WELDMENT TESTING OF HIGH STRENGTH DEFORMED REBARS

H.M. Hendawy
Tanta University, Tanta, Egypt.

M.T. Ayoub
Alexandria University, Alexandria, Egypt.

SUMMARY

Due to the rapid extensions made For producing high Strength rebars, an experimental program is carried out in Alexandria University with cooperation of the ANSDK. The steel company sponsor the experimental program to explore the possibility of sound welding of high strength rebars, since customers are permanently soliciting knowledge on welding precautions feasibility and strength of such weldments, particularly for high strength concrete having intensive reinforcements.

INTRODUCTION

The Alexandria National Iron & Steel Co. ANSDK is producing various steel rebar grades. The high strength grades are presently prevalent. Therefore the weldability of high strength rebars steel has to be emphasized to produce crack free sound bar jointS (1). Most of the ASTM specifications on structural rebars can be welded with out special precautions. However high strength and carbon steel require special care and procedures before welding. Moreover there is no available standard or specifications to refer soundness of such welds.

An experimental trial has been made in this investigation to check strength in tension, shear and compare them with those evaluated according to weld volume and size stipulated by other specifications like AWS, AISC (2).

WELD ELECTRODE AND FILLER MATERIAL

The electrode used in shielded metal arc welding (SMAW) serves as filler material covered by American welding society AWS A5.1 and A5.5 for high strength rebars of grade 60. The AWS A5.5 specifying low hydrogen electrode designated as 80 xx .Melting electrode material matching the parent rebars should have strength properties very close to that of the welded rebars as given in the following table.

Table 1. Properties Of Rebar And Correspondent Electrode.

Strength	Grade 60 Rebar	Electrode E80 XX
Yield	42.2 kg/m^2	46.9 kg/mm^2
Ultimate	63.2 kg/mm^2	50.5 kg/mm^2

Weld procedures of rebars are based on the steel's chemistry rather than its alloy content. The following table shows the preferred limits for carbon steel rebars. (3).

Most mild steel rebars fall well within these limits

Table 2. Electrodes Commonly Used For Welding High Strength Rebars.

AWS-ASTM electrode class	Coating	Current, Polarity	Welding Position
E 60 XX	Low-hydrogen, pot.	dcrp, ac	F,V,O
E 80 XX	Low-hydrogen, iron	dcrp, ac	H,H
E 6020	High iron oxide	dcrp, dcsp, ac	F,H
E 77024	Iron powder, titania	dcrp, dcsp,ac	F,H
E 6027	Iron powder, iron	dcrp, dcsp, ac	F,H
			F,H

dcrp, ac direct current reversed polarity , A.C. current
dcsp, ac direct current straight polarity , A.C. current
F,V,H flat, vertical, horizontal

Table 3. Preferred Chemical Limits Of High Carbon Steel.

ANSDK Rebars	Limits of ASTM
C x100 -	0.35
Mn x100 -	1.4
P x1000 60	40
S x1000 50	50

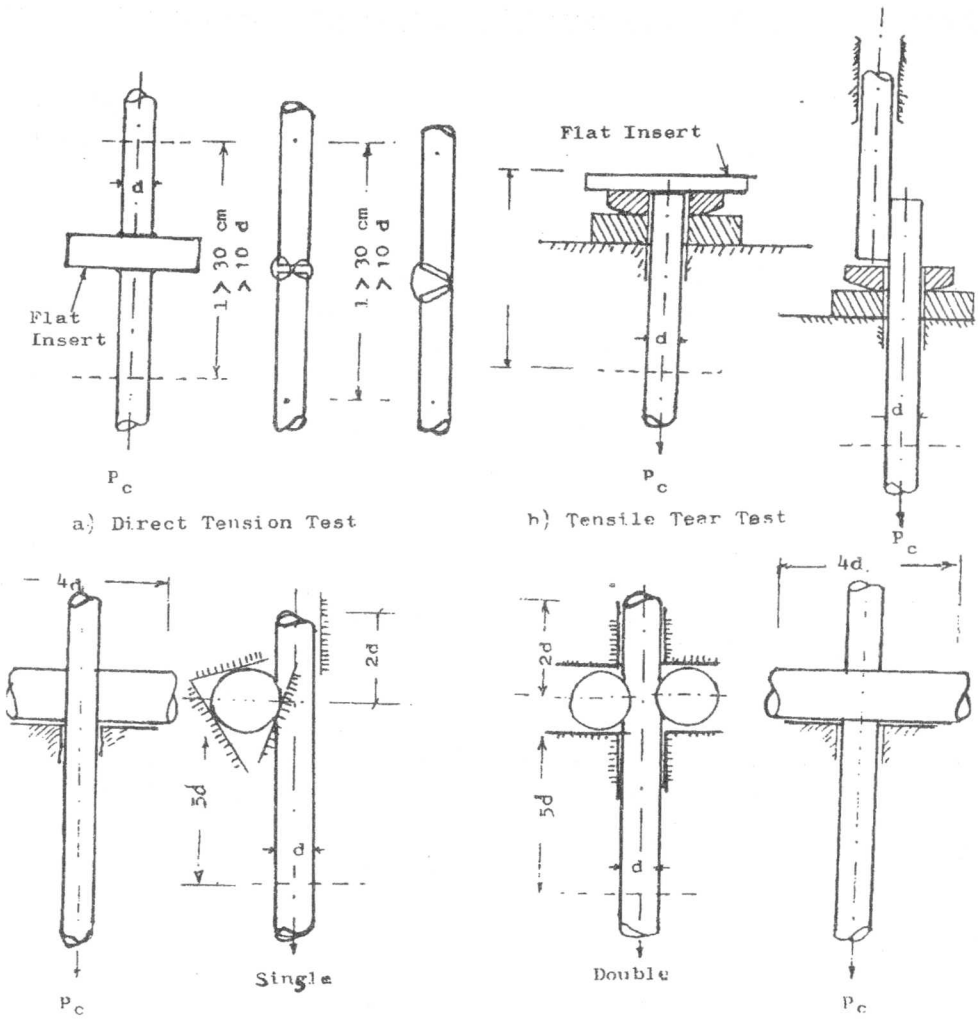

Figure 1. Acceptance tests

TYPE OF JOINTS

The type of joint depends on size shape and number of bars coming into it of reinforcement cage or mesh. Nevertheless, groove joints are the most pleasant and ethical joint currently used for weldments of rebars.

The lap joint which requires fillet weld is not desirable for its inconvenient eccentricity developed during steel bar arrangements.

Unless spacers are required to joint short bar terminals, the groove weld adopted and symboled from AISC and AWS are classified as full penetration or partial.

- Full penetration weld extend to the full bar diameter, types square, V groove or bevel groove.
- Partial penetration weld do not extend to the full diameter of the bar having the same types of edge preparations .

TESTING OF WELDED JOINTS

Acceptance tests of welded reinforcement cages and meshes are carried out in single units at random during intermediate commissioning from the manufacturer, see Figure (1) for types of acceptance tests.

Strength tests of welded joints made under the same conditions of products and materials are as follow:

1- Tensile test, standard specimens should have a length not less than 30 cm or not less than 10 times the diameter having the groove joint in the middle of the specimen .

2- Shear test, double or single cruciform joints. The control test load is determined according to specimen tensile strength $P_c \geq \sigma_t A_{bar}$ in any case.

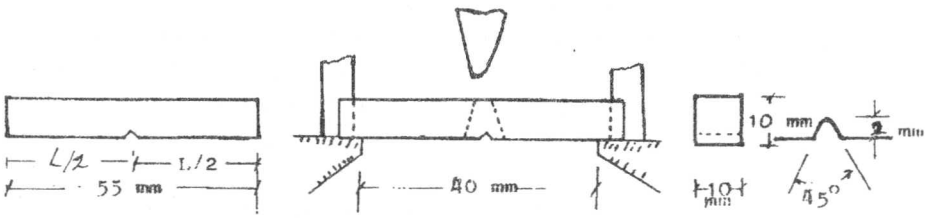

Figure 2. Standard testing charpy V notch impact layout.

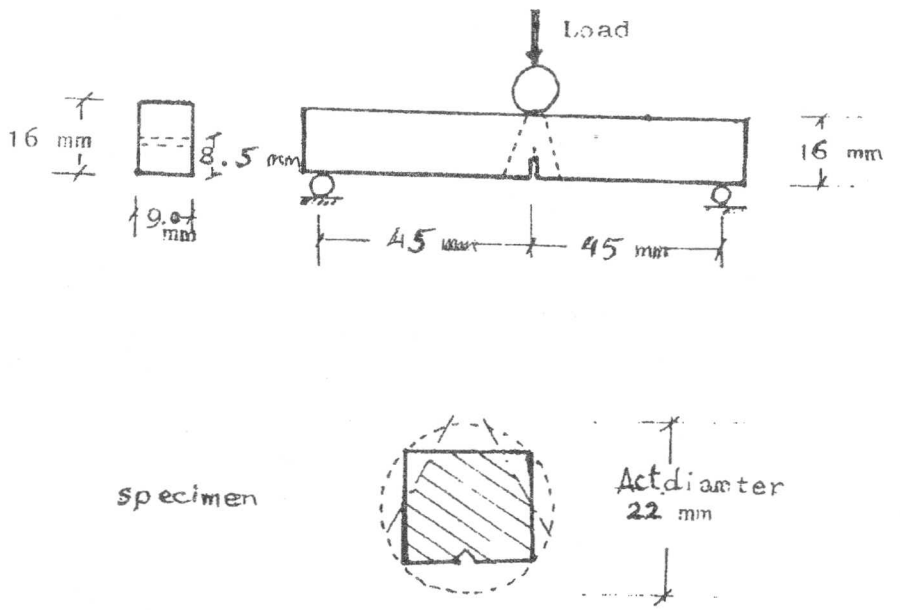

Figure 3. Method of preparing fracture toughness bend specimens.

3- Cold bend test may be carried out on tore steel bars up to 32mm through an angle of 90^0 on mandrel with a diameter, three times the bar diameter for deformed steel bars .

Table 4. Results Of Tensile Tearing Test Load Per Unite length (t/cm)Compared With Alternative AISC According To Weld Length.

Rebar Size mm	Transverse	Longitudinal	AISC
10	2.5	2.1	1.32
13	2.6	2.4	1.51
16	2.6	2.5	1.88
19	2.5	2.7	2.26
22	2.7	2.9	2.84

Table 5. Results Of Testing Deformed Rebar Weldments Compared With Alternative AISC According To Weld Volume.

Rebar Size mm	Direct Tensile Strength Kg/mm^2			
	Tested Bars G 60	Tested Bars G 40	Estimated	
			Single V AWS	Double V AWS
10	65	62.5	53	74
13	72	68	64	83.5
16	86	76	72	104
19	105	84	79	117
22	128	95	88	130

FRACTURE TOUGHNESS TESTING

The general method of testing for both impact energy

or stress intensity according to ASTM E23 (standard method for notched bars) (4) are conducted . Accordingly the stress intensity fracture test specimens are also prepared according to ASTM test method 399-74. Welded rebars are taken and formed in a rectangular shape by machining the four faces straightly in accurate specified dimensions. As shown in Figures. (2) and (3).

The experimental testing program has assigned five type of reinforcement steel bars and results are tabulated hereafter .

Table 6. Rebar weldments and toughness measurements, properties

Steel Type	Type of weld	σ0.2% off set kg/ m m^2	VNC charpy N.m mpa m	kic stress intensity m	ΔL % after Welding
G 60 ASTM A 706	Dounle V comp. penet.	50	122	220	7
G400 ASTM A 615	single V comp.penet.	57	135	195	12
HY 80 ASTM A 82	Butt incomp.penet.	64	122	190	8
HY 90 ASTM A 496	Double V incomp.penet.	68	108	170	9
HY 100	Butt incomp.penet.	71	55	154	11

DISCUSSION AND CONCLUSION

Most of the ASTM specification of rebar steels can be welded without special precautions because most mild steel rebars fall well within acceptable range of steel's chemistry table (3) high strength rebar may exceed these limits and therefore needs particular precautions .

Since welds must transmit the entire load from one member to another, weld size and electrode material to match parent metal, are selected.

Results of laboratory testing of welded high strength rebar connections require certain limits comparable with those obtained experimentally in Table (4) while allowable shear stresses on the effective area of all lap jointed connection results are prescribed in Table (5).

Experimental verifications of tensile strength of various weld shape indicate compatible results with those connection conducted with identical steel of AWS specifications (5).

Tearing strength of lap joints are measured by shearing load per unite length of lap.

However impact strength is emphasized for high strength weldments according to the steel fracture toughness. Rebar weldments do not maintain constant level of resistance to fracture according to heating process during welds. The loss of fracture toughness results from loss of ductility near the weld tips. Weld ductility is measured from charpy impact described in ASTM specification on A 370-68. Table (6).

Moreover sensitivity to notch action is measured by obtaining the plane strain fracture toughness of welded rebars according to ASTM test method E 399- 74. Crack length proves its dependance on parent metal ductility rather than strength

REFERENCES

[1] Steel reinforcement properties and availability, *reprint of ACI committee 439*, J. ACI, Vol. 74, 1977.

[2] Commentary on structural welding code, AWSD. 2-77 florida, *American welding society*, 1977.

[3] *Steel structures, Design and Behaviour*, Salmon, Johnson Harber international, 1980.

[4] M. Ayoub, "Charpy imact and fracture toughness of low alloy steel", *Modelling simulation control AMSE Press*, Volume 5 No 3, 1985.

[5] *Fracture and fatigue control in structures*. Rolf/Barsom, Prentice - hall inc. 1977.