OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

To: M. Rothstein
Engineer of Design

From: K. A. Allemeier

Subject: Investigation of Chemical and Physical Properties of Structural Steel. B03 of 51021 - Cooley Bridge, M 55 over Pine River. Research Project 73 TI-180. Research Report No. R-894.

This report covers the results obtained from tensile and metallurgical evaluation of samples removed from structure B03 of 51021, Cooley Bridge, M 55 over the Pine River in Manistee County, as requested in your memo of October 22, 1973.

The purpose of this investigation was to determine the yield strength of the structural steel employed in various members of the structure. Your letter also stated a requirement that certain members must have a minimum yield strength of 33,000 psi, in order to allow full legal commercial vehicle loads on the bridge. All members tested exceeded that minimum.

Experimental Details

Twenty-six metallurgical samples were removed from various members of the structure. Their locations are given in Table 1.

The samples consisted of approximately 3/4-in. diameter plugs removed from the members with a metal cutting hole saw powered by a portable drill press.

The samples were submitted to the Charles C. Kawin Metallurgical Laboratories for chemical analysis.

Tension samples were removed from the suggested locations by sawing with a reciprocating saw. The samples were approximately 1 in. wide by 9 in. long by the thickness of the member. Sawing was initiated in all cases at the location where a metallurgical sample was removed in order to minimize sharp notches which could develop stress concentrations. In no instance was more than one tension sample removed from the same member. After removal, the member was cleaned and the area of removal was painted.

The samples were machined to ASTM specifications for flat tensile specimens utilizing a 2-in. gage length, except that instead of using the full thickness, all the specimens were machined to a reduced area, 0.250 in. thickness by 0.500 in. width. By doing this, it was possible, in some cases, to obtain two tension specimens from one sample. It also allowed the use of a more sensitive testing machine due to the smaller loads required for testing. Samples from which two tensile specimens were obtained, are designated "A" and "B" in Table 1.

The machined specimens were tested for yield and ultimate strength in a 20,000-lb capacity Instron machine equipped with autographic printout. The yield and ultimate strengths were obtained directly from the stress-strain plot. Since all traces exhibited a definite yield point (or "knee") in the curve, the highest point on the knee is reported as the yield strength. The stress at 0.2 percent strain varied from about 1,000 psi higher to 2,400 psi lower than the reported values, but in no case was below 33,000 psi.

Results

The results of the chemical analysis and tension tests are shown in Table 1. A brief discussion follows:

24 by 3/8-in. Web Plates - There were no tension samples obtained from these members. Chemical analysis of the metallurgical samples obtained from the plate indicate the composition to be quite similar to that of sample No. 7 which showed a tensile strength of 55,500 psi and a yield point of 38,800 psi. Therefore, we would expect the mechanical properties of the plate to be similar.

6 by 6 by 3/8-in. Angles - Chemical analysis showed no wide deviations from the norm. The average yield strength was 39,500 psi and the average ultimate strength 59,500 psi.

31-1/2 by 7/8-in. Web Plates - There were no tension samples obtained from these members. The mechanical properties should be similar to those of sample No. 15 which has approximately the same chemical composition. Sample No. 15 showed an average yield strength of 37,200 psi and an average ultimate strength of 63,100 psi.

6 by 6 by 7/8-in. Angles - Chemical anslysis showed no wide deviations from the norm. The average yield strength was 38,600 psi and the average ultimate strength 64,000 psi.

30W124 Intermediate Floor Beams - Chemical analysis of samples obtained from these members exhibited approximately 40 percent more manganese content than the average. The average yield strength was 38,750 psi and

the average ultimate strength 64,150 psi. As can be seen, the variation in manganese content of these members did not seem to alter the strength significantly. Since manganese is usually added to provide toughness, this seems reasonable.

30W116 End Floor Beams - The chemical composition and mechanical properties of these members are quite similar to those of the intermediate floor beams. The average yield strength was 37,700 psi and the average ultimate strength 63,950 psi.

21W59 Stringers - Chemical analysis of samples obtained from these members showed greater phosphorous content than the average. Theoretically, increasing the phosphorous content of low carbon steels, up to a limit, increases strength. From the results of tension tests, this was found to be true. The average yield strength was 20 percent higher than the average of other samples and the average ultimate strength showed a 6 percent increase. Values for these members were 46,350 psi average yield strength and 67,400 psi average ultimate strength.

Conclusions

All categories showed mechanical properties above the required minimum of 33,000 psi yield strength.

On the basis of chemical and tension tests performed, the subject structure does not require posting for load limit.

TESTING AND RESEARCH DIVISION

K-A Allemann

Acting Engineer of Testing and Research

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TABLE 1
LOCATIONS OF SAMPLE REMOVAL AND RESULTS OF CHEMICAL ANALYSIS AND TENSION TESTS

Structural Member	Sample No.	Location of Sample	Chemical Composition				Mechanical Properties	
			C	Mn	P	S	Yield Strength, psi	Ultimate Strength, psi
24 by 3/8 Web Plates	1	L0-L1, SW corner near Gussett, outside plate	0.15	0.44	0.012	0.029	--	--
	2	L0-L1, NW corner near Gussett, outside plate	0.16	0.47	0.014	0.022	--	--
	3	L0-L1, NE corner near Gussett, outside plate	0.17	0.45	0.011	0.018	--	--
	4	L0-L1, SE corner near Gussett, outside plate	0.17	0.44	0.011	0.020	--	--
6 by 6 by 3/8 Angles	5	L0-L1, SW corner near Gussett, outside top angle	0.21	0.47	0.016	0.025	40,100	65,300
	6	L0-L1, NW corner near Gussett, outside top angle	0.23	0.49	0.016	0.024	--	--
	7	L0-L1, NE corner near Gussett, outside top angle	0.15	0.41	0.011	0.023	38,800	55,500
	8	L0-L1, Outside top angle, SE near support	0.20	0.44	0.011	0.030	--	--
31-1/2 by 7/8 Web Plates	9	L4-L5, SW near Gussett, outside plate	0.21	0.44	0.013	0.023	--	--
	10	L4-L5, NW near Gussett, outside plate	0.24	0.51	0.013	0.018	--	--
	11	L4-L5, NE near Gussett, outside plate	0.20	0.49	0.016	0.026	--	--
	12	L4-L5, SE near Gussett, outside plate	0.20	0.50	0.017	0.026	--	--
6 by 6 by 7/8 Angles	13	L4-L5, SW near Gussett, outside top angle	0.29	0.51	0.018	0.026	A 39,700 B 40,300	64,700 65,100
	14	L4-L5, NW near Gussett, outside top angle	0.22	0.50	0.015	0.025	--	--
	15	L4-L5, NE near Gussett, inside top angle	0.20	0.48	0.015	0.023	A 36,600 B 37,800	62,600 63,600
	16	L4-L5, SE near Gussett, outside top angle	0.23	0.46	0.018	0.027	--	--
30W124 Intermediate Floor Beams	17	U1, NW near support bottom flange	0.21	0.76	0.015	0.025	A 39,700 B 39,600	64,300 64,800
	18	U1, SW near support bottom flange	0.20	0.79	0.014	0.026	--	--
	19	U1, SE near support bottom flange	0.20	0.78	0.013	0.022	A 37,700 B 38,000	63,500 64,000
	20	U1, NE near support bottom flange	0.20	0.78	0.014	0.022	--	--
21W69 Stringers	21	U0, West end, third stringer from south, inside bottom flange near support	0.19	0.61	0.061	0.034	47,600	68,100
	22	U0, West end, third stringer from north, inside bottom flange near support	0.17	0.60	0.061	0.034	--	--
	23	U0, East end, third stringer from north, inside bottom flange near support	0.19	0.62	0.058	0.032	45,100	66,700
	24	U0, East end, third stringer from south, inside bottom flange near support	0.17	0.62	0.058	0.034	--	--
30W116 End Floor Beams	25	U0, SW bottom flange near support	0.20	0.78	0.014	0.024	A 38,900 B 36,900	64,300 64,700
	26	U0, NE bottom flange near support	0.22	0.77	0.013	0.025	A 38,700 B 36,300	63,300 63,500