

**APPENDIX C**  
Report Letters

October 23, 2009

Mr. Bill Dittrich  
Bridge Inspection Engineer  
Indiana Department of Transportation  
Indianapolis, IN.

*Subject: Assessment of CVN Data from I-465 Bridge*

Dear Bill,

We have reviewed the results from the CVN testing provided by Steel Dynamics. As you know, cores were removed from the web and the bottom cover plate of several beams at selected locations.

Prior to discussing the results, a short discussion on CVN requirements is in order. Before the early 1970's, neither the AASHTO Bridge Design Specifications nor the IN DOT Bridge Design Manual specified any minimum CVN requirements for bridge steels. Thus, it would not be necessarily appropriate to compare these bridge steels to the modern specifications and requirements as specified in AASHTO.

It is also well recognized in the steel community that the mechanical properties (CVN, yield strength, etc.) of steel plates and rolled beams varies with the rolling direction. Data obtained from specimens in the longitudinal direction (*direction of rolling and in this case, the direction of traffic*) will be higher than those obtained in the transverse direction from the same plates or beam. Hence, data from transversely obtained specimens provide a conservative or lower-bound estimate of the actual material properties, including CVN.

Our assessment of the CVN test data obtained from these samples is as follows:

Web Samples

- A total of seven (7) samples were tested. Four (4) from regions exposed to fire and three (3) from a region nominally protected from fire by the embankment. The notch of all samples was oriented transverse to the longitudinal axis of the beam and parallel with the surface of the web.
- All measured data are well above modern AASHTO requirements for Zone II Non-fracture critical applications as specified in ASTM A709. The modern specification requires 15 ft-lbs @ 40F. The lowest value measured was 94 ft-lbs.

### Bottom Flange Cover plate Samples

- A total of seven (7) samples were tested. Four (4) from regions exposed to fire and three (3) from a region nominally protected from fire by the embankment.
- These CVN specimens were oriented transversely to the rolling direction. Hence, the notch is oriented parallel to the longitudinal axis of the beam. As stated, these data provide a conservative lower-bound estimate of the longitudinal mechanical properties.
- The fact that the data are from transversely oriented specimens is actually very good as it provides an estimate of the CVN impact energy available in the event of a future over-height vehicle impact. It is noted that no specifications, modern or older, have ever had any transverse CVN requirements specified.
- The modern specification requires 15 ft-lbs @ 40F for specimens oriented in the longitudinal direction.
- The data obtained are as follows:
  - 11 ft-lbs, 19 ft-lbs & 40 ft-lbs, (regions nominally protected from the fire)
  - 8 ft-lbs, 12 ft-lbs, 16 ft-lbs, & 20 ft-lbs (regions exposed to fire)

As can be seen, both sets of data contain results that are below the modern AASHTO Zone II non-fracture critical requirements for the longitudinal direction. However, as stated, these data were obtained from specimens oriented transversely. Such results are expected and the longitudinal CVN impact energies will be substantially greater.

Based on the data and the orientation of the specimens, it is our opinion that the CVN impact energy data are adequate for this bridge. It is also our opinion that the fire did not adversely affect the CVN impact energy values of the bridge steel.

If any additional information is required or if you have any questions, please do not hesitate to contact us.

Sincerely,



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October 30, 2009

Mr. Bill Dittrich  
Bridge Inspection Engineer  
Indiana Department of Transportation  
Indianapolis, IN.

*Subject: Assessment of hardness data from steel obtained for CVN cores from I-465 Bridge*

Dear Bill,

We have performed hardness testing on the 14 core samples obtained last week. As you know, cores were removed from the web and the bottom cover plate of several beams at selected locations and used to make CVN specimens. Using the remaining steel, we were able to perform hardness testing to further evaluate if the fire had affected the steel. The steel was identified as ASTM A36 on the original design drawings.

The hardness testing was performed using an Instron automated testing machine and Rockwell Hardness Scale 'B'. Using established ASTM correlations, estimates of the ultimate strength ( $F_u$ ) of the steel can be made from the hardness data. Based on the ASTM specifications the ultimate strength of A36 steel is permitted to be between 58 ksi and 80 ksi. The results are summarized in the attached table.

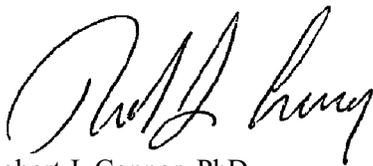
There are two primary observations that can be made from the table:

- The estimated ultimate strength ( $F_u$ ) of the steel is well within the ASTM specification limits.
- There is no statistical difference between the control data set and the data obtained from samples that were exposed to fire.

Hence, it is our opinion that based on the results of this hardness testing, the fire did not have any effect on the structural steel in the bridge. This finding is also consistent with the observations made after review of the CVN data obtained last week.

If any additional information is required or if you have any questions, please do not hesitate to contact us.

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	AS MARKED	LAB ID	WEB OR CP	EB OR WB BRIDGE/SPAN	ROCKWHEEL B (HRB)				ESTIMATED F <sub>U</sub> (KSI)
					TEST 1	TEST 2	TEST 3	AVG.	
<b>CONTROL SPECIMENS</b>	1	AA	WEB	WB/D	67.5	66.5	70.0	68.0	59.0
	2	BB	CP	WB/D	65.5	66.5	72.7	68.2	59.0
	3	CC	WEB	WB/D	66.7	71.5	75.0	71.1	62.0
	4	DD	CP	WB/D	X	70.5	71.5	71.0	62.0
	5	EE	WEB	WB/D	X	70.7	73.5	72.1	63.0
	6	FF	CP	WB/D	74.5	84.5	80.5	79.8	72.0
<b>EXPOSED TO FIRE</b>	A	A	CP	WB/B	73.5	68.5	76.5	72.8	64.0
	B	B	WEB	WB/B	X	65.0	68.5	66.8	58.0
	C	C	CP	EB/B	78.5	75.0	80.0	77.8	69.0
	D	D	CP	EB/B	80.0	80.0	79.5	79.8	72.0
	E	E	WEB	EB/B	X	66.5	70.0	68.3	59.0
	F	F	WEB	EB/B	71.5	73.0	69.0	71.2	62.0
	G	G	CP	EB/B	75.5	78.5	80.0	78.0	69.0
	H	H	WEB	EB/B	70.0	71.5	74.0	71.8	63.0
'X' DENOTES INVALID DATA								<b>HRB</b>	<b>F<sub>U</sub></b>
<b>AVERAGE CONTROL DATA</b>								<b>71.7</b>	63.0
<b>AVERAGE FOR EXPOSED SAMPLES</b>								<b>73.3</b>	64.0

November 3, 2009

Mr. Bill Dittrich  
Bridge Inspection Engineer  
Indiana Department of Transportation  
Indianapolis, IN.

*Subject: Assessment of data from testing of bolts taken from I-465 Bridge*

Dear Bill,

As you know, several A-325 HS bolts were removed from selected girder splices on the I-465 bridges as part of our ongoing investigation as to whether or not the propane fire had resulted in any damage to the bridges. The bolts are ASTM A-325 HS bolts with ASTM A563 Grade C nuts. These bolts obtain their strength from a quench and tempering process (Q/T), in other words a heat treatment process. For materials that obtain their strength or any property for that matter, through a controlled heat treatment, there is greater concern and likelihood that material properties are degraded as a result of uncontrolled heating and cooling, such as may have occurred during the fire.

The bolts were removed by others at both the web splices and flange splices and tested as a courtesy to INDOT by NUCOR fasteners in Indiana. Dr. Victor Hong witnesses the tests for IN DOT.

Our assessment of the results follow:

**Results of Bolt Testing**

Two of the bolts did not meet the hardness requirements per ASTM A-325 (bolts 7 and 8). Proof load testing was also performed for all bolts and revealed that only bolt 7 did not pass both types of proof load tests. Bolt 8 only failed one of the tests. All other bolts passed the proof load tests. It is important to note that the proof load tests are an indicator of axial elongation and not load carrying capacity in tension. In the test, the proof load is applied and then released. The elongation of the bolt is then measured and checked to be within allowable limits. All bolts carried the required proof load, however bolts 7 and 8 showed signs of permanent elongation that is greater than permitted. All bolts passed the wedge tension test.

Considering that there was no physical evidence of fire on the bolts (*i.e., no heat marks or paint damage*), that the minimum acceptable hardness is 25 HRC (*bolts 7 and 8 had average hardness values of 22 and 23 respectively*), we do not believe there was any measurable fire damage to the bolts. It is our opinion that the strength of the bolts was not decreased (as evidenced by the fact the bolts achieved the minimum proof load and all bolts met the wedge tension test requirements). We believe that these bolts are simply slightly out of specification (*note we are comparing to modern 2009 specifications*) and were so from the day they were installed. We do not believe that the bolts are not fully pretensioned. Considering the vintage of these bolts and the fact that very limited lot testing is done, is not unreasonable for some bolts to be slightly out of specification. It is noted that none of the bolts exceeded the maximum hardness limits.

### **Results of Nut Testing**

Hardness testing was performed on all nuts. Based on the markings on the nuts, they are suitable for use with A325 bolts and are Grade C nuts. The average hardness values of for all eight (8) bolts ranged from 4 to 15 HRC. The minimum and maximum hardness values permitted by ASTM A563 for these Grade C nuts are 78 HRB and 38 HRC respectively. This is a rather broad range. Note, all testing was done using Rockwell C scales, hence the data needs to be converted to Rockwell B scale to compare to the minimum acceptable value. Using established correlations, the minimum value of 4 HRC corresponds to a Rockwell B scale of 85 HRB, which is greater than the minimum requirement of 78 HRB. None of the nuts exceeded the maximum hardness limits.

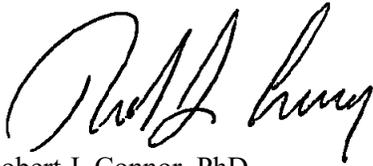
Hence, it is our opinion that based on the results of this hardness testing, the fire did not have any effect on the integrity of these nuts.

### **Summary**

In summary, the results of the bolt testing and the results of the previously reported material testing (*i.e., hardness testing conducted on the base metal and the results of the CVN testing*) indicated that the fire did not negatively impact the material properties of the structural steel in these bridges.

If any additional information is required or if you have any questions, please do not hesitate to contact us.

Sincerely,



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