Fatigue Behavior and Monotonic Properties For AISI 4120 Modified Steel Four Point Bending Iteration 207

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

UNIVERSITY OF Waterloo

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

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Contents

List of Figures

List of Tables

Summary

The required strain-life fatigue data for AISI Iteration 207 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 4120 modified Steel specimens (Iteration 207). 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 4. 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 207.
After failure was indicated by the 50% load drop specified by ASTM, the specimens were often only partially cracked. 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 20 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 5.
In order to observe the fracture surfaces, the failed specimens were held in a vice at one end and then struck with a hammer on the other end. No subsurface crack initiation sites were found.

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

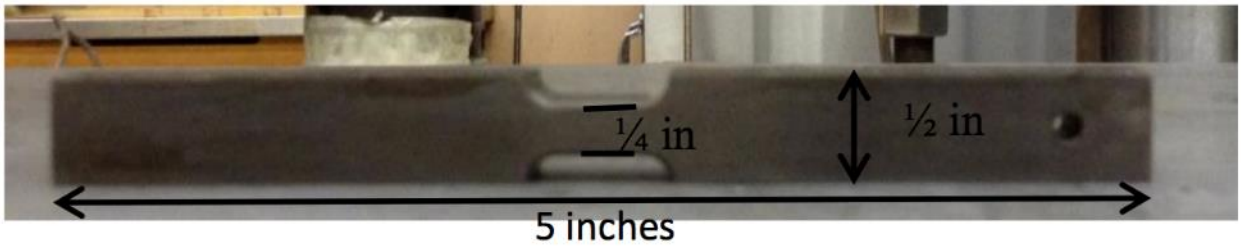

Figure 1: Bending specimen side view

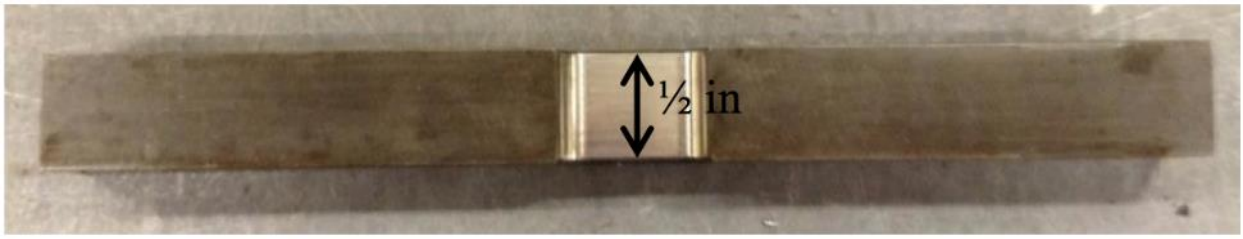

Figure 2: Bending specimen top view

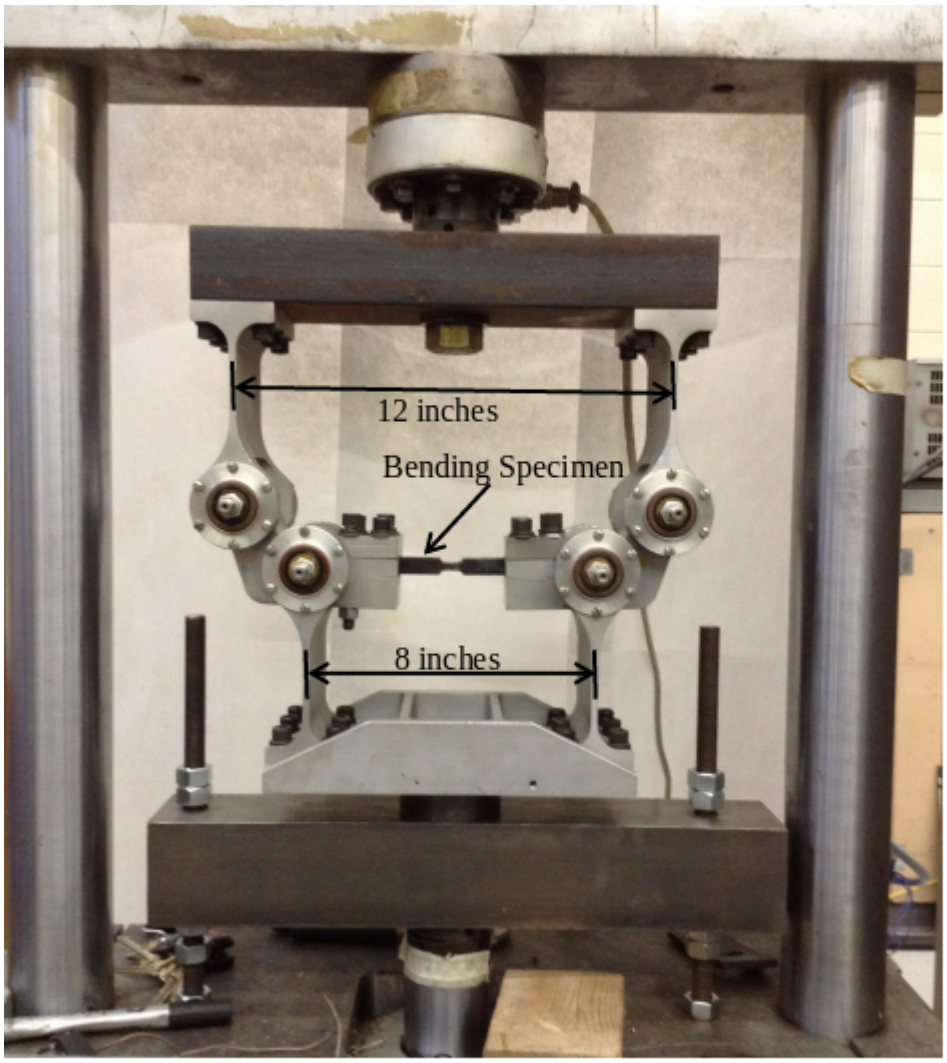

Figure 3: Bending Rig in the testing frame

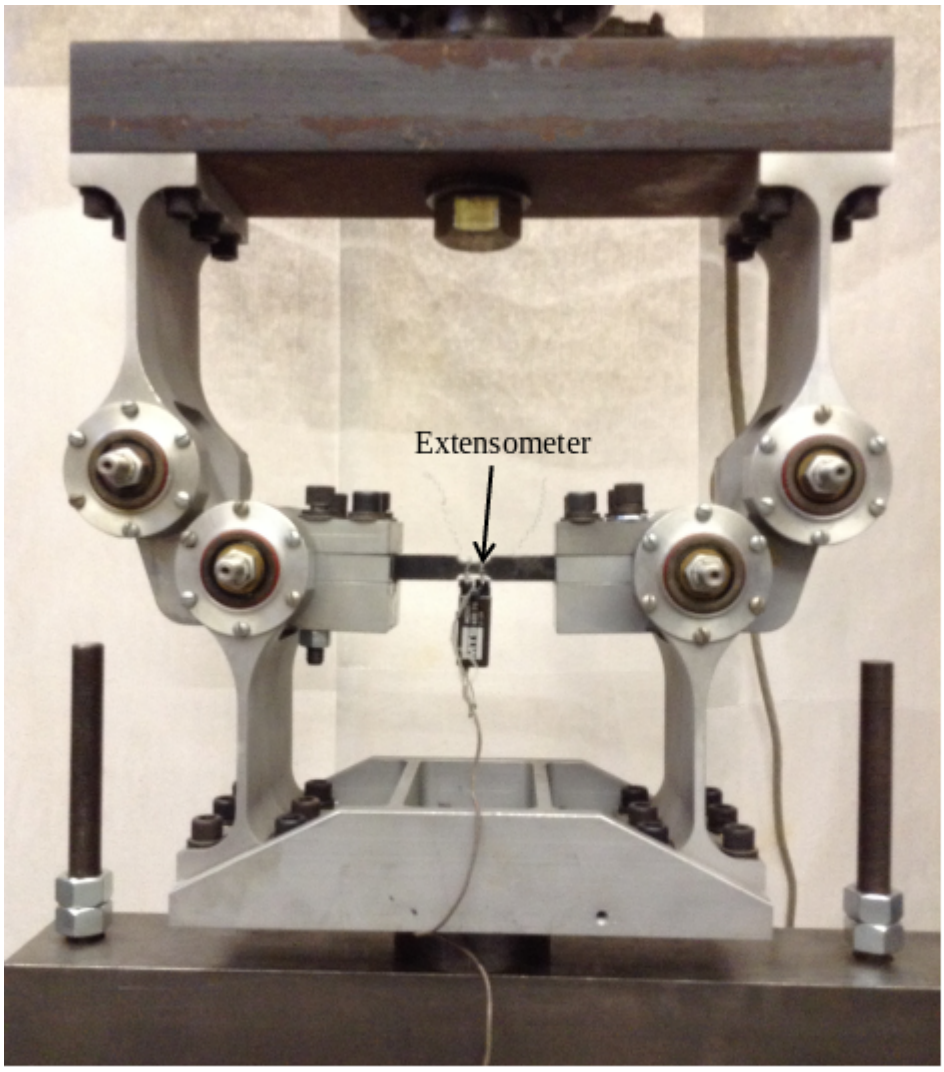

Figure 4: Extensometer installed on the bending specimen to measure the strain

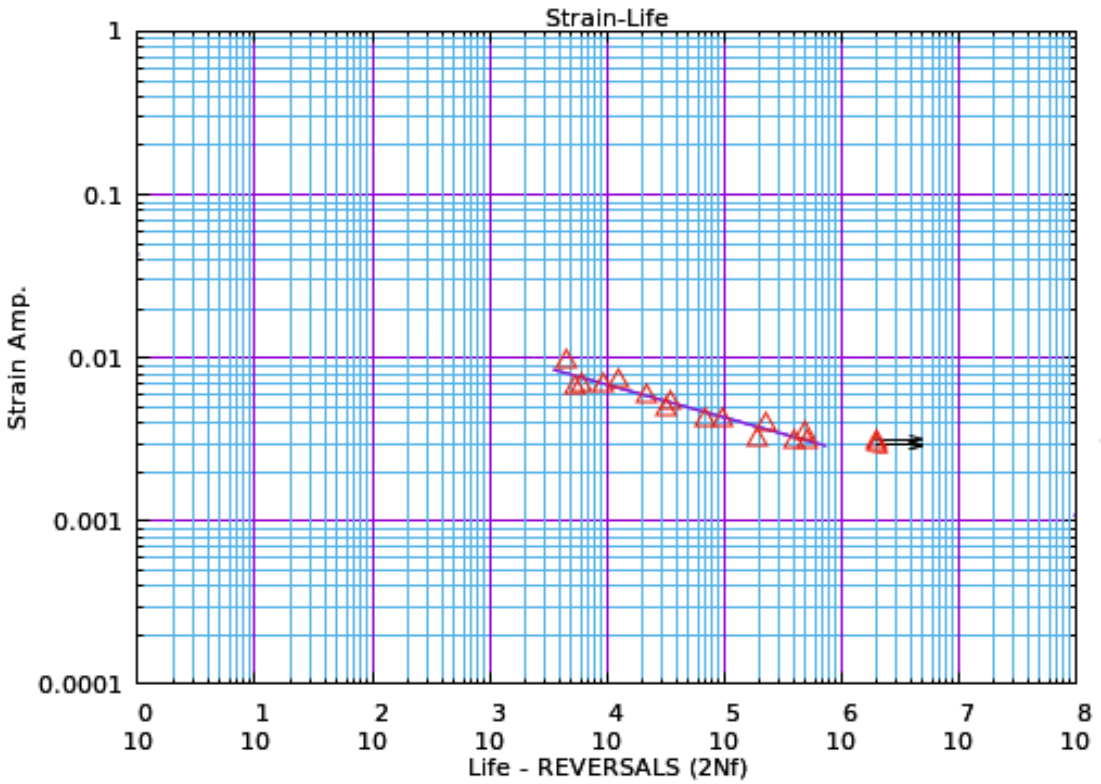

Figure 5: Strain-life fatigue curve for AISI 4120 modified (IT 207)

Table 1: Constant Strain Amplitude Data for AISI 4120 modified Steel (IT207)

StrAmpl	2Nf	StressAmpl*	Mean Stress*	PlsStrAmp	Modulus**	Comments	Spec ID***
		Mpa	Mpa		Mpa		
0.009780	4446	1491	0	0	152446		1
0.006810	5376	1436	0	0	210913		6
0.007000	6210	1441	0	0	205897		3
0.007055	9210	1299	0	0	184121		4
0.007340	12510	1309	0	0	178324		2
0.006045	21680	1162	0	0	192164		5
0.005045	32870	1084	0	0	214838		7
0.005390	35480	1095	0	0	203235		8
0.004255	68270	978	0	0	229836		9
0.004225	97240	882	0	0	208752		10
0.003265	193808	761	0	0	233134		12b
0.003985	225730	723	0	0	181461		15
0.003190	399350	678	0	0	212678		11
0.003591	495376	672	0	0	187112		14
0.003180	507770	659	0	0	207103		16
0.003178	2000000	652	0	0	205151	#runout	13
0.002910	2000000	563	0	0	193338	#runout	17
0.002910	2000000	564	0	0	193906	#runout	12

* "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.)

** Some specimen IDs, have a digital number with a letter B, such as 9B, it means that specimen no.9 was tested at a low strain amplitude without failure, and then tested again at a higher strain amplitude and given the label "9B"

Table 2: Rockwell C Hardness Test Data for AISI 4120 modified Steel

Specimen ID	Test 1	Test 2	Test 3	Average
7	42.5	44	42.5	43.00
1	42.5	43.5	43	43.00
8	42.5	41.5	41.5	41.83
Overall				42.61