Testing of CSS Georgia Casement Rail

Preliminary Report

For

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By

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Notice

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Summary

This report summarizes material testing results on casement rails. The rails originate from the casement of the Confederate gunship CSS Georgia which was sunk during the Civil War in the Savannah River just downstream from the City of Savannah, GA. The tests included tensile, flexural, split, and fracture toughness.

Introduction

A series of tests were performed on casement rails to determine the material properties of the rail iron and the structural strength of the rails. The section of casement, which came from the sunken Confederate gunship CSS Georgia, which was approximately 7’-3” long by 19” wide, contained a total of 10 rails that were encrusted together. The tests were performed on several short sections of rail at the request of the U. S. Army Corp. of Engineers, Savannah District, Savannah, Georgia. The tests were performed at the Structural and Materials Testing Laboratory of the Zachry Department of Civil Engineering at Texas A&M University, College Station, Texas. The testing was performed over a two-month period during October and November 2014.

Results

<u>Split Test</u>

A test was performed to determine the magnitude of force required to separate or split a group of rails apart. The test setup involved supporting the casement section in the long direction and applying a force from a 50-kip actuator at the middle of the short span (14-3/8”). The setup for the test is shown in Figure 1. The force required to split the rails apart was 15.1 kips. The casement section separated in two parts with each half containing five rails.

Figure 1: View of rail casement split test setup.

The relatively high force required to separate the rail group can be attributed to the mixture of corrosion product and river sediment located in the gaps between the rails. This mixture had bonded the rails together and can be seen in a cross sectional view of one group of five rails in Figure 2. From this group of 5 rails, a 3-inch long section and an 8-inch long section were cut to be utilized for test specimens.

Figure 2: Cross-sectional view of five rails after cutting.

<u>Cross Sectional Area</u>

Examination of the five separated rails indicated that corrosion of the individual rails was limited to the flanges of each rail as these components where on the outer surfaces of the casement. Both the web and rail head were in the interior of the casement and were relatively protected from extensive corrosion damage.

The grouping of 3-inch length rails were separated from each other, cleaned, and then ground smooth on one end by hand to provide a more uniform cross-sectional surface. This allowed for a measurement of the cross-sectional area using a digital microscope, which also provided high-resolution images of the cross-sectional surface. The cross-sectional areas are given in Table 1. The cross-sectional images of the five rails are given in Figures 3 through 7.

Table 1: Rail cross-sectional areas.

Rail No.	Cross-sectional Area (in.^{2})
1	4.381
2	4.658
3	4.195
4	4.242
5	4.245

Figure 3: Cross-sectional area of Rail 1.

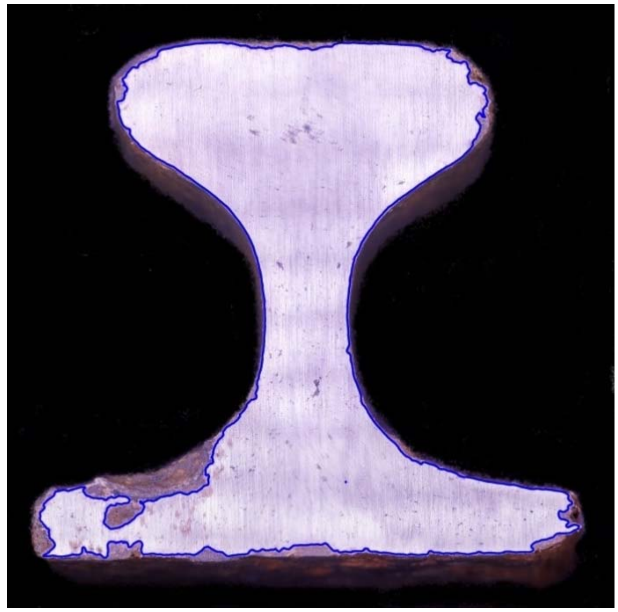


Figure 4: Cross-sectional area of Rail 2.

Figure 5: Cross-sectional area of Rail 3.

Figure 6: Cross-sectional area of Rail 4.

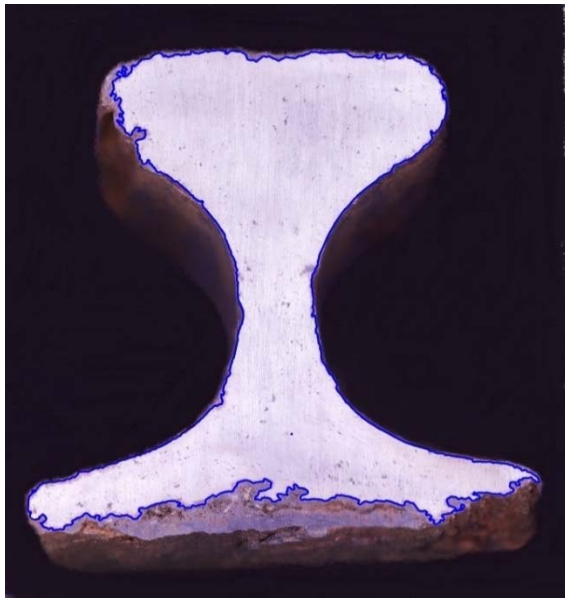


Figure 7: Cross-sectional area of Rail 5.

Fracture Toughness

The fracture toughness of the iron was estimated by machining standard Charpy V-Notched (CVN) specimens from Rail No. 1. All specimens were tested at room temperature (approximately 70°F). The results from these tests are summarized in Table 2.

Table 2: Summary of Charpy impact testing

Specimen No.	Width (in.)	Thickness (in.)	Energy Absorbed (ft.-lbs.)	Test Temperature (°F)
1	0.394	0.394	18.41	70.0
2	0.392	0.392	19.99	70.3
3	0.393	0.395	19.43	70.2
4	0.396	0.393	19.06	70.1
5	0.396	0.398	26.19	70.0
6	0.396	0.395	6.55	70.0
7	0.395	0.396	14.80	69.9
8	0.394	0.395	15.34	70.0
9	0.393	0.394	30.16	70.0
10	0.394	0.394	18.41	70.0

Axial Tensile Strength

Axial tensile tests were performed on one 8-inch section of rail (Rail No. 4). This section of rail was cut up to produce six tensile specimens, one of which is shown in Figure 8. All of the tensile specimens tested failed with respect to the relatively large impurity inclusions. This is evidenced by the darker regions being the impurities versus light grey of the iron, as shown in Figure 9.

Table 3: Summary of axial tensile tests

Specimen No.	Width (in.)	Thickness (in.)	Yield Strength (ksi)	Tensile Strength (ksi)
1	0.496	0.247	23	29
2	0.499	0.249	23	42
3	0.499	0.248	23	37
4	0.500	0.250	24	35
5	0.501	0.250	25	45
6	0.497	0.249	20	35

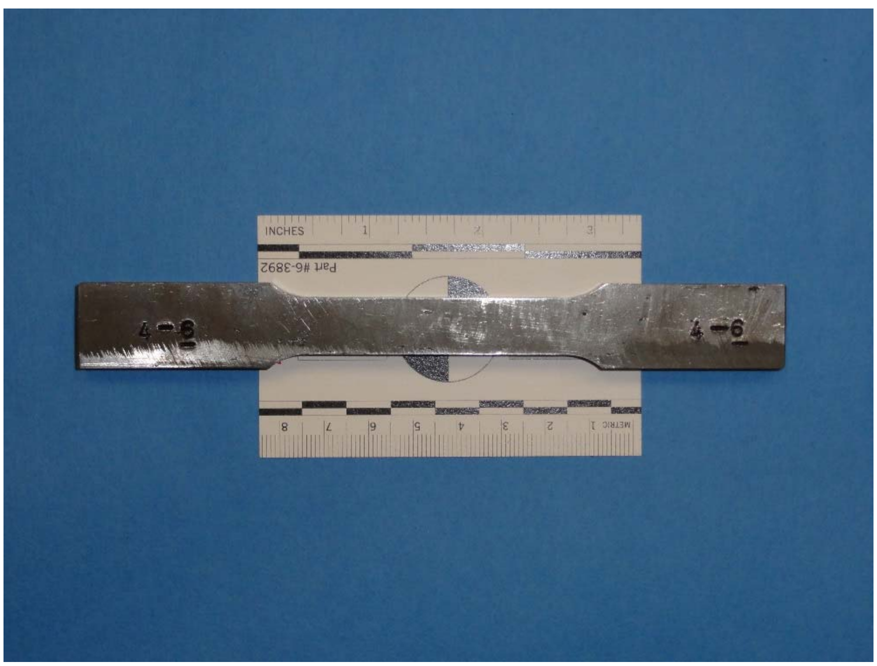


Figure 8: View of axial tensile specimen (4-6).

Figure 9: Failure location view of axial tensile specimen (4-1).

<u>Flexural Tests</u>

Bend tests were performed on four of the rails. The length of these rails was the as-received length of 7’-3”. The test setup is shown in Figure 10. The span length between the simple supports was four feet while the distance between the two load points was 18 inches. Three of the rails were tested with the rail head up (in compression) while one rail was tested upside-down to place the rail head in tension. Table 4 summarizes the results of the flexural tests.

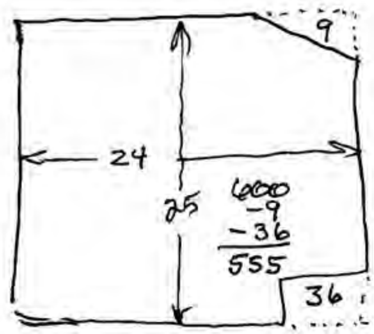
Figure 10: Test setup for rail flexural test.

Table 4: Summary of flexural tests.

Test No.	Rail No.	Rail Head Position	Maximum Load (kips)
1	6	Top	22.8
2	7	Top	22.1
3	8	Top	22.1
4	9	Bottom	21.5

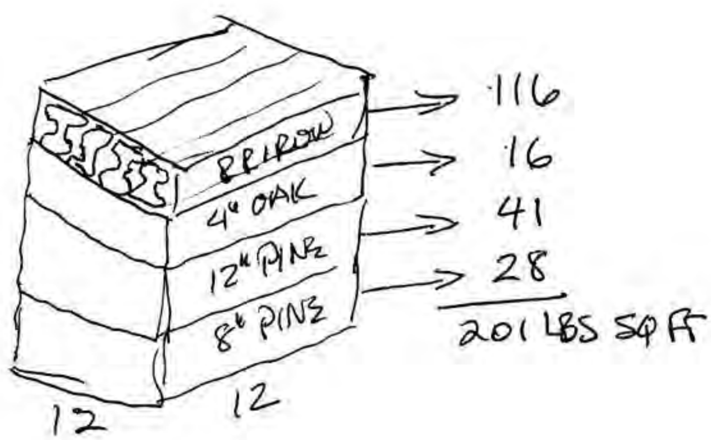
APPENDIX C: ESTIMATED CALCULATIONS FOR WEIGHT AND SQUARE FOOTAGE

EAST (MID) SECTION

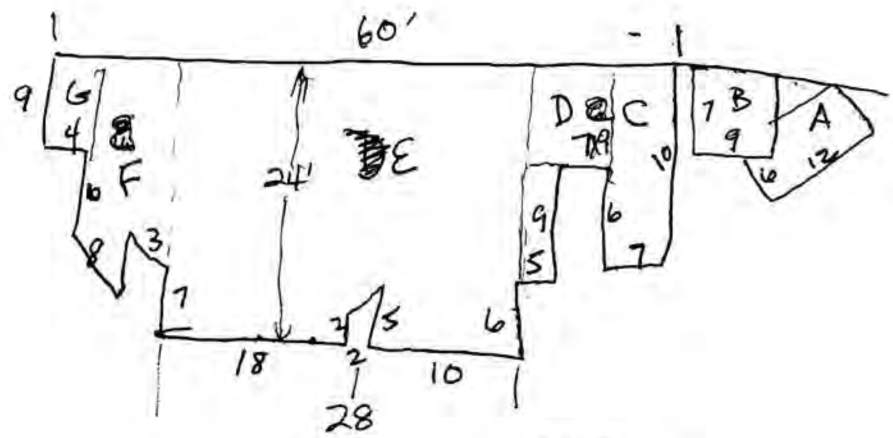


64,380 LBS — 555 SQ FT CONCRETED IRON @ 116 LBS SQ FT
8,880 LBS — 555 SQ FT OAK @ 16 LBS
22,755 LBS — 555 SQ FT 12X12 PINE @ 41 LBS
15,540 LBS — 555 SQ FT 8X12 PINE @ 28 LBS
2,000 LBS — FASTENERS

113,555 LBS 56.78 TONS MAX



WEST SECTION



	SQ FT	MAX LBS	÷ 2,000 MAX TONS
A	= 72	14,472	7.24
B	= 63	12,663	6.33
C	= 70	14,070	7.03
D	= 63+45 = 108	21,708	10.85
E	= 672	135,072	67.54
F	= 162	32,562	16.28
G	= 36	7,236	3.62

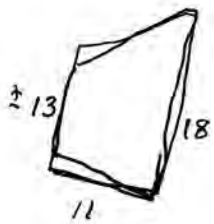
1183 SQ FT X 201 LBS 237,783 or 118.89 TONS

FASTENERS 5 TONS

123.89 TONS MAX

1 ROW @ 116 = 137,228
4" OAK @ 16 18,928
12" PINE @ 41 48,503
8" PINE @ 28 33,124

237,783



EASTERN MOST CASEMATE SECTION

170.5 SQ FT

NO APPARENT WOOD

170.5 × 116 = 19,778 ÷ 2,000 = 9.89 TONS

	CUFT STORAGE SPACE
HAWSE THROAT	16
PROPELLOR	972
STEAM CYLS(2)	250
CYL #3	90
6PDR	32
8" GUN	192
32 PDR	192
NEW GUN #4	192
BOILER	±480
SMALL CASEMATE	±341
EAST CASEMATE	± 1,665
WEST CASEMATE	3,549
MISC RRIRON	900
MISC ARTIFACTS	800