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Welded Built-Up Columns

MATERIAL PROPERTIES OF STRUCTURAL CARBON  
AND HIGH STRENGTH STEELS

by

N. R. Nagaraja Rao

This work has been carried out as part of an investigation sponsored jointly by the Column Research Council, the Pennsylvania Department of Highways, the U. S. Department of Commerce Bureau of Public Roads and the National Science Foundation

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MATERIAL PROPERTIES OF STRUCTURAL CARBON AND  
HIGH STRENGTH STEELS

This is a summary of tests on the material properties of A7, A36, A242, A440 and A441 steels. The results include the static yield stress, modulus of elasticity, strain hardening modulus, and strains at first attainment of yield stress and at the onset of strain hardening. These properties are shown in Fig. 1.

The tests were conducted in connection with various projects listed below:

- Project 220A. Residual Stress & Compressive Properties of Steel
- Project 249. Residual Stresses & Welded Columns
- Project 269. Residual Stresses & A242 Steel Columns
- Project 288. Large Bolted Connections
- Project 296. Hollow Structural Tubing
- Project 297. Plastic Design in High Strength Steels

All the coupons were tested in a 120,000 lb screw type universal testing machine with an electronically operated load indicator and automatic recorder. The properties were determined directly from the recorded load-strain diagram. Elongation was measured over an 8" gage length <sup>after</sup> fracture. The tests were conducted according to ASTM specifications.

The results of the tests are given below.

Property	A7*	A36	A242	A440	A441
$\sigma_{ys}$ (ksi)	34.1	38.1	54.5	43.4	54.8
E (ksi)	29,600	29,500	30,900	30,450	29,400
$E_{st}$ (ksi)	700	728	734	786	442
$\epsilon_y$ (in/in)	0.0013	0.00123	0.00167	0.00143	0.00188
$\epsilon_{st}$ (in/in)	0.014	0.0106	0.0166	0.0104	0.0206
$\epsilon_{st}/\epsilon_y$	12.0	8.4	10.3	7.3	11.1
Elongation(%)		24.4	26.3	27.2	21.5

Range of variation of these properties are given in the Appendix

\* The values for this steel are taken from the Proc. AISC Nat'l Engr. Conf., 1956

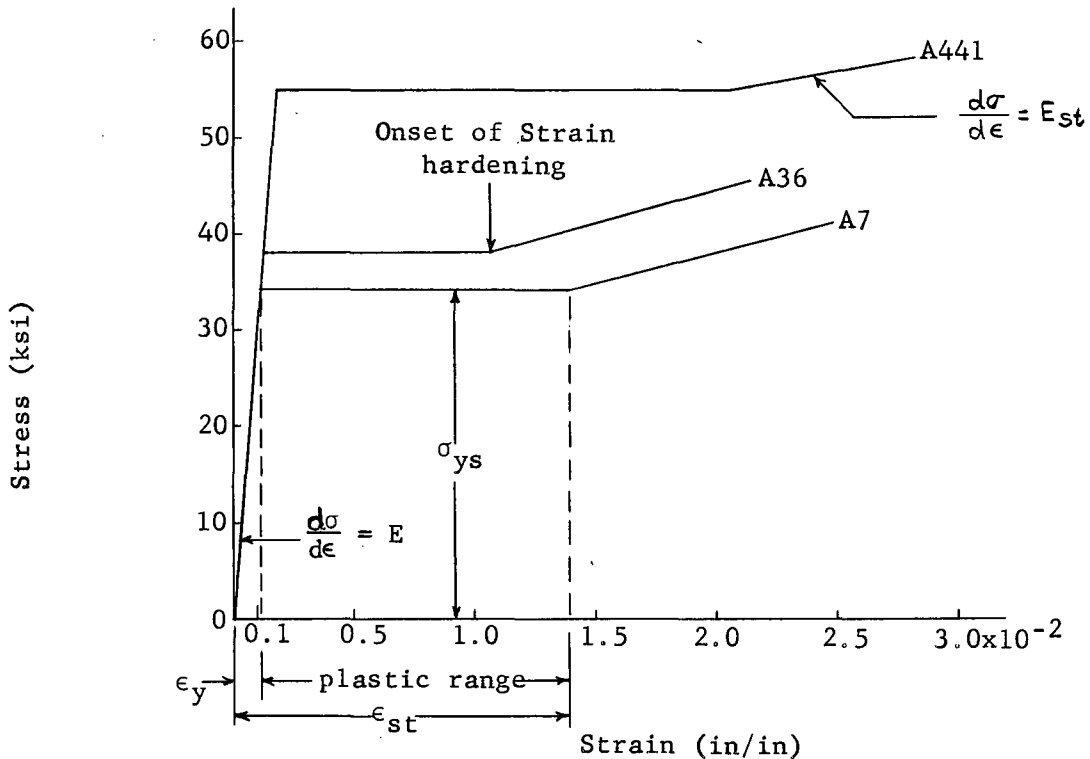


Fig. 1 Typical Stress-Strain Diagram

GLOSSARY OF TERMS

Yield Stress Level ( $\sigma_y$ ) - The average stress during actual yielding in the plastic range. It remains fairly constant for structural steel provided the strain rate remains constant.

Static Yield Stress ( $\sigma_{ys}$ ) - The yield stress level at zero strain rate. (This is obtained by stopping the movement of crossheads in the plastic range.)

Modulus of Elasticity (E) - The ratio of stress to corresponding strain below the proportional limit.

Strain Hardening Modulus ( $E_{st}$ ) - The ratio of stress to corresponding strain in the strain hardening region.

Elongation - The increase in gage length of a tension test specimen, usually expressed as percentage of the original gage length.

Appendix

## A36

Property	No. of Tests	Mean	Maximum	Minimum
$\sigma_{ys}$ (ksi)	80	38.1	44.6	34.5
E (ksi)	78	29,500	35,700	26,100
$E_{st}$ (ksi)	13	728	1,160	525
$\epsilon_y$ (in/in)	13	0.00123	0.00130	0.00112
$\epsilon_{st}$ (in/in)	13	0.0106	0.0182	0.0060
$\epsilon_{st}/\epsilon_y$	13	8.4	15.7	4.1
% Elongation	77	24.4	30.5	17.2

## A242

Property	No. of Tests	Mean	Maximum	Minimum
$\sigma_{ys}$	15	53.5	55.8	50.4
E (ksi)	14	30,900	32,800	28,900
$E_s$ (ksi)	4	734	990	500
$\epsilon_y$ (in/in)	9	0.00167	0.00187	0.00155
$\epsilon_{st}$ (in/in)	4	0.0166	0.0180	0.0148
$\epsilon_{st}/\epsilon_y$	4	10.3	10.5	10.0
% Elongation	15	26.3	33.5	20.5

## A440

Property	No. of Tests	Average	Maximum	Minimum
$\sigma_{ys}$ (ksi)	2	43.4	44.3	41.4
	40	42.9		
E (ksi)	2	30,450		
$E_{st}$ (ksi)	1	786	797	775
$\epsilon_y$ (in/in)	2	0.00143	0.00145	0.00140
$\epsilon_{st}$ (in/in)	2	0.01040	0.01055	0.01025
$\epsilon_{st}/\epsilon_y$		7.3	-	-
% Elongation	2	27.2	28.1	26.2
	40	28.0	30.6	26.2

## A441

Property	No. of Tests	Average	Maximum	Minimum
$\sigma_{ys}$ (ksi)	15	54.8	66.5	49.3
E (ksi)	14	29,400	31,700	26,000
$E_{st}$ (ksi)	15	442	683	297
$\epsilon_y$ (in/in)	15	0.00188	0.00220	0.00170
$\epsilon_{st}$ (in/in)	14	0.02060	0.02800	0.01538
$\epsilon_{st}/\epsilon_y$	14	11.1	15.4	7.0
% Elongation	11	21.5	25.8	15.6