Fatigue Behavior
For AISI 16MnCr5 Modified Steel
Simulated Core 1900F
Four Point Bending Test
Iteration 197

Wanhua Liang, T. H. Topper and F. A. Conle

Department of Civil and Environmental Engineering
University of Waterloo
Waterloo, Ontario, Canada, N2L 3G1

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Summary

The required strain-life fatigue data for AISI Iteration 197 have been obtained using bending tests. The American Iron and Steel Institute (AISI) provided the material in the form of metal bars. These bars were machined into bending fatigue specimens, polished and then tested. The Rockwell C hardness (RC) was determined as the average of nine measurements. Constant-amplitude tests under bending were conducted in the laboratory at room temperature to establish the strain-life curve.

Introduction

This report presents the results of fatigue tests performed on a group of 16MnCr5 modified simulated core specimens heat treated at 1900F (Iteration 197). The American Iron and Steel Institute provided the material. The objective of this investigation is to obtain a constant amplitude strain-life curve of the material under a four-point bending cyclic test.

Experimental Procedure

Specimen Preparation

Bending fatigue specimens, shown in 1 and 2, were machined from the metal bars and polished with a small 500 grit wheel that was spinning in the same direction as the beam length. The samples were then carburized and quenched in oil by the AISI group and returned for fatigue testing. Before testing, the specimens had a final polish in the loading direction in the gauge sections using 600 emery paper.

Test Equipment and Procedure

Hardness tests were performed on the surface of three fatigue specimens using a Rockwell C scale. The hardness measurements were repeated three times for each specimen and the average value was recorded in Table 2. All fatigue tests were carried out in a laboratory environment at approximately 25°C using an MTS servo-controlled closed loop electro hydraulic testing machine. A bending rig was installed in the hydraulic testing machine as shown in Figure 3. An extensometer was installed on the bending specimen to measure the strain as shown in Figure 3. Epoxy was applied to attach the extensometer onto the specimen to prevent slipping.

A process control computer, controlled by FLEX software [1] was used to output constant stroke amplitudes for Iteration 197.

After failure was indicated by the 50% load drop specified by ASTM, the specimens were often only partially cracked. In order to observe the fracture surface, these specimens were placed at one end in a vice and then struck with a hammer on the other end after failure.

In order to conform with the AISI database structure Tables 1 also report a "bending stress" that assumes no plasticity in the beam. The stress is the bending moment, M, multiplied by the half height, c, of the beam section and divided by the moment of Inertia I as per Stress = M*c/I. Similarly the "Modulus" reported in the tables is simply the calculated Stress Amplitude divided by the Strain Amplitude.

Results

Chemical Composition

The chemical composition information is currently unavailable.

Constant Amplitude Fatigue Data

Constant strain amplitude, fully reversed (R=-1) stroke-controlled fatigue tests were performed on bending specimens. The tests were run under stroke control and the corresponding strain measurements were recorded. The load-strain limits for each specimen were recorded at logarithmic intervals throughout the test via a peak reading oscilloscope. Failure of a specimen was defined as a 50 percent drop in the tensile peak load from the peak load observed at one half the expected specimen life. The loading frequency varied from 0.5 Hz to 15 Hz. Constant amplitude fatigue test data obtained in this investigation are given in Table 1. A constant strain- amplitude fatigue life curve for the steel is given in Figure 4.
No "Fisheye" or subsurface crack initiation site was observed on the fractured surface. Some typical fracture surfaces were photographed and shown in figure 5 and 6. Note that the fast fracture darker regions are created by opening the crack.

References

[1] M. Pompetzki, R. Saper, T. Topper, Software for rig frequency control of variable amplitude fatigue tests, Canadian Metallurgical Quarterly 25 (2) (1987) 181-194

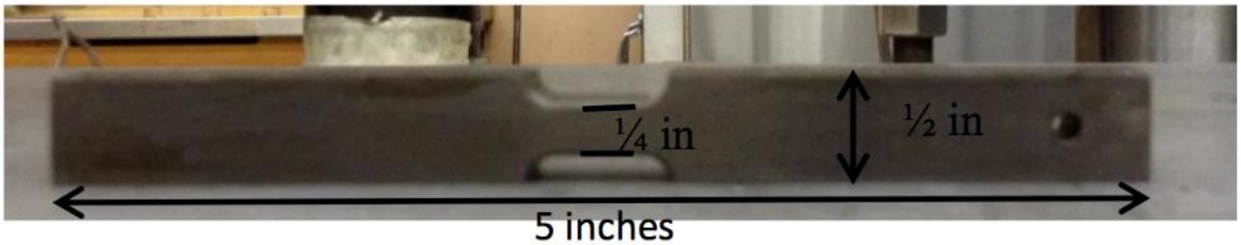

Figure 1: Bending specimen side view

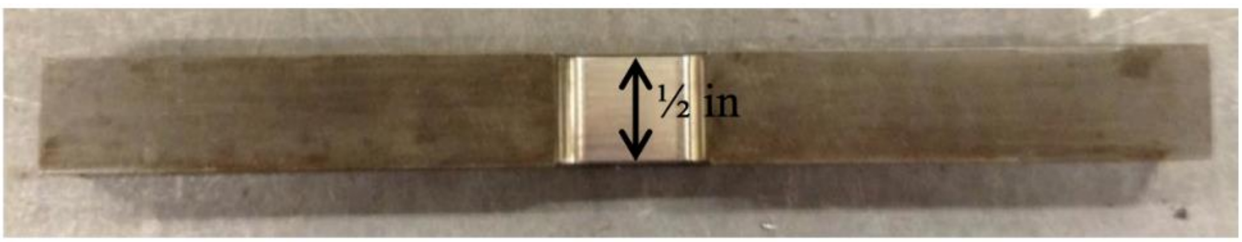

Figure 2: Bending specimen top view

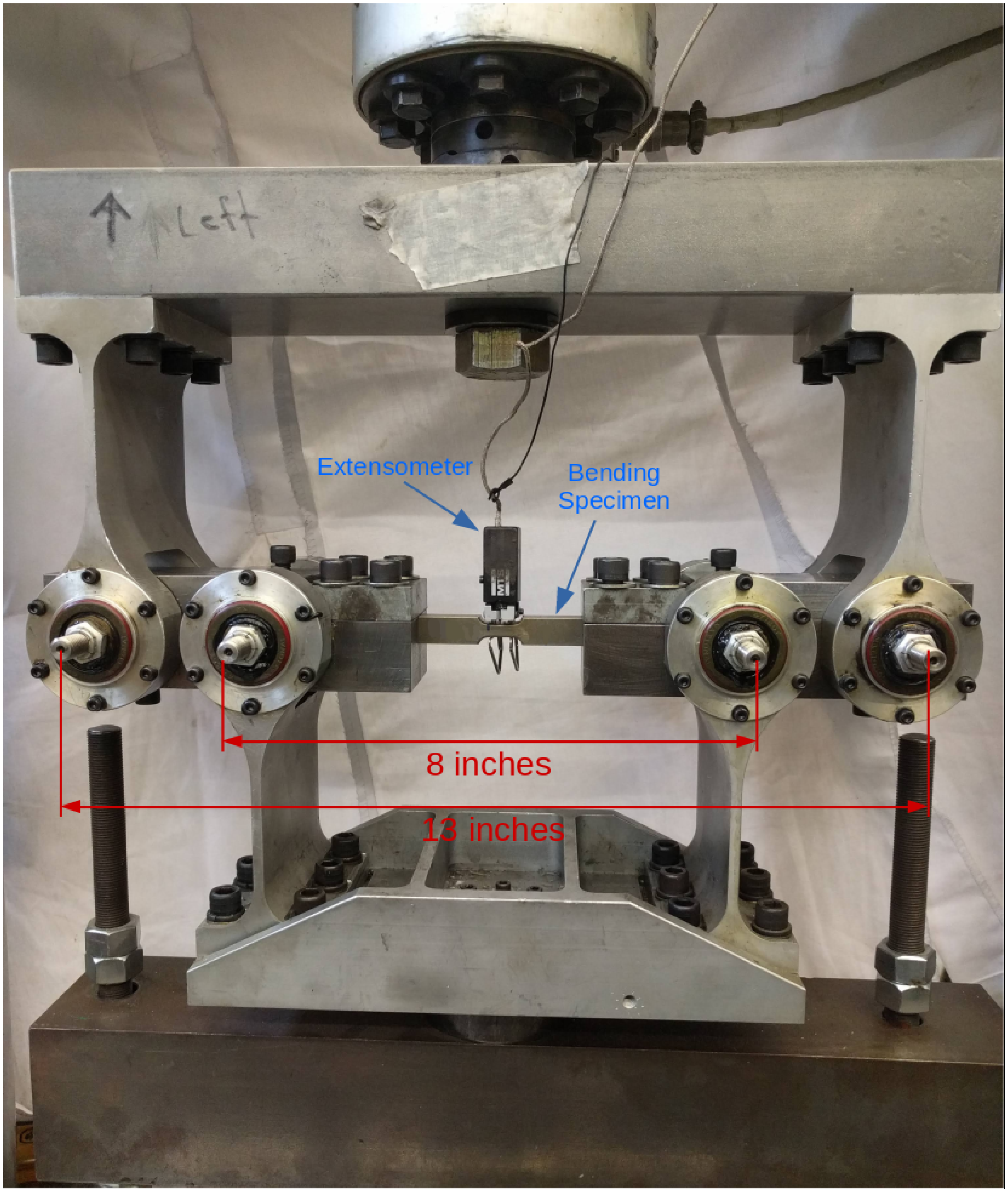

Figure 3: The Bending Rig and the Extensometer on the bending specimen

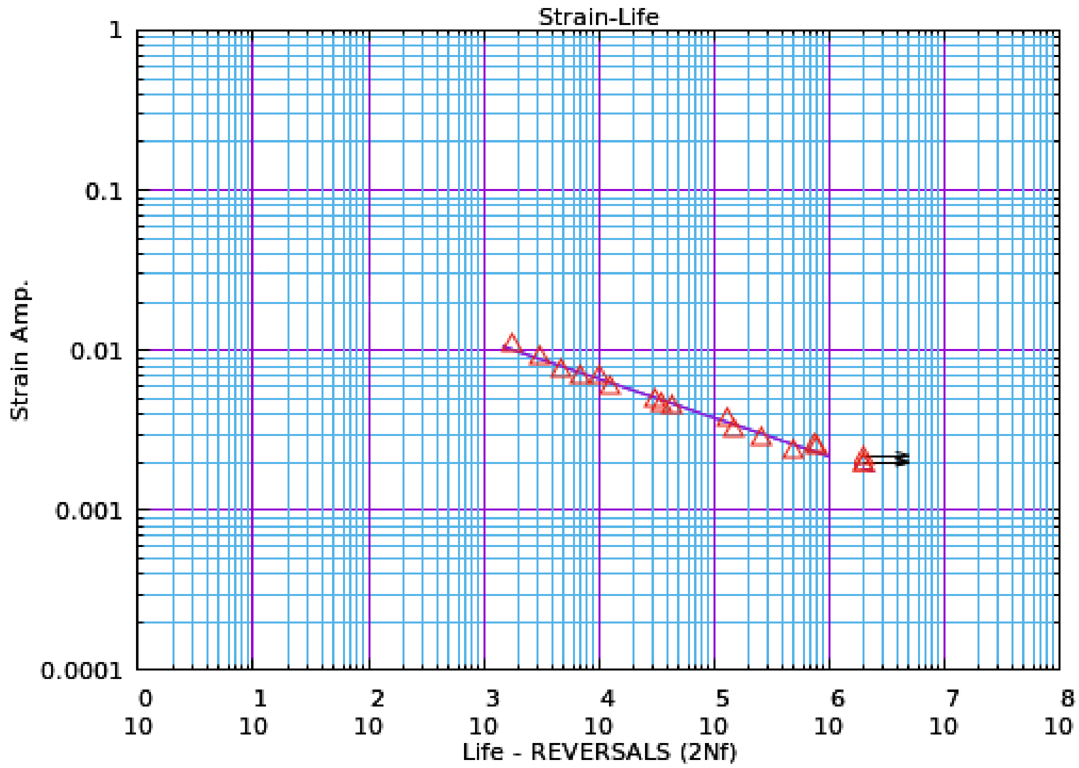

Figure 4: Strain-life fatigue curve for AISI 16MnCr5 modified simulated core 1900F (IT 197)

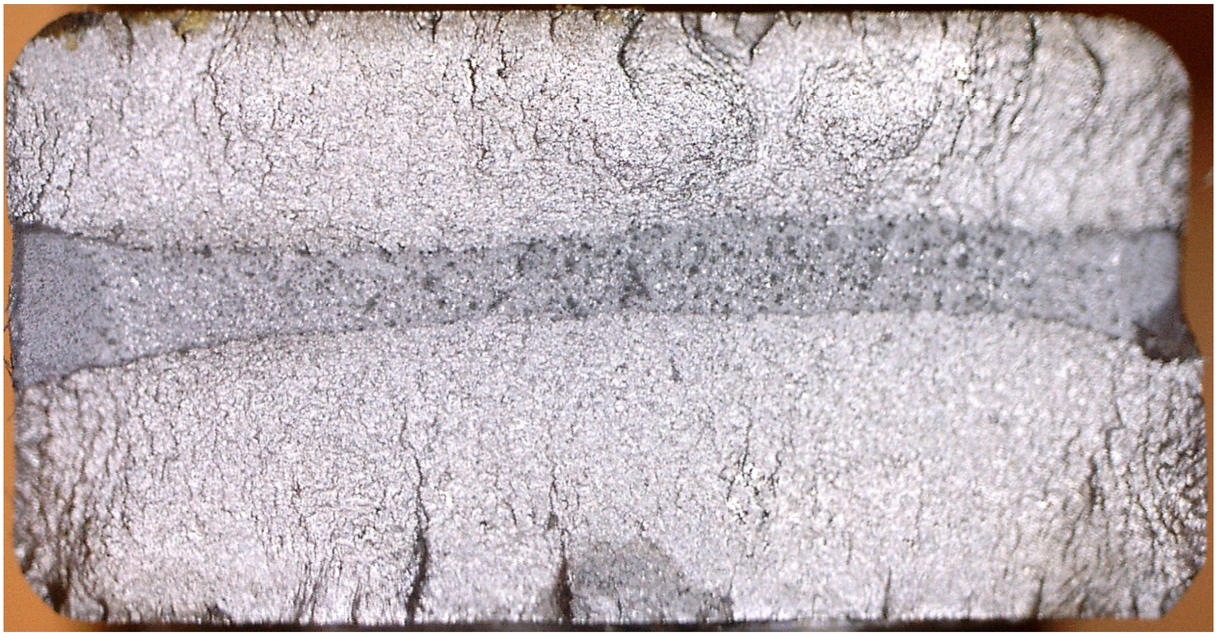

Figure 5: Fracture surface of specimen IT197-29, 2Nf=6,816

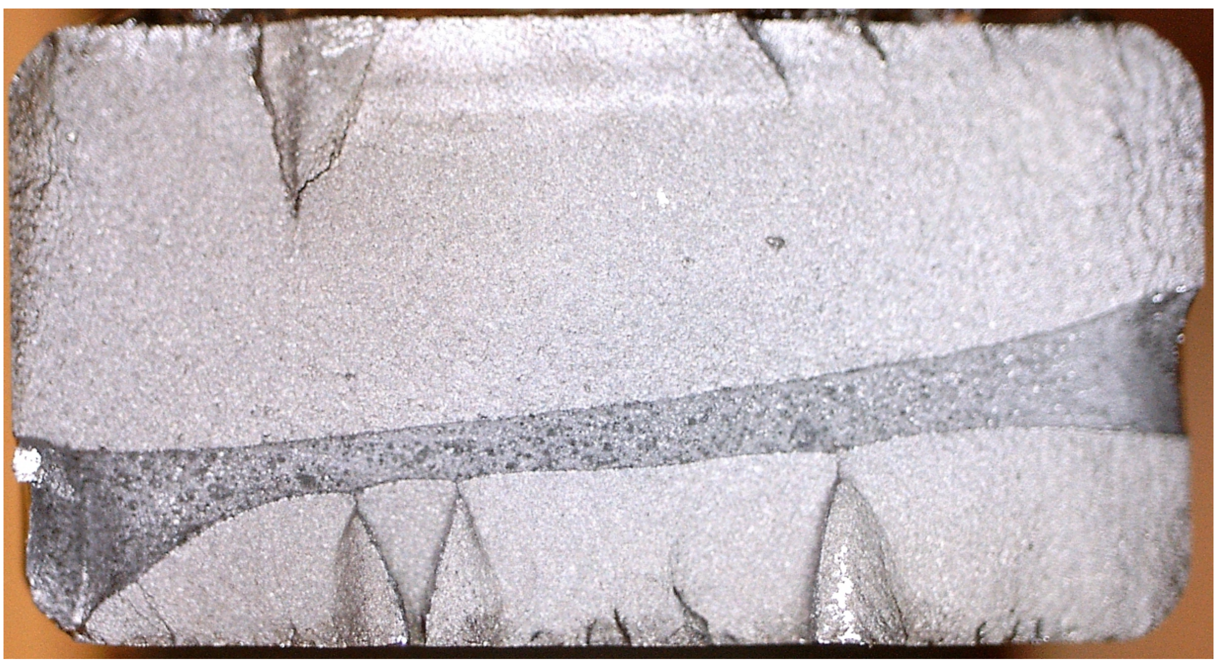

Figure 6: Fracture surface of specimen IT197-16, 2Nf=149,808

Table 1: Constant Strain Amplitude Data for AISI 16MnCr5 modified simulated core 1900F Steel (IT197)

StrAmpl	2Nf	StressAmpl* Mpa	Mean Stress* Mpa	PlsStrAmp	Modulus** Mpa	Comments	Spec ID
0.011067	1744	1427	0.00	0	128965		22
0.009300	3060	1293	0.00	0	139007		20
0.007600	4680	1187	0.00	0	156221		2
0.007067	6816	1196	0.00	0	169182		29
0.007067	10276	1111	0.00	0	157181		26
0.006000	12582	1034	0.00	0	172369		1
0.004967	30618	910	0.00	0	183243		3
0.004633	34512	863	0.00	0	186158		27
0.004500	42750	848	0.00	0	188457		8
0.003767	132512	662	0.00	0	175725		6
0.003267	149808	635	0.00	0	194390		16
0.002867	257280	565	0.00	0	196982		14
0.002600	759120	484	0.00	0	186158		12
0.002500	780720	449	0.00	0	179540		21
0.002367	503190	426	0.00	0	180041		13
0.002200	2000000	439	0.00	0	199321	#runout	5
0.002000	2000000	393	0.00	0	196501	#runout	11
0.002000	2000000	407	0.00	0	203740	#runout	4

* "Stress" implies Stress = M*c /I where M is bending moment, c is half height of beam, and I is moment of inertia

** Modulus = (StressAmpl. / StrainAmpl.)

Table 2: Rockwell C Hardness Test Data for AISI 16MnCr5 modified simulated core 1900F Steel

Specimen ID	Test 1	Test 2	Test 3	Average
16	36	37	36.5	36.50
12	39	37.5	39	38.50
27	37.5	39.5	36	37.67
Overall				37.56