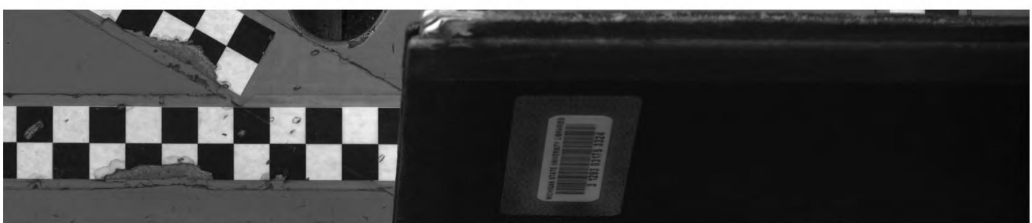
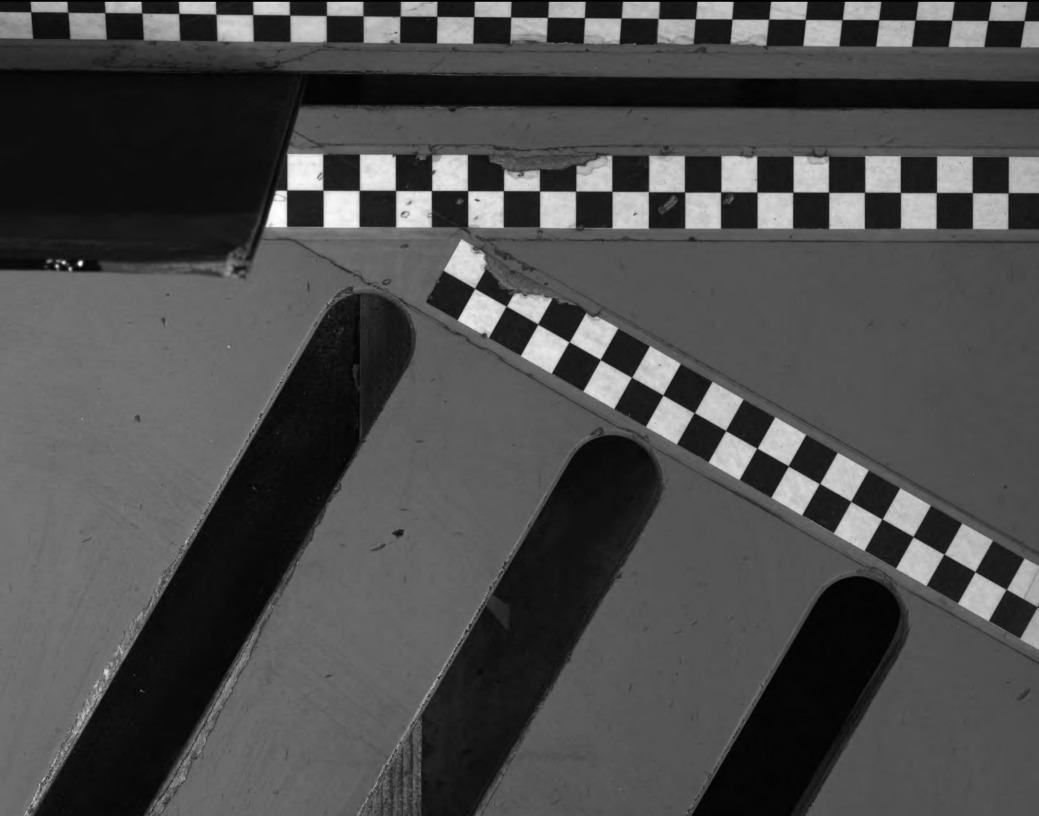
THESIS.

THE PROPERTIES OF SEMI-STEEL.

J. H. Steele. 1896.





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T H E S I S

on

THE PROPERTIES OF SEMI-STEEL

by

J. H. Steele.

Michigan Agricultural College,

August 14, 1888.

THE PROPERTIES OF SEMI-STEEL.

The object of this thesis was an investigation of the properties of Semi-Steel. All that was known of semi-steel at the beginning of the work was that it was a mixture of cast iron and steel and that in some instances a certain alloy had been mixed to give the resulting product certain desired qualities. It was desired to procure test bars of semi-steel and test them and compare the results with the results obtained from ordinary cast iron. It was also desired to have a chemical analysis of the alloy which is used to make the semi-steel, and to manufacture in the College foundry, according to the analysis, some semi-steel and compare it with the test bars of semi-steel procured outside.

In the first place some specimens of the alloy were procured and were analyzed by the Chemical Department. The specimens procured were small pieces that had evidently been melted. The results of the analysis are as follows:

Mn	15.62
P	00.17
Si	01.73
C	04.00
Fe	78.46
	100.00

The results of the analysis showed that the alloy was nothing more or less than spiegeleisen. Chemistry says: "Spiegeleisen is a variety of white cast iron containing 3.5 to 6 % of carbon and from 5 to 20 % of manganese."

The specimen analyzed is seen to contain 15.6 % of manganese, 4 % of carbon and the remainder iron with traces of silicon and phosphorus. Following this clue, the Mechanical Department sent for a quantity of spiegeleisen with a view to casting some test bars of semi-steel.

Meanwhile I learned, that the McDowell Steel Co. of Chicago were the originators of the semi-steel process and that all the material used in the process by the various foundries of the country came from them. I also found that they claimed for their product a tensile strength of 34000 to 38000 # per sq. in.

I wrote to the Chicago company and asked them for some test bars, promising to pay all expenses. In reply they said that "they had no test bars at present but perhaps Robt. Hunt & Co. might spare me some." Not knowing the relation between the McDowell Steel Co. and Robt. Hunt and Co., I wrote to the latter firm and asked for some test bars. Here, to my disappointment, I was met by a polite refusal and I found that the Robt. Hunt Co. were consulting engineers to the McDowell Steel Co.

However, from other sources, a number of test bars of semi-steel were obtained and these were tested on the Olsen testing machine belonging to the Mechanical Department.

Test bar # 1 of semi-steel was put in the machine and extensometer readings taken up to 11000 # or 17000 # per sq.in.

At 13200 #= 20000 # per sq. in. the piece broke in the upper jaw of the machine. An examination of the piece showed that it had been crushed in the jaws instead of pulling apart. The grain was that of fine grained, gray cast iron. These pieces have a slight bulb cast on each end to hold in the jaws of the machine. It was in this bulb that the piece crushed. The next piece crushed just as did the first at 14000 #= 23750 # per sq. in. Modulus of elacticity = E for t this piece = 12750000 #.

Bar # 3 broke in exactly the same way at 14000 # = 21000# per sq. in. E for this piece = 13498000 #.

These three bars having all crushed in the jaw of the machine we began to study to find some way to pull them apart. An attempt was made to find the crushing strength of the material. A compression piece was turned down from the end of one of the test bars. It had a length of .899" and a diameter of .411" and stood 40000 # without crushing. The crushing in the jaws must have been due to the wedge action there. The material was cut very easily by the lathe tool and the drill, behaving like cast iron.

A piece was prepared with the bulbs turned off to give the jaws a better grip. This piece pulled apart at 13000 # = 22700 # per sq. in. Another piece broke at 13600 # = 21100# per sq. in.

Finally a piece was put in the machine which was turned

the whole length. This broke at 14700 # = 22050 # per sq. in. Elastic limit 16000 # per sq. in. For the sake of comparison with the above results I tested some bars of ordinary cast iron which I bought at the foundries at Lansing. Bar # 1 from the Lansing Iron Works broke at 18400 or 28000 # per sq. in. E = 16420000 #. Bar # 2 broke at 20000 # = 25400 # per sq. in. E = 12975000 #. From the Olds Engine Works I received a bar whixh broke at 13000 # = 26000 # per sq. in. E = 9816000. Elastic limit reached at 9000 # = 19566 # per sq. in. and had E = 14732000 #. One from the Bement foundry broke at 8365 # = 25980 # per sq. in. From these results I think it is clearly shown that the specimens of semi-steel which I tested possessed a tensile strength equal to but not above good cast iron.

I will here quote from one from whom I learned the recipe for making semi-steel: The cupola is charged with 30 % pig iron, 30 % cast iron scrap and 40 % scrap steel. After this is all melted it is drawn off in ladles and for every 100 # of molten metal in the ladle 1 # of alloy is added. The % of alloy is only guess work as they pick up a handful and throw it into the ladle as it is being carried away. There is nothing peculiar in the casting of semi-steel, the only difference from the heats taken at the College is the addition of the scrap steel in the cupola and the addition of the alloy in the ladle.

From the chemical analysis given before, it is seen that 78 % of the alloy is iron and only 20 % of it is manganese and carbon. From this it seemed to me that the addition of 1 % of alloy would not have a perceptible influence because .20 of 1 % seemed too small a proportion to exert much influence. It seemed to me that if any extra strength were found in the compound the greater part would come from the 40 % scrap steel.

This matter we proceeded to test in the College foundry using the proportions given. We used 30 % of Lake Superior pig, 30 % cast scrap and 30 % boiler scrap, a low grade of steel. As has been shown above, the alloy showed by analysis that it was merely spiegeleisen. We, therefore, used spiegel instead of the alloy.

After waiting until the iron was quite hot, some test bars were poured, first without any spiegel in them, and then some with 1 % of spiegel in them. We desired to have some bars with larger per cents of spiegel, but we found that over 1 % of spiegel cooled the iron so rapidly that it could not be poured. The spiegel was crushed into small pieces about the size of bullets and in this form it was thrown into the ladles which had been previously warmed. We did not guess at the per cent of spiegel but I filled one of the ladles with water, putting as much water as the ladle usually contained

iron, and multiplied the weight of the water put in by the specific gravity of iron. I thus found that the ladle held 43 #' of iron, and I weighed .43 #' = 1 ℘' of spiegel.

A bar with no spiegel in it broke at 12000 #' = 22767 #' per sq. in. This piece had a flaw in it. Another piece broke at 107000 #' = 19000 #' per sq. in. A bar with 1 ℘' spiegel in it broke at 10000 #' = 18000 #' per sq. in. This piece had E = 10926000 #'. Another piece broke at 10500 #' = 18550 #' per sq. in.

It may, perhaps, be argued that in the limited opportunities of this term's work I have not given semi-steel a trial sufficiently extensive to do it justice; but I think the results noted above point, at least, to these conclusions:

1. The alloy which companies are buying by the pound and paying $300.00 a year for the right to use is nothing more or less than spiegeleisen.

2. Semi-steel has the same tensile strength as good cast iron and is similar to it in its various properties.

3. The addition of the spiegeleisen to the mixture of pig, cast scrap and scrap steel does not seem to affect the result.

In conclusion I wish to thank the professor in charge and also the foreman of the foundry for the interest they have taken in my thesis and the assistance they have given me.

TABLE OF SPECIMENS SUBJECTED TO TENSION.

SEMI STEEL

No.	Broke at # per sq.in.	Original Area, sq.in.	Elastic Limit	Modulus of Elasticity	Remarks.
1	20000		17000		Crushed in jaws of machine
2	23750	.63		12755000	" " " " "
3	21000	.6075		13498000	" " " " "
4	22700	.58			Ends turned down. Pulled apart.
5	21100	.641			" " " " "
6	22050	.52	16000		Bar turned whole length.

BARS CAST AT M. A. C.

No.	Broke at # per sq.in.	Original Area, sq.in.	Elastic Limit	Modulus of Elasticity	Remarks.
1	22767	.60			No Spiegel in this Flaw in bar.
2	19000	.644			" " " "
3	16000	.644		10926000	1/2 " " "
4	18550	.644			" " " "

CAST IRON

No.	Broke at # per sq.in.	Original Area, sq.in.	Elastic Limit.	Modulus of Elasticity.	Remarks
1	28000	.66		16420000	From Lansing Iron & Engine Works.
2	25400	7854		12975000	" " " "
1	26000	4987	20000	9816000	" Olds Engine Works.
2	19566	.46	17400	14732000	" " "
1	25980	.32			" Bemento.
1	29500	.644		12420000	
2	26390	.644