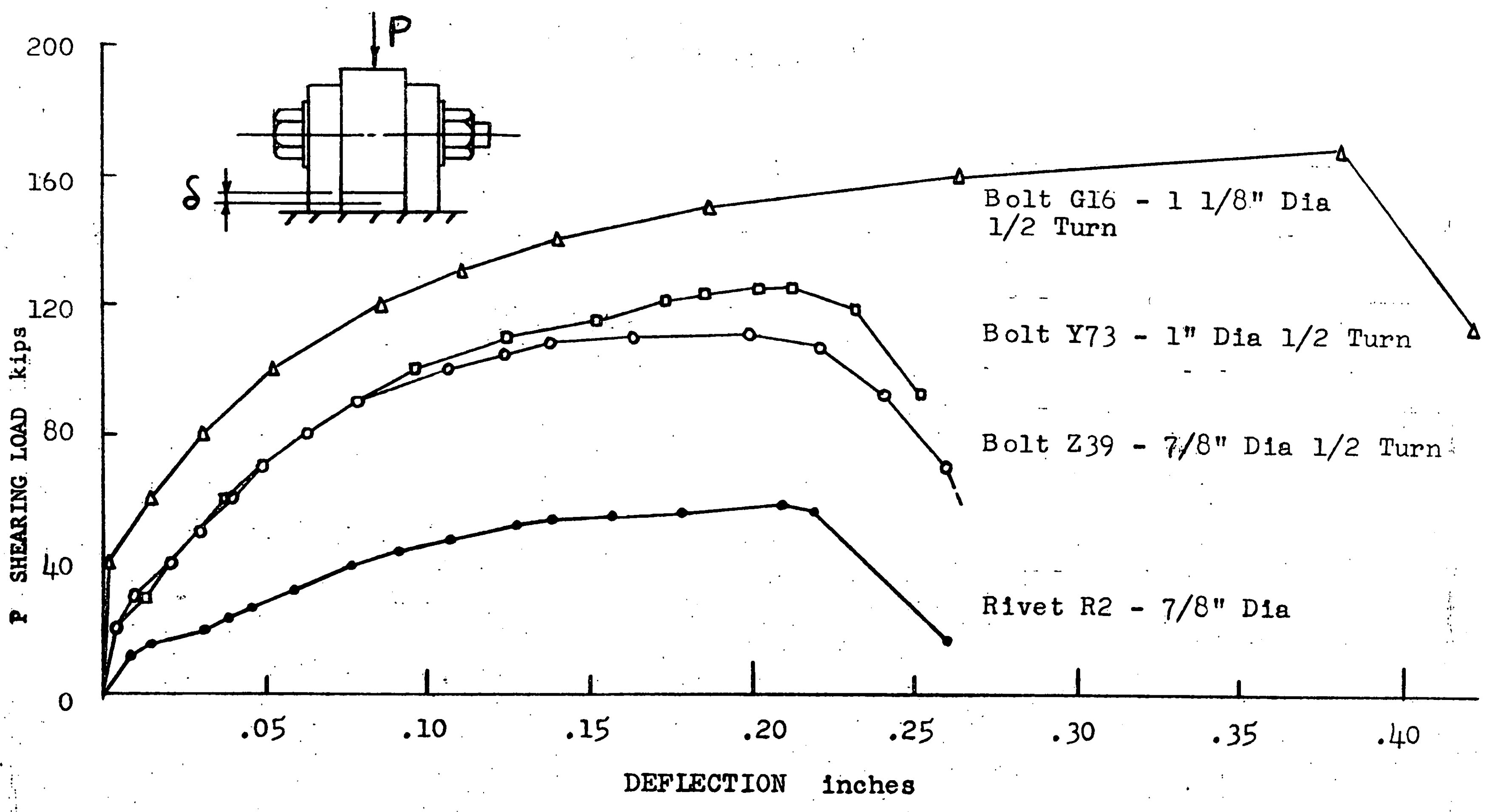

FIG 5 TYPICAL LOAD-DEFLECTION CURVES