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TITLE

Fracture Properties of 350 WT Steel at Very High Loading Rates

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Fracture Properties of 350 WT Steel at Very High Loading Rates

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ABSTRACT

Fracture studies were conducted on 12.7 mm thick compact tension specimens of 350 WT steel at very high loading rates. The equipment used in the studies consisted of a specially designed Split Hopkinson Bar system capable of delivering sufficient energy to fracture the specimens on impact. Projectile speeds in the Split Hopkinson Bar were in excess of 50m/s.

Following fracture, the extent of the shear lip as well as the stretch zone width which occurs before crack extension, were measured in all the specimens tested. Test temperatures ranged from -45 to 15C. It was found that above 0C, fracture is ductile with a shear lip extending across the fracture surface for the specimens with no fatigue precrack. For those with a fatigue precrack, the shear lips are smaller.

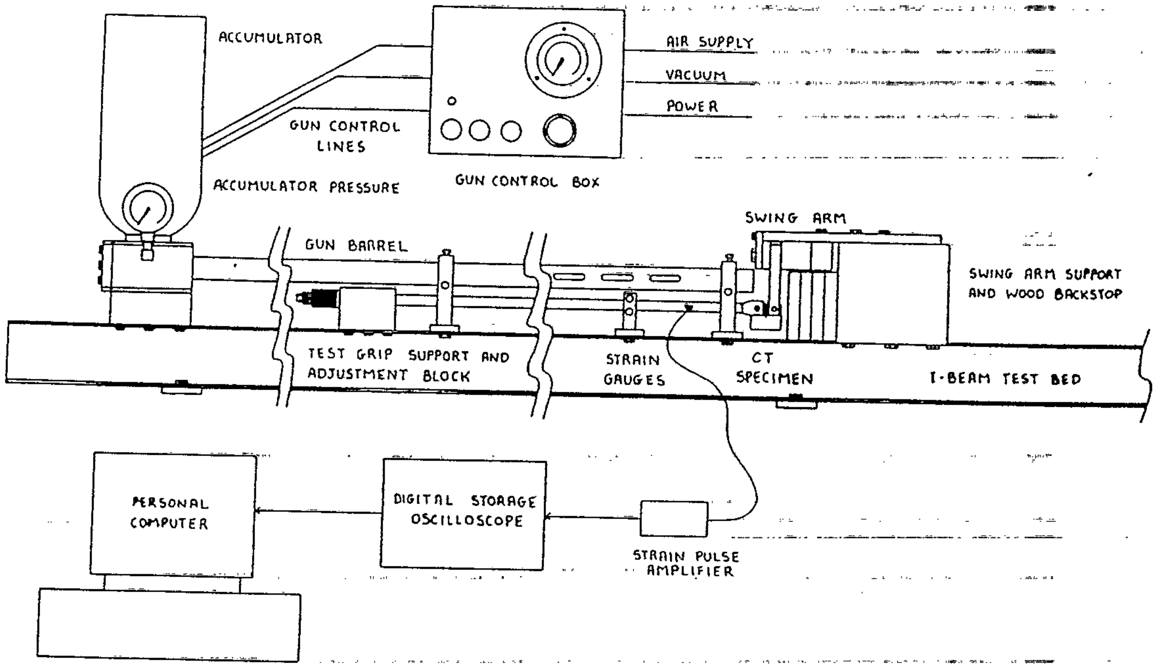
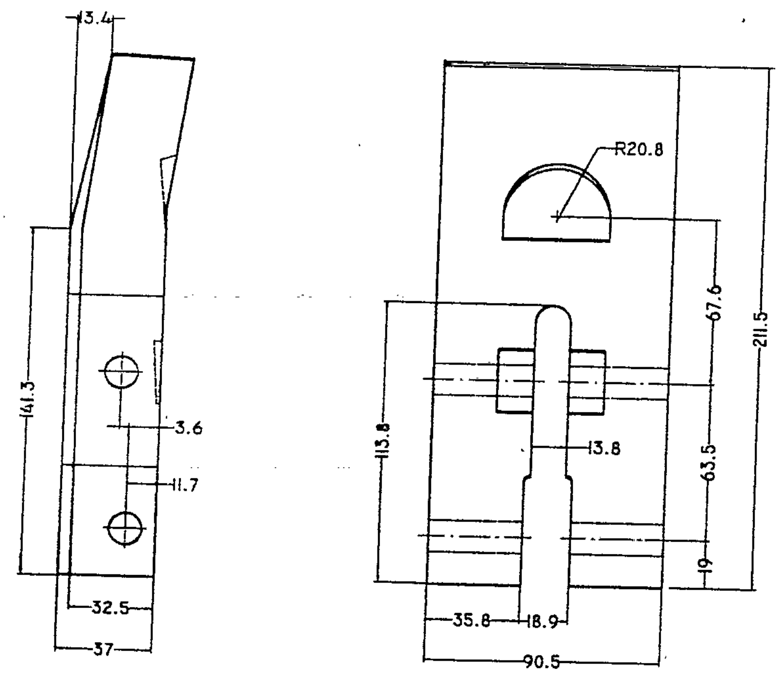
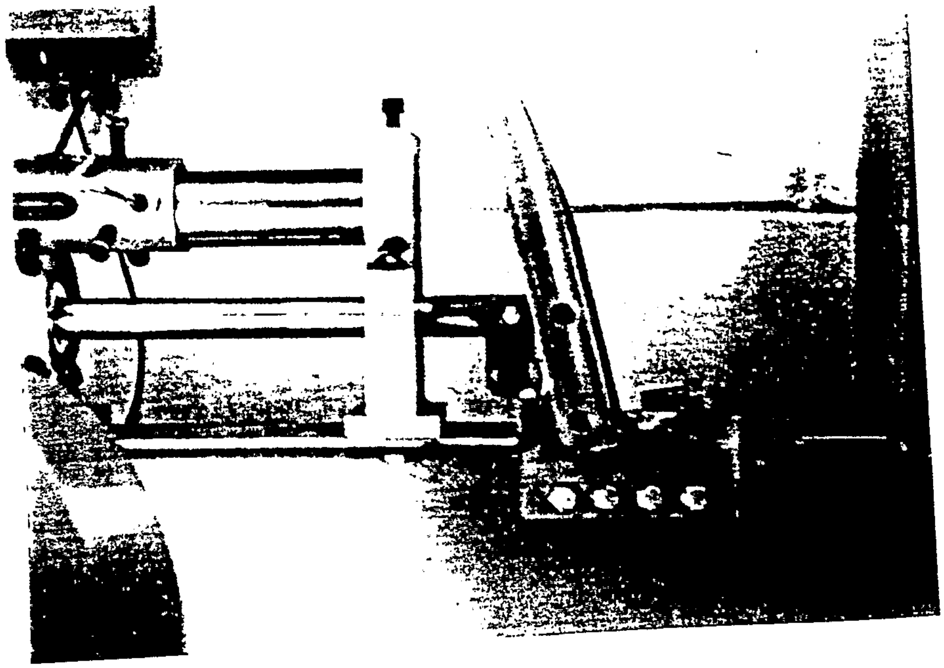


Figure 1a: Split Hopkinson Bar Assembly For CT Specimen Testing.

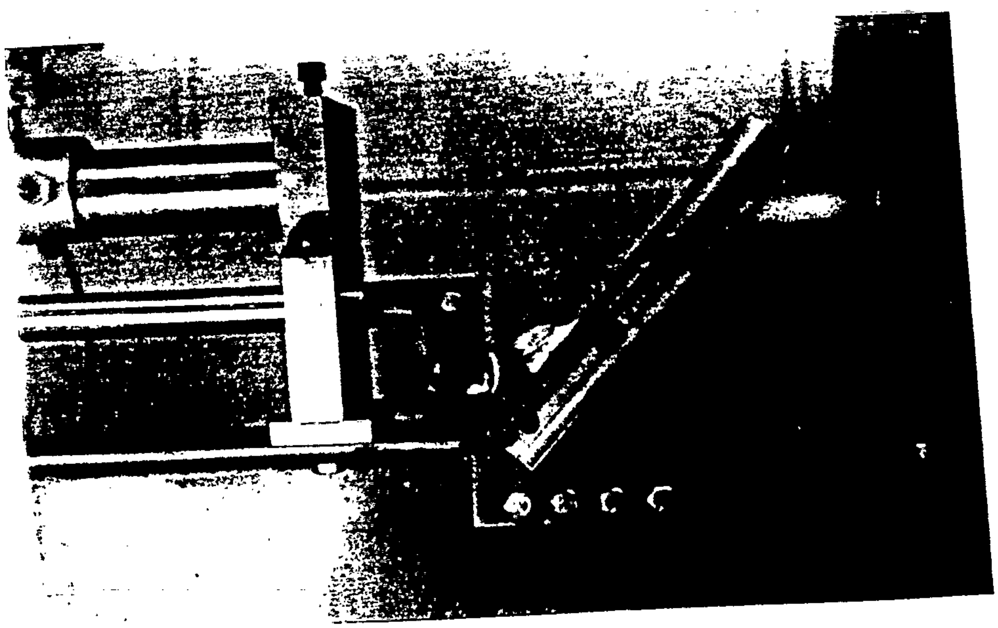


All dimensions are in mm

Figure 1b: Swing Arm Assembly Mechanism.

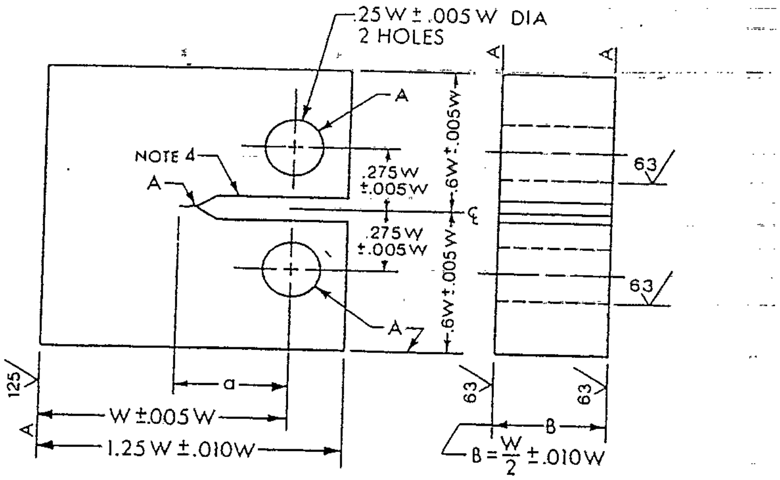


(a)



(b)

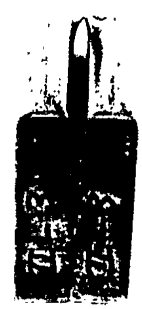
Figure 1c: Swing Arm Mechanism (a) at the beginning of specimen fracture and (b) at the end of specimen fracture.



W = 50 mm
B = 12.7 mm
a/W = 0.5

Figure 2a: Compact Tension Specimen Dimensions.

(a)



(b)

Figure 2b: (a) Broken Specimen and (b) Fracture Surface

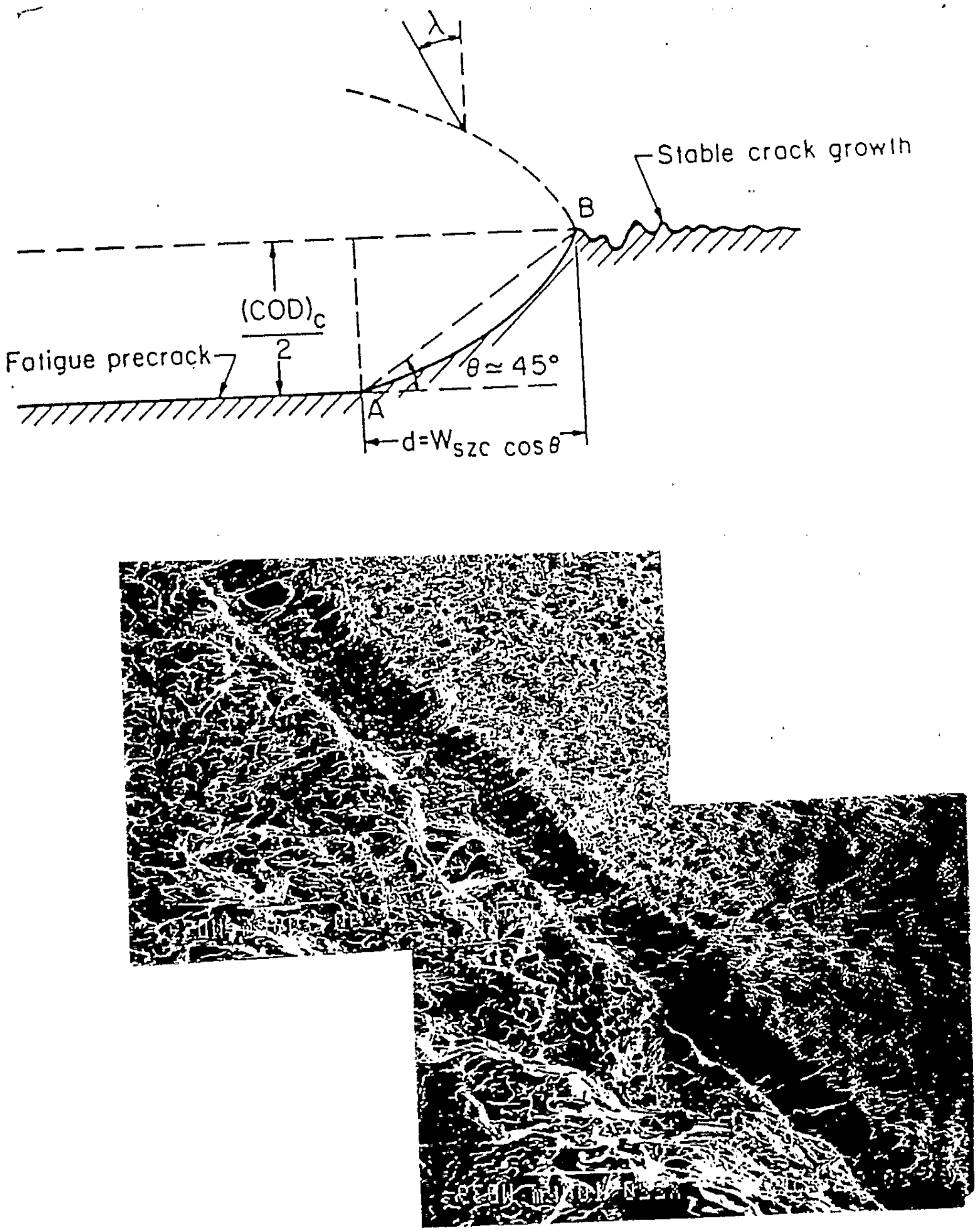


Figure 3: Concept of the Stretch Zone Analysis.

Table 1: Stretch Zone Width (SZW) measurements of fatigue precracked specimens from 1998 contract.

ID	Temperature Deg. C	Orientation	Notch	SZW	SZW Value Microns	Shear Lip Mm
II-1	15	L-T	Pressed			6.1
II-2	15	T-L	Pressed			6.0
II-3	0	L-T	Pressed			6.1
II-4	0	T-L	Pressed			6.0
II-5	15	L-T	Fatigue Precracked			6.0
II-6	0	L-T	Fatigue Precracked			6.0
II-7	15	L-T	Fatigue Precracked	Yes	1080[1]	5.5
II-8	15	T-L	Fatigue Precracked	Yes	990[1]	6.0
II-9	0	L-T	Fatigue Precracked	Yes	863[1]	3.0
II-10	0	T-L	Fatigue Precracked	Yes	975[1]	3.8

Table 2: Summary of testing results of 350WT steel (1999)

Temperature Deg. C	Orientation	Notch	SZW	SZW Value Microns	Shear Lip Mm
-45	T-L	Fatigue Precracked	Yes	147	1.5
-45	L-T	Fatigue Precracked	Yes	210	2.0
-45	T-L	Pressed			2.0
-45	T-L	Pressed			2.0
-30	T-L	Fatigue Precracked	Yes	343	2.5
-30	L-T	Fatigue Precracked	Yes	450	2.0
-30	T-L	Pressed			2.0
-30	T-L	Pressed			6.0
-15	T-L	Fatigue Precracked	Yes	812	6.0
-15	L-T	Fatigue Precracked	Yes	1177	6.0
-15	T-L	Pressed			5.5
-15	T-L	Pressed			3.5

Table 3: Shear Lip and Stretch Zone Width (SZW) measurements of fatigue precracked and pressed specimens from 1997 contract (slowed tests).

ID	Temperature Deg. C	Orientation	Notch	SZW	SZW Value Microns	Shear Lip Mm
APA	-45	T-L	Pressed			0.39
APB	-30	T-L	Pressed			0.64
APE	15	T-L	Pressed			2.58
ATE	15	L-T	Pressed			2.8
BPA	-45	T-L	Fatigue Precracked	Yes	56	0.39
BPB	-30	T-L	Fatigue Precracked	Yes	83	0.79
BPC	-15	T-L	Fatigue Precracked	Yes	97	1.31
BPD	15	T-L	Fatigue Precracked	Yes	175	2.21
BPE	0	T-L	Fatigue Precracked	Yes	600	3.08
BTA	-45	L-T	Fatigue Precracked	Yes	46	.24
BTB	-30	L-T	Fatigue Precracked	Yes	55	.3
BTC	-15	L-T	Fatigue Precracked	Yes	69	1.11
BTD	0	L-T	Fatigue Precracked	Yes	140	1.96
BTE	15	L-T	Fatigue Precracked	Yes	500	2.80

Note: all specimens a/W of 0.55

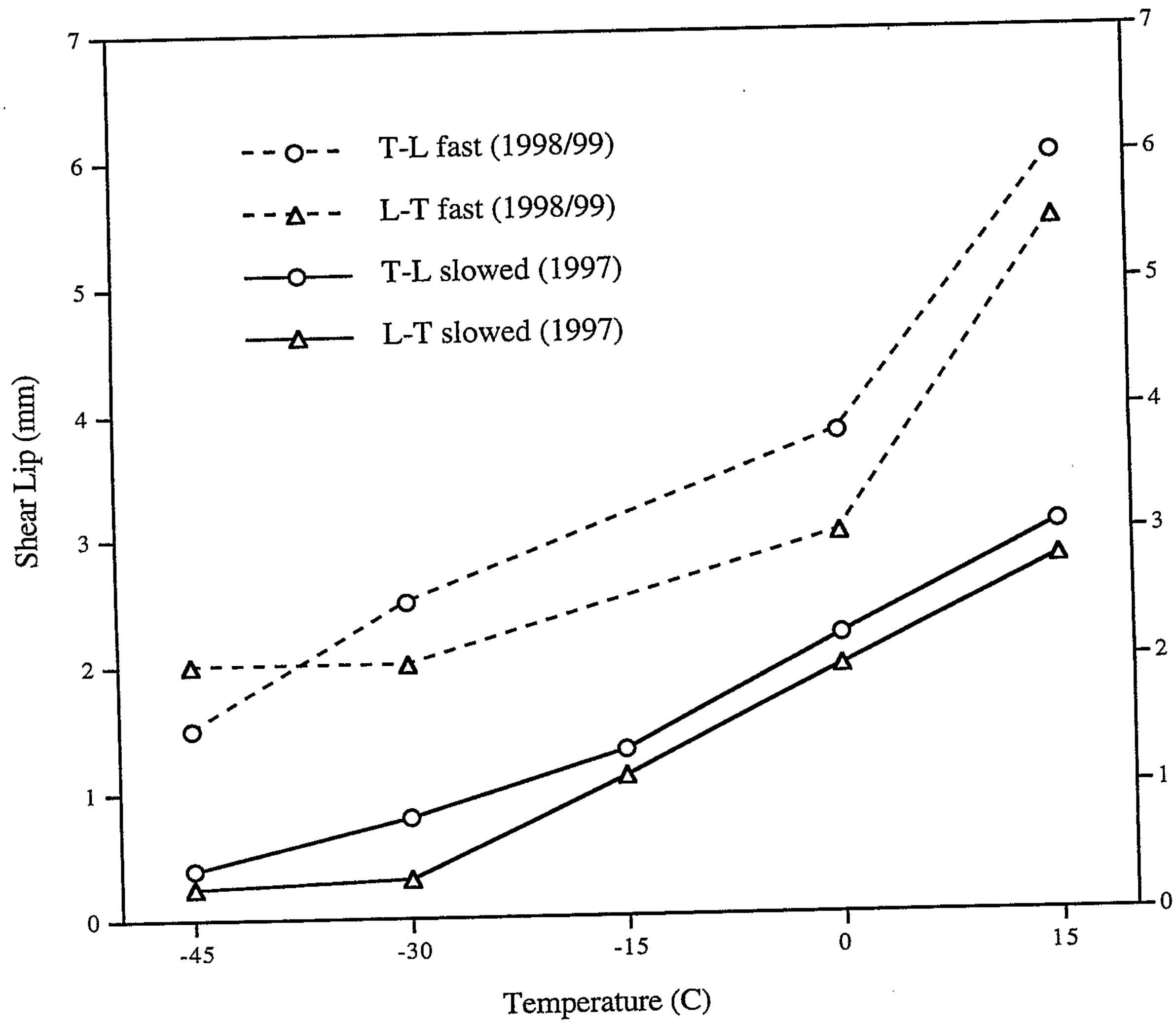


Figure 4: Comparison of the results for the unmodified Splt Hopkinson Bar (1997) which slowed considerably during the test and actually stopped at 0 and 15°C and results with the modified Split Hopkinson Bar (1998 and 1999). Graph shows variation of Shear Lip with Temperature for Fatigue Pre-Cracked Specimens.

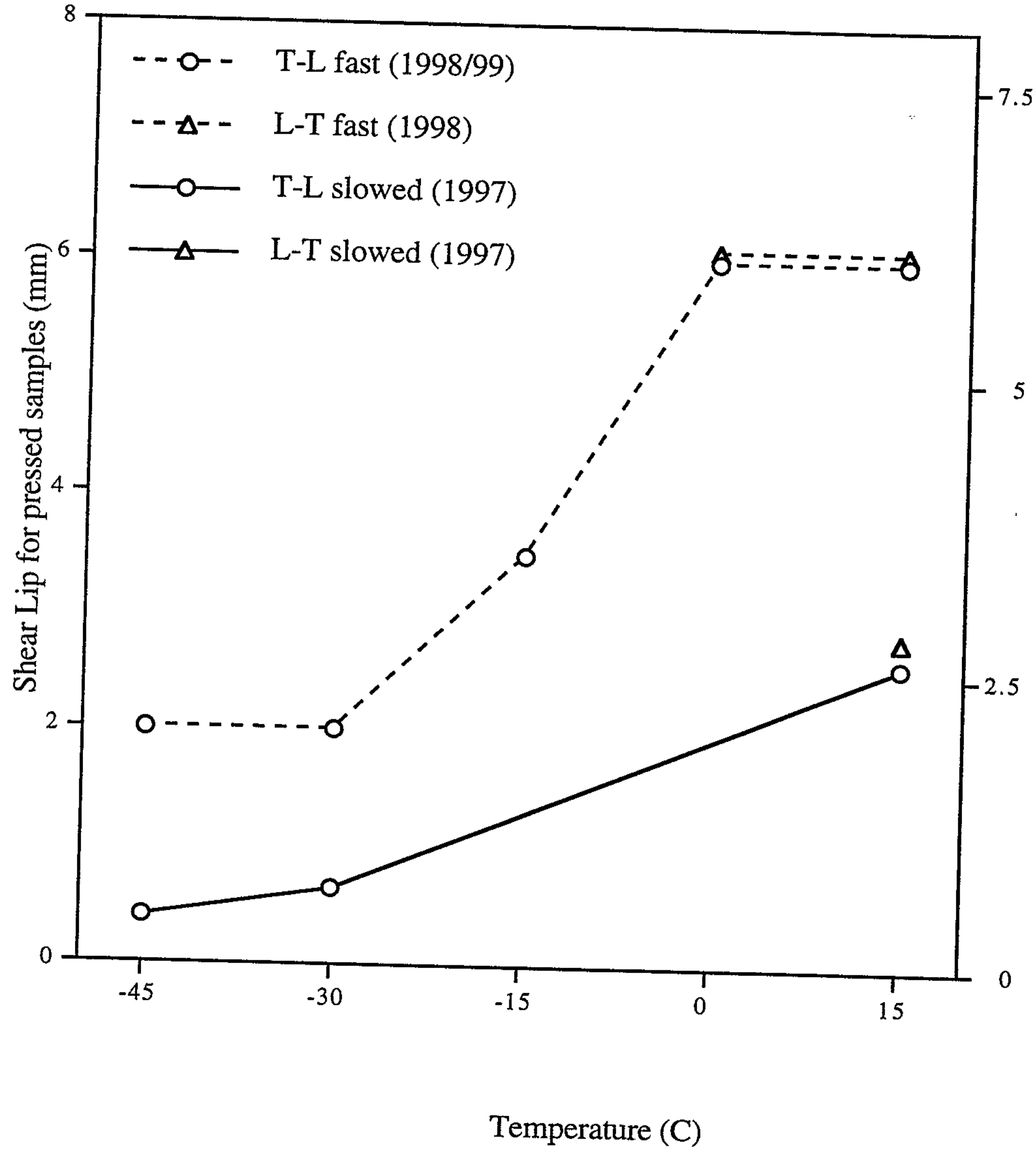


Figure 5: Graph shows variation of Shear Lip with Temperature for Pressed Notched Specimens.

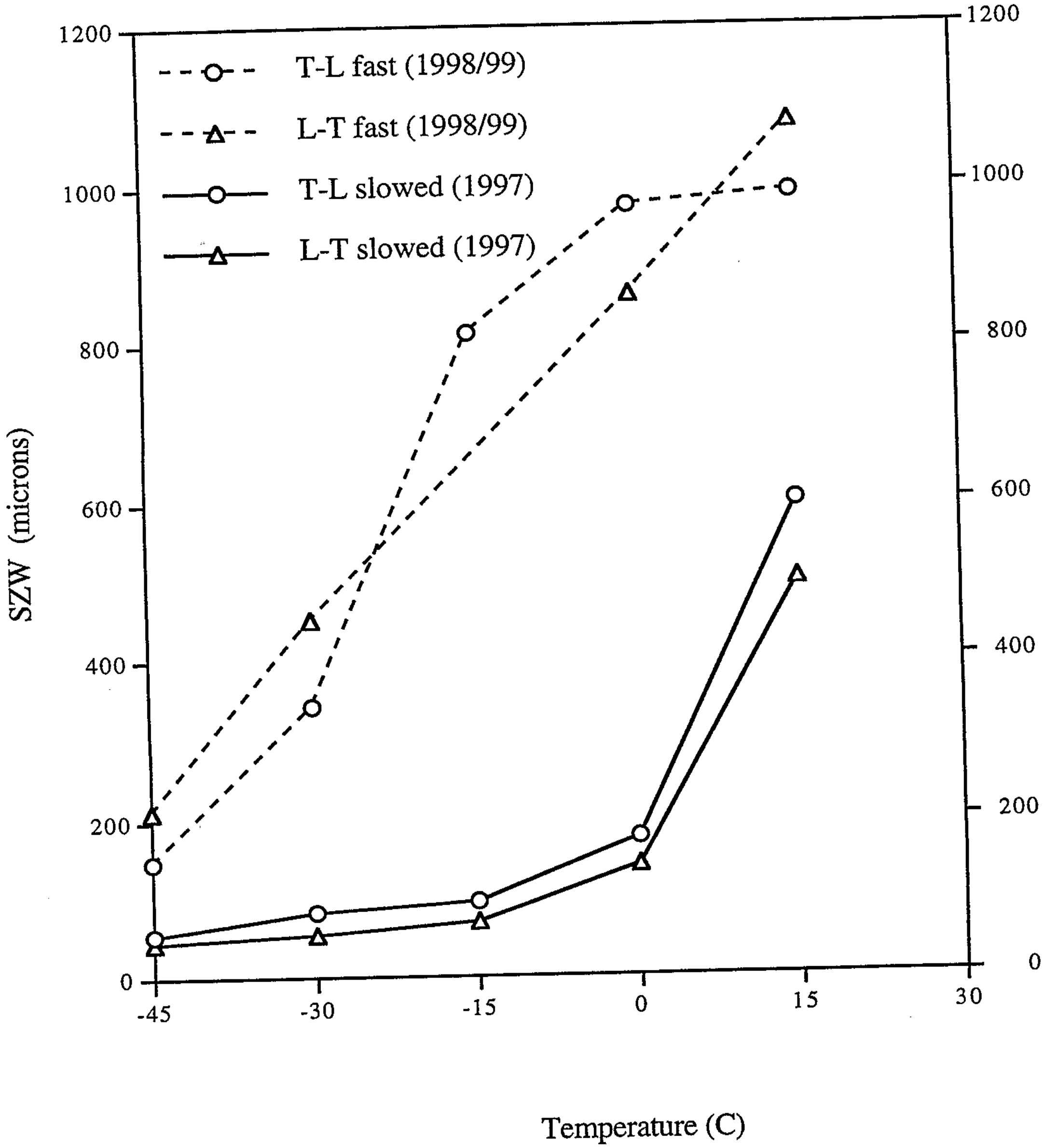


Figure 6: Graph shows variation of SZW with Temperature for fast and slowed.

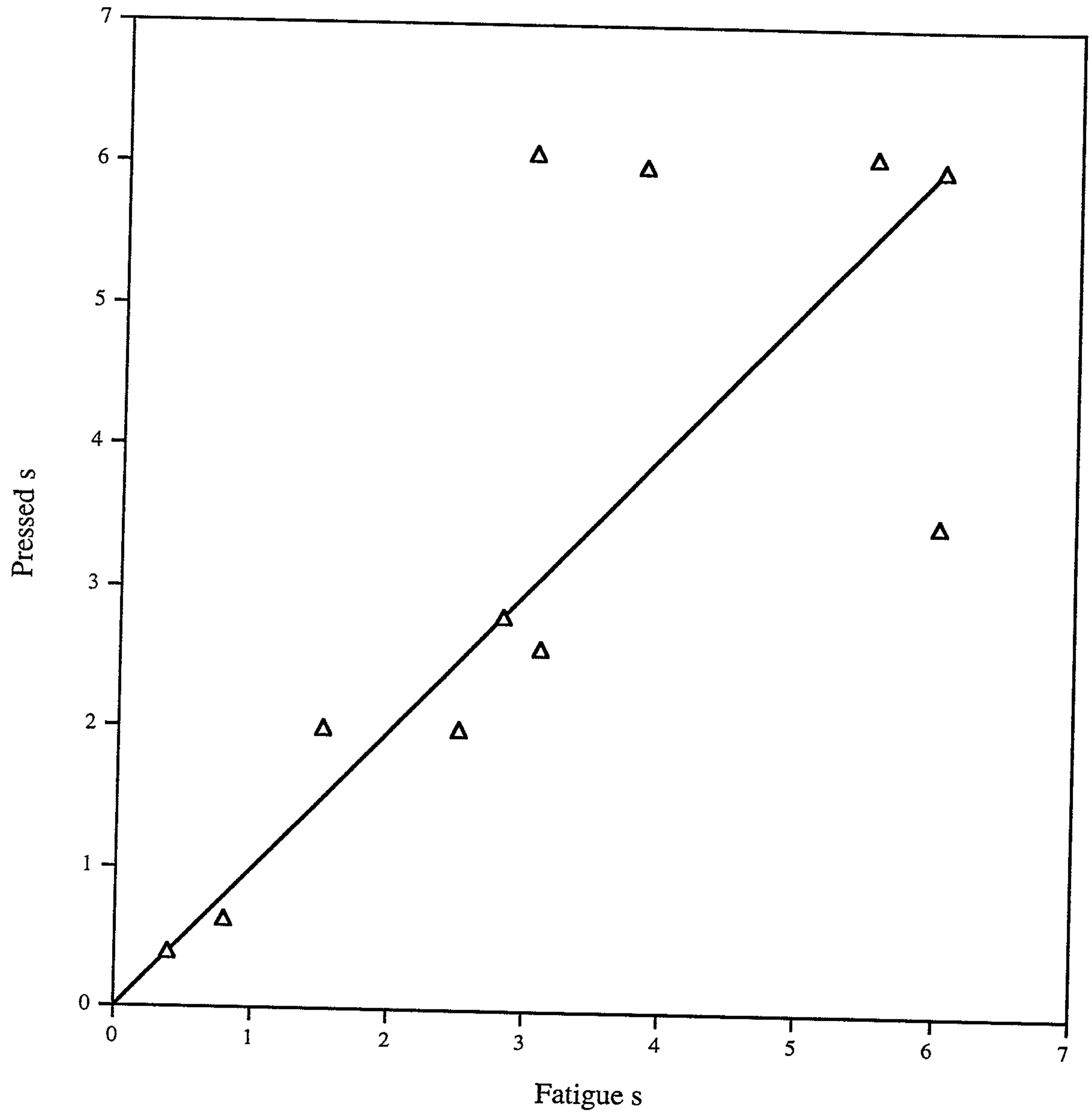


Figure 7: Graph shows relationship between Shear Lip for Pressed Notched Specimens and Fatigue Pre-Cracked Specimens.

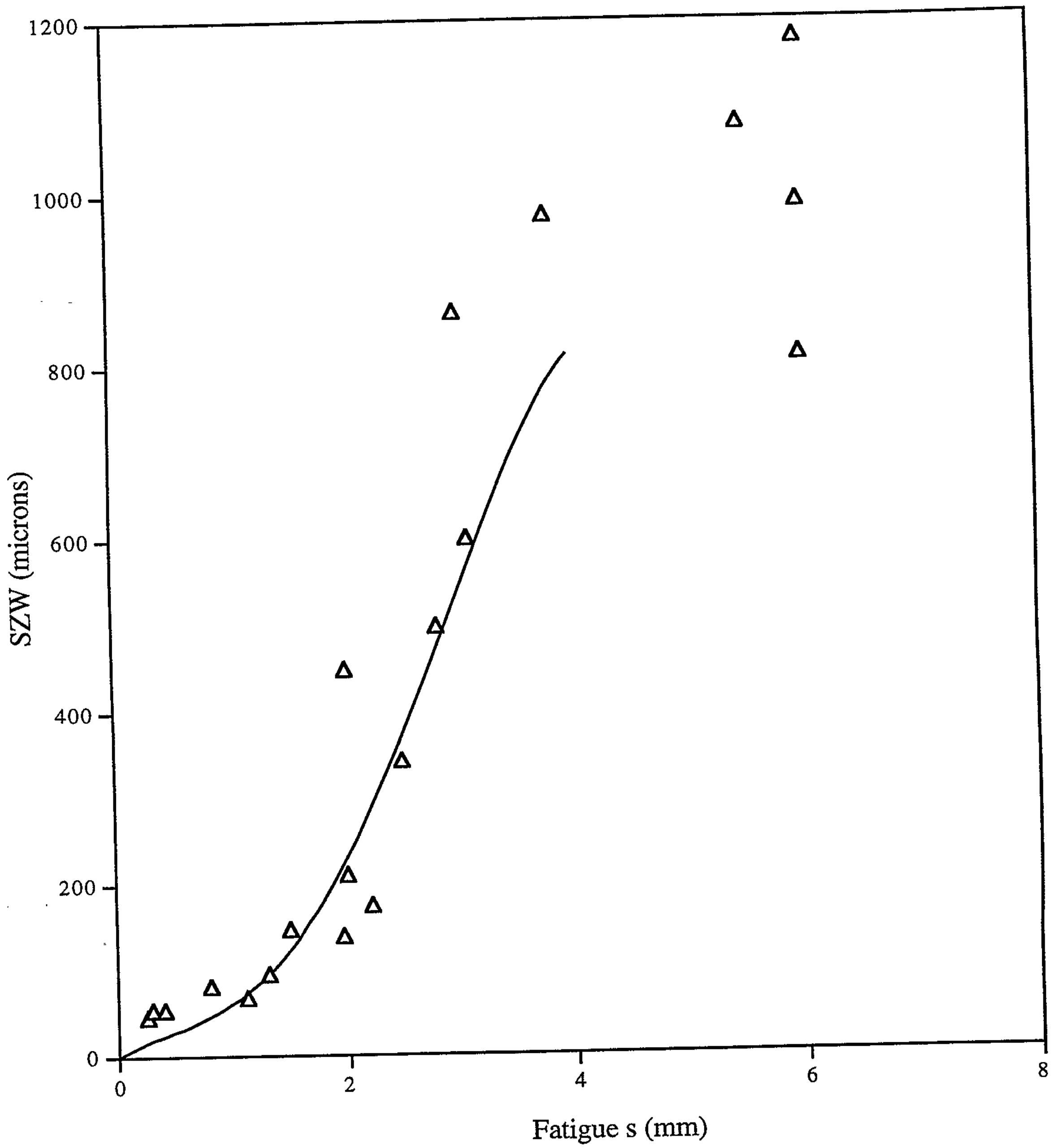


Figure 8: SZW vs shear lip on fatigue pre-cracked specimens.