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16. Abstract

In 2004, the Texas Department of Transportation initiated Project 0-5197 to investigate the feasibility of increasing the allowable compressive stress limit at prestress transfer. Initially, the live load performance of 36 specimens was evaluated by Birrcher and Bayrak (TxDOT Report 5197-1, 2007). Report 5197-4 presents the subsequent research conducted based on recommendations of Birrcher and Bayrak (2007). In this portion of TxDOT Project 0-5197, 45 Type-C beams and 10 4B28 box beams were tested to experimentally determine their cracking load. The Type-C beams were produced in four different fabrication plants using conventionally consolidated concrete. The 10 4B28 box beams were produced in two fabrication plants using concrete mixture designs of both self consolidating concrete as well as conventional concrete (Schnittker and Bayrak, CTR, 2008). After testing the 10 box beams procured in TxDOT Project 0-5197, Schnittker and Bayrak (2008) reported increased amounts of top flange cracking at release, substantially lower modulus of elasticity (along with increased deflections under live loading), slightly higher cambers near 28-days, and lower than expected flexural cracking loads under live loads. The present investigation is carried out in an effort to explain the poor performance of the beams fabricated with SCC as reported in research report 0-5197-4.

17. Key Words	18. Distribution Statement
Box Beams, Self Consolidating Concrete, Allowable Release Stress	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161; www.ntis.gov.

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Aggregate Distribution Investigation in Box Beams Fabricated With Self Consolidating Concrete

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Disclaimers

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Engineering Disclaimer

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O. Bayrak

Research Supervisor

Acknowledgments

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Aggregate Distribution Investigation in Box Beams Fabricated With Self Consolidating Concrete

1. Introduction

In 2004, the Texas Department of Transportation initiated Project 0-5197 to investigate the feasibility of increasing the allowable compressive stress limit at prestress transfer. Initially, the live load performance of 36 specimens was evaluated by Birrcher and Bayrak (TxDOT Report 5197-1, 2007). Report 5197-4 presents the subsequent research conducted based on recommendations of Birrcher and Bayrak (2007). In this portion of TxDOT Project 0-5197, 45 Type-C beams and 10 4B28 box beams were tested to experimentally determine their cracking load. The Type-C beams were produced in four different fabrication plants using conventionally consolidated concrete. The 10 4B28 box beams were produced in two fabrication plants using concrete mixture designs of both self consolidating concrete (SCC) as well as conventional concrete (technical report 5197-4, Schnittker and Bayrak, CTR, 2008). After testing the 10 box beams procured in TxDOT Project 0-5197, Schnittker and Bayrak (2008) reported that the beams fabricated with SCC had increased amounts of top flange cracking at release, substantially lower modulus of elasticity (along with increased deflections under live loading), slightly higher cambers near 28 days, and lower than expected flexural cracking loads under live loads. During and after beam fabrication, signs of improper concrete consolidation were noted by TxDOT personnel and University of Texas researchers. However, these observations were not detailed to the point where the inferior performance of SCC box beams could solely be attributed to consolidation problems. In an effort to explain the difference in performance between beams fabricated with SCC and those fabricated with conventional concrete, the present investigation was carried out. Improper concrete consolidation and/or aggregate segregation could be two possible explanations for the observations made above by Schnittker and Bayrak (2008). Hence, transverse cuts were deemed to be the most direct way to evaluate if any consolidation and/or segregation problem was present in the specimens tested.

This technical report summarizes the observations and findings obtained after placing transverse cuts in four box beams specimens tested in TxDOT Project 0-5197 and visually examining the exposed surface.

2. Investigation Program

A diamond wire saw was procured and utilized to produce 25 cuts in the box beams previously tested as part of TxDOT project 5197. For the purposes of this investigation, the majority of the cuts (21 out of 25) were done through box beams fabricated with SCC. In order to have a control sample that would allow the investigators to make a practical comparison, some cuts (4 out of 25) were made in box beams fabricated with conventional concrete. The complete distribution of the cuts can be observed in Table 1.

Each cut surface was later pressure washed and examined visually for signs of aggregate segregation or any other concrete quality issue. High resolution photographs of the cut surfaces (2 surfaces per cut per 25 cuts) are included in Appendix A of this document.

Table 1: Cut Distribution by Specimen

Beam Mark	Concrete and Aggregate Type	Number of Cuts
BB02	Conventional concrete with Limestone	4
BB07	Self consolidating concrete with River Rock	7
BB08	Self consolidating concrete with River Rock	7
BB09	Self consolidating concrete with River Rock	7

3. Findings

After a meticulous examination of 25 cross sections exposed by cutting 4 specimens, it was found that the 21 cross sections of beams fabricated with self consolidating concrete exhibited normal aggregate distribution with no noticeable segregation problems. Furthermore, the vertical distribution of coarse aggregate in the aforementioned SCC specimens was found to be comparable to that seen in the four cross sections of beams fabricated with conventional concrete.

Two differences were noticeable between the specimens made with different types of concrete. First, a lighter overall color was observed in specimens made with conventional concrete. This difference was solely because of the different aggregate type. The conventional concrete beams studied in this investigation were fabricated using limestone as coarse aggregate, whereas the beams fabricated with self consolidating concrete studied herein used round river gravel. The second difference was the paste fraction. The examination of the cuts indicated that beams fabricated with SCC had a higher paste fraction. This was expected since the concrete mixture design for SCC requires the use of higher paste fraction and smaller coarse aggregate.

In addition, it was observed that the Styrofoam void placement was reasonably accurate within a 1/4" tolerance.

4. Conclusions

The present investigation allowed the authors to conclude that the poor performance of the beams fabricated with SCC cannot be attributed to improper concrete consolidation or aggregate segregation.

Visual evidence included in Appendix A suggests that the quality of the self consolidating concrete used in fabricating box beams for TxDOT Project 5197 has minimum room for improvement, if any. Hence, the performance of beams fabricated with SCC is expected to be worse than those beams fabricated with conventional concrete as previously noted by Schnittker and Bayrak (2008.)

The advantages of using SCC in beam fabrication and the inferior overall performance observed in TxDOT Project 5197 box beams must be carefully weighed prior to the statewide implementation of SCC in bridge applications.

References

Schnittker, B. and Bayrak, O., “Allowable Compressive Stress at Prestress Transfer,” Research Report 0-5197-4, Center for Transportation Research, The University of Texas at Austin, December 2008, 206 pp.

Appendix A: Cross Section Photographs

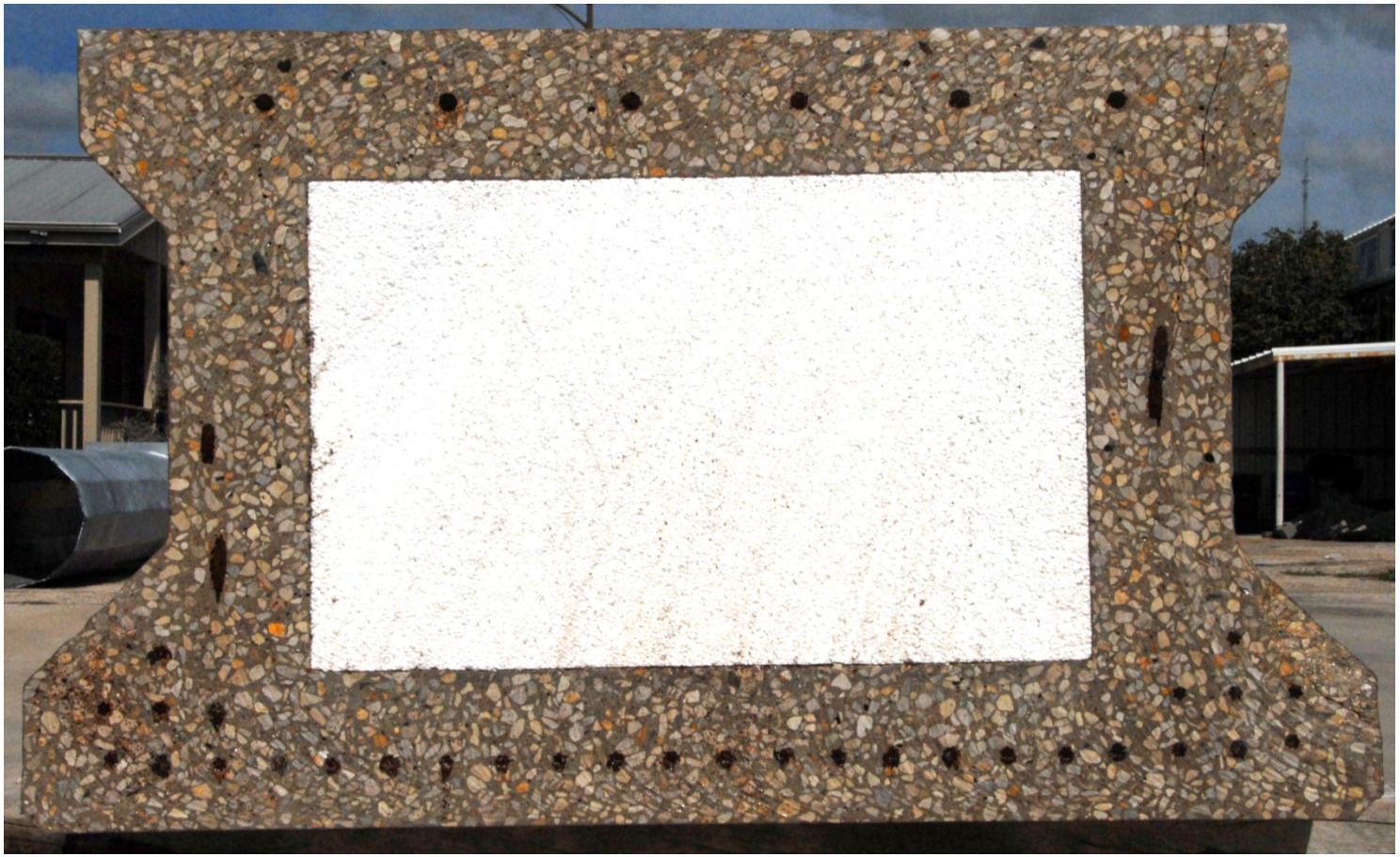


Figure A. 1: Picture BB02C1A

Beam Mark: BB02	Cut Location and View: 
Concrete Type: Conventional Concrete	
Aggregate: Limestone	
Cut ID: BB02C1A	

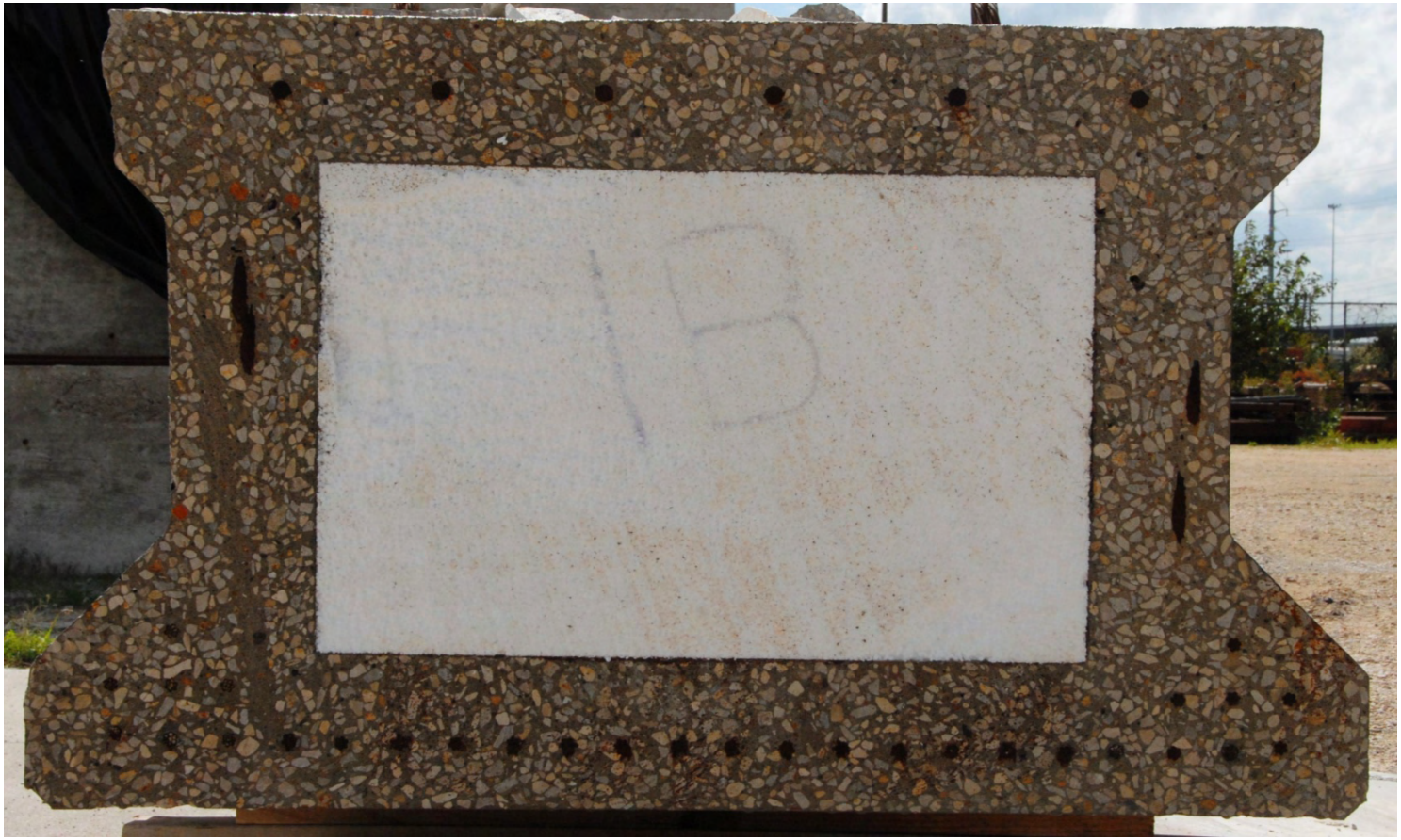


Figure A. 2: Picture BB02C1B

Beam Mark: BB02	Cut Location and View: 
Concrete Type: Conventional Concrete	
Aggregate: Limestone	
Cut ID: BB02C1B	

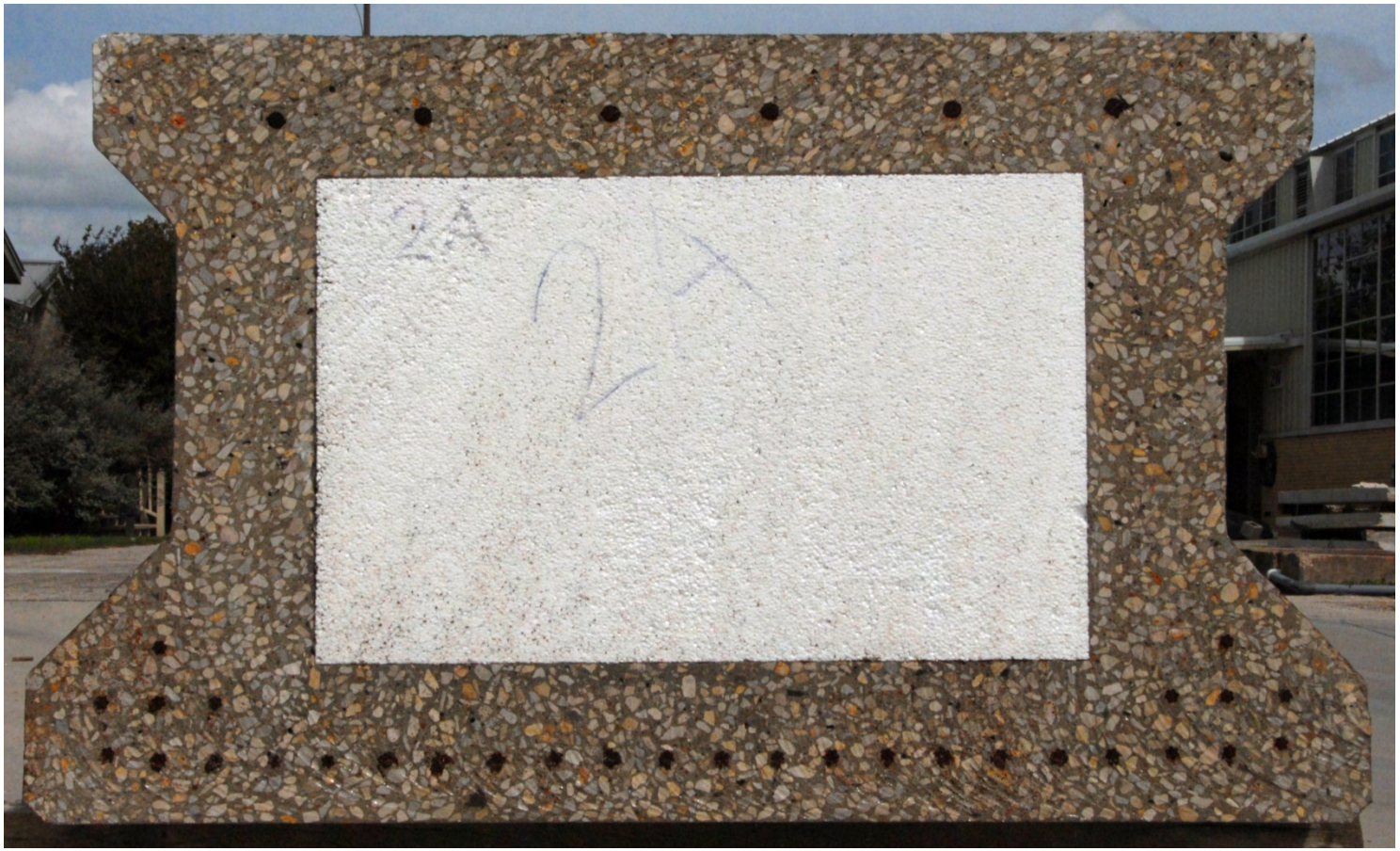


Figure A. 3: Picture BB02C2A

Beam Mark:	BB02
Concrete Type:	Conventional Concrete
Aggregate:	Limestone
Cut ID:	BB02C2A

Cut Location and View:

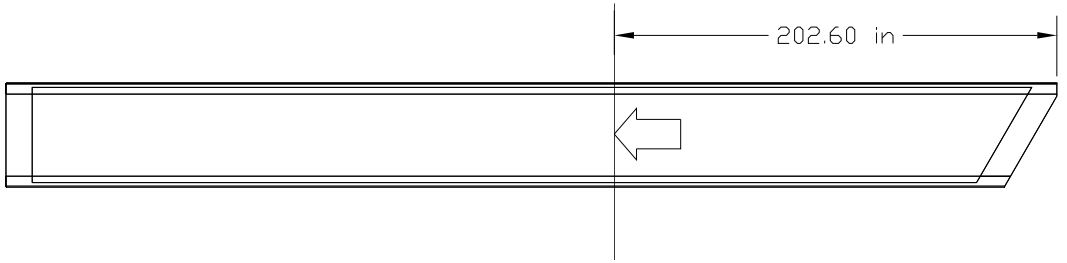


Figure A. 4: Picture BB02C2B

Beam Mark:	BB02
Concrete Type:	Conventional Concrete
Aggregate:	Limestone
Cut ID:	BB02C2B

Cut Location and View:

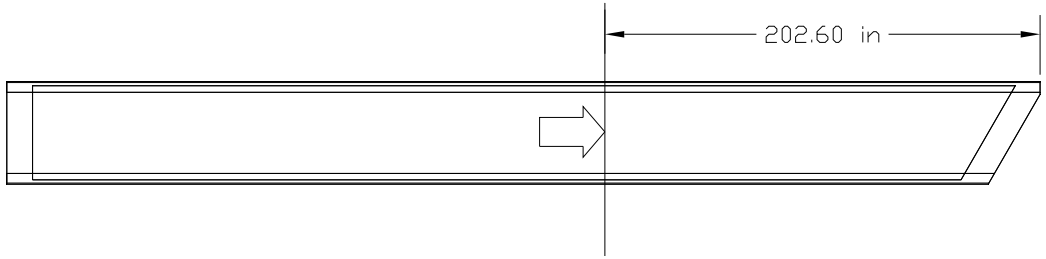


Figure A. 5: Picture BB02C3A

Beam Mark:	BB02
Concrete Type:	Conventional Concrete
Aggregate:	Limestone
Cut ID:	BB02C3A

Cut Location and View:

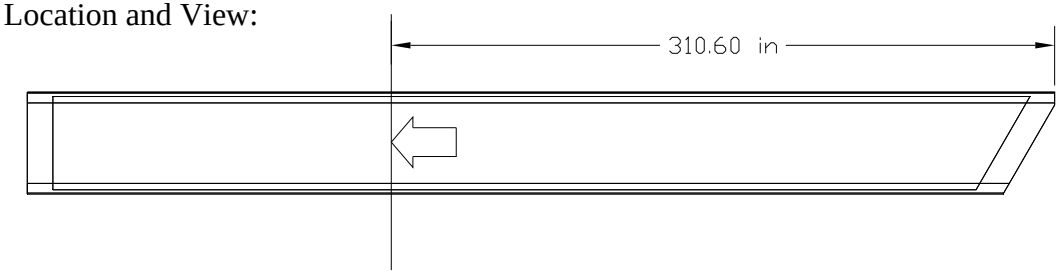


Figure A. 6: Picture BB02C3B

Beam Mark:	BB02
Concrete Type:	Conventional Concrete
Aggregate:	Limestone
Cut ID:	BB02C3B

Cut Location and View:

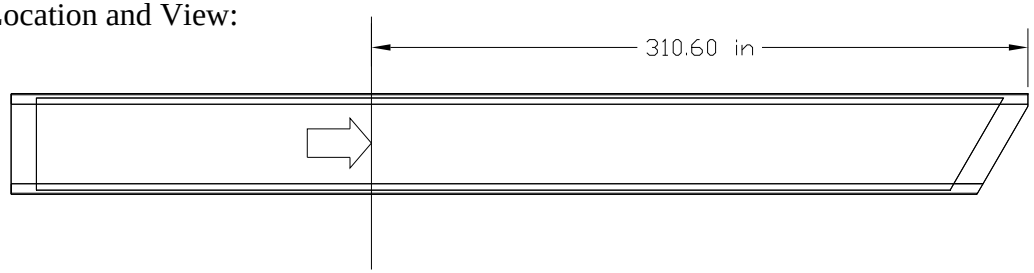


Figure A. 7: Picture BB02C4A

Beam Mark:	BB02
Concrete Type:	Conventional Concrete
Aggregate:	Limestone
Cut ID:	BB02C4A

Cut Location and View:

Figure A. 8: Picture BB02C4B

Beam Mark: BB02	Cut Location and View: 
Concrete Type: Conventional Concrete	
Aggregate: Limestone	
Cut ID: BB02C4B	

Figure A. 9: Picture BB07C1A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C1A

Cut Location and View:

Figure A. 10: Picture BB07C1B

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C1B

Cut Location and View:

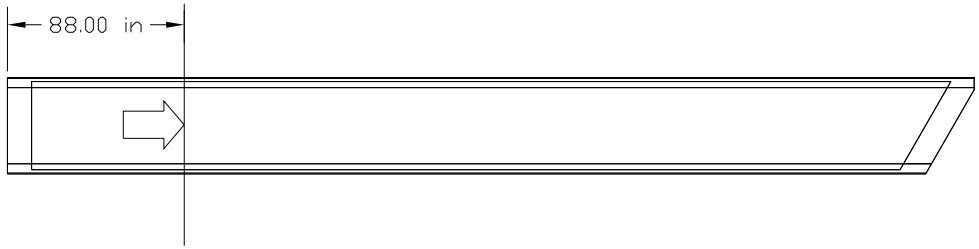


Figure A. 11: Picture BB07C2A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C2A

Cut Location and View:

Figure A. 12: Picture BB07C2B

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C2B

Cut Location and View:

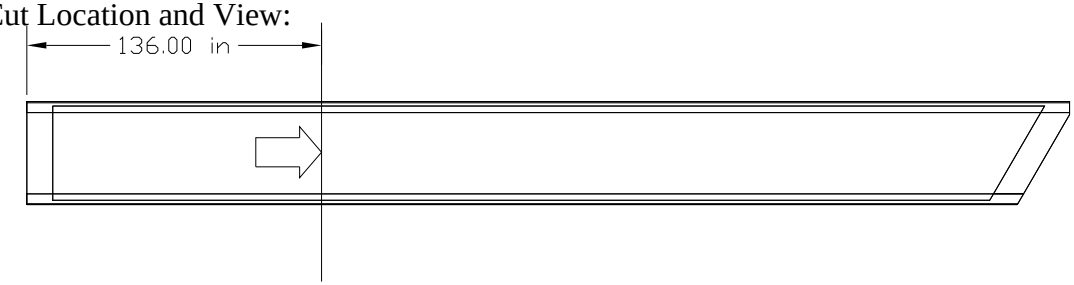


Figure A. 13: Picture BB07C3A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C3A

Cut Location and View:

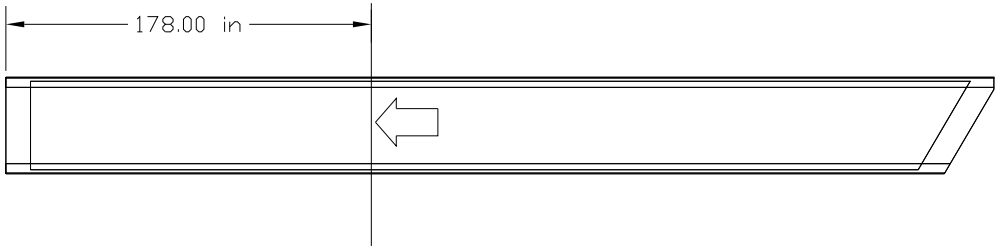


Figure A. 14: Picture BB07C3B

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C3B

Cut Location and View:

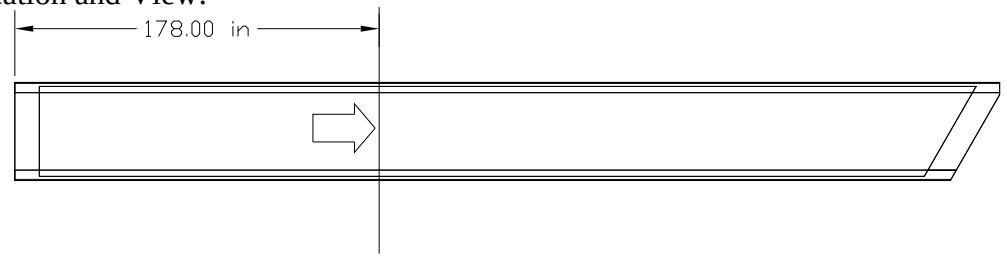


Figure A. 15: Picture BB07C4A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C4A

Cut Location and View:

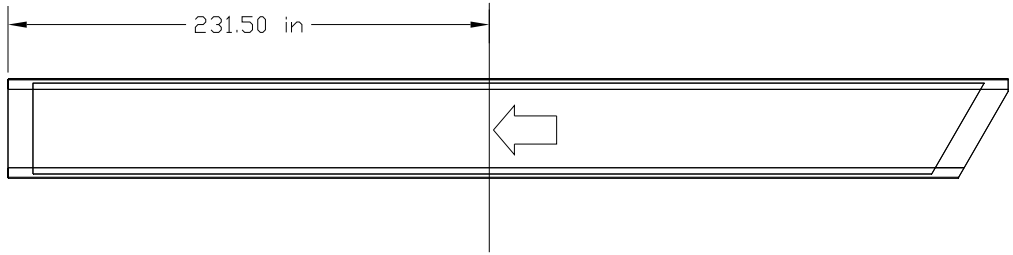


Figure A. 16: Picture BB07C4B

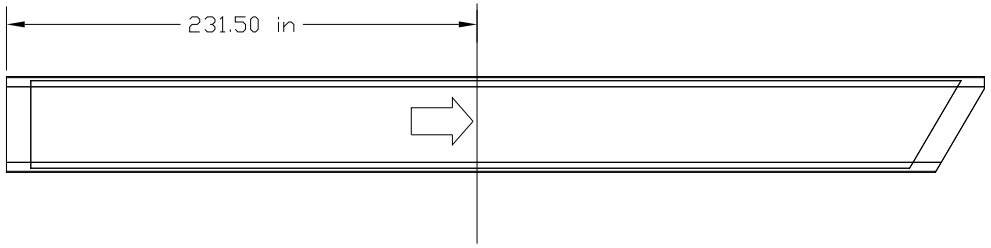
Beam Mark: BB07	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB07C4B	

Figure A. 17: Picture BB07C5A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C5A

Cut Location and View:

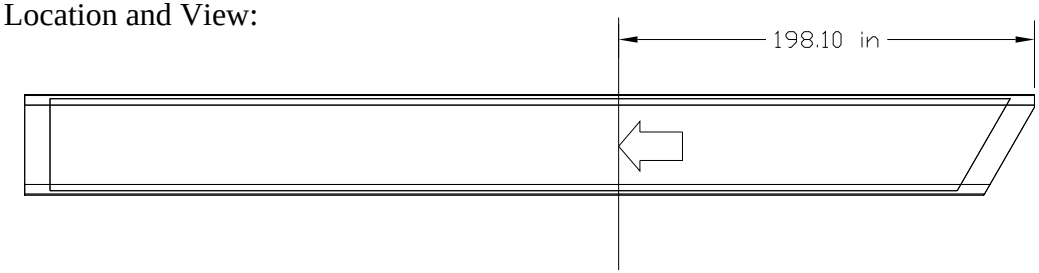


Figure A. 18: Picture BB07C5B

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C5B

Cut Location and View:

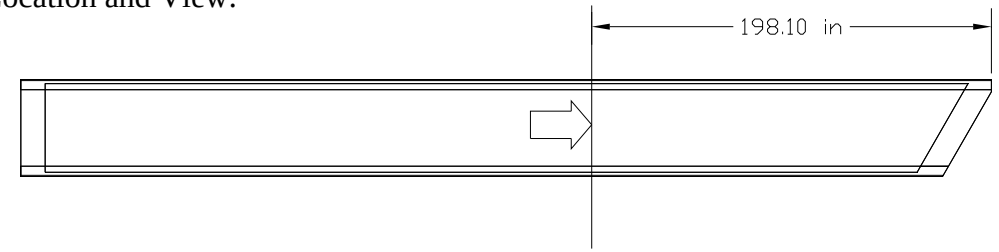


Figure A. 19: Picture BB07C6A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C6A

Cut Location and View:

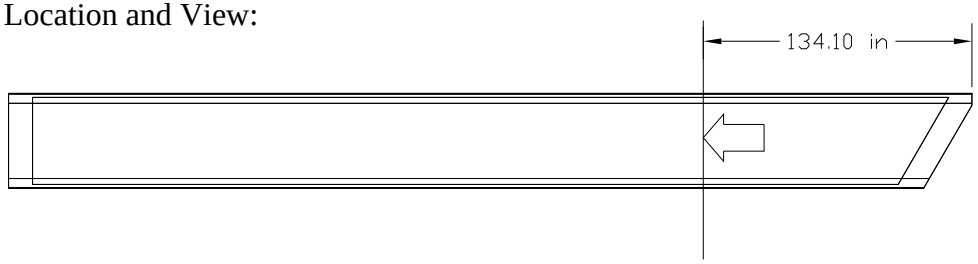


Figure A. 20: Picture BB07C6B

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C6B

Cut Location and View:

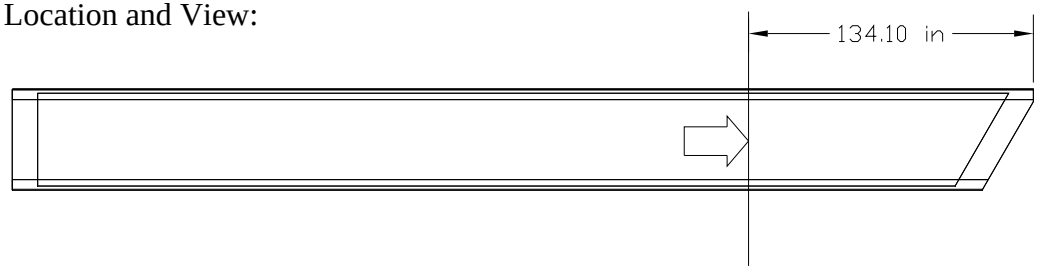


Figure A. 21: Picture BB07C7A

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C7A

Cut Location and View:

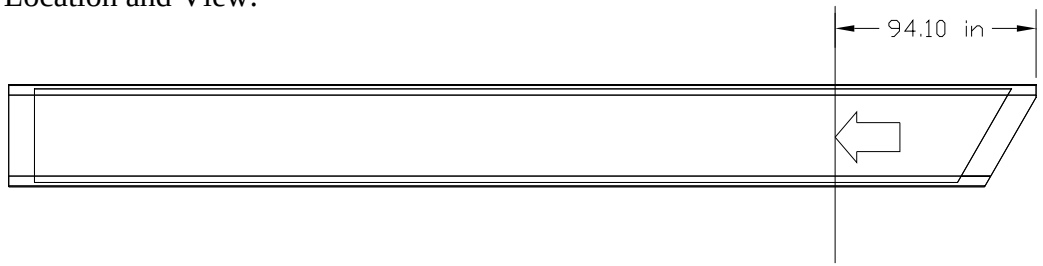


Figure A. 22: Picture BB07C7B

Beam Mark:	BB07
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB07C7B

Cut Location and View:

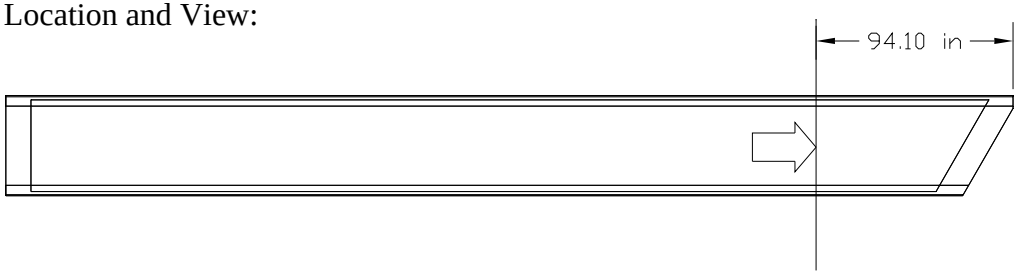


Figure A. 23: Picture BB08C1A

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C1A

Cut Location and View:

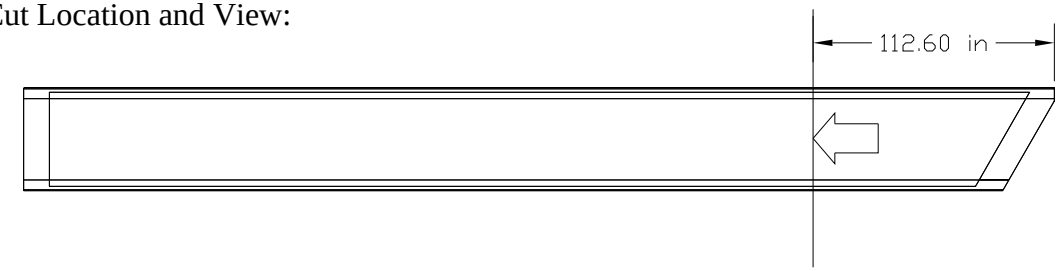


Figure A. 24: Picture BB08C1B

Beam Mark: BB08	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB08C1B	

Figure A. 25: Picture BB08C2A

Beam Mark: BB08	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB08C2A	

Figure A. 26: Picture BB08C2B

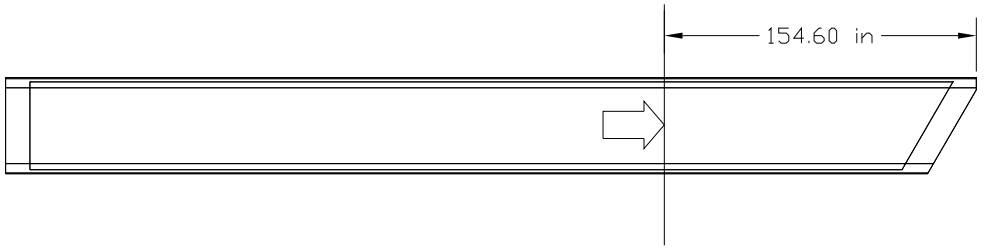
Beam Mark: BB08	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB08C2B	

Figure A. 27: Picture BB08C3A

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C3A

Cut Location and View:

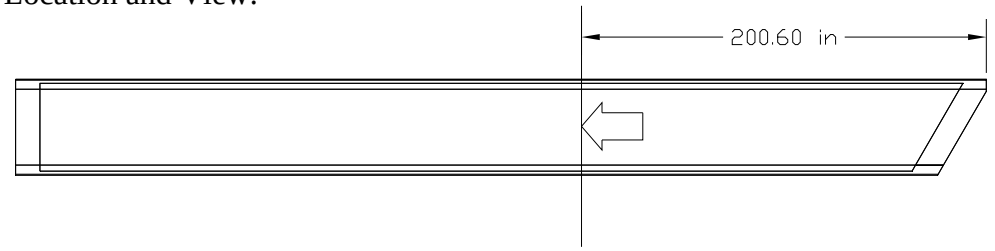


Figure A. 28: Picture BB08C3B

Beam Mark: BB08	Cut Location and View:
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB08C3B	

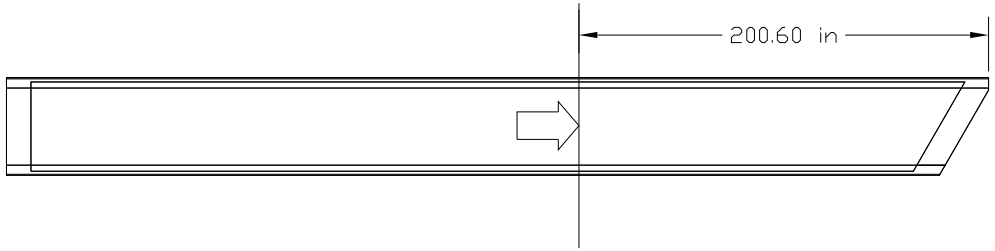


Figure A. 29: Picture BB08C4A

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C4A

Cut Location and View:

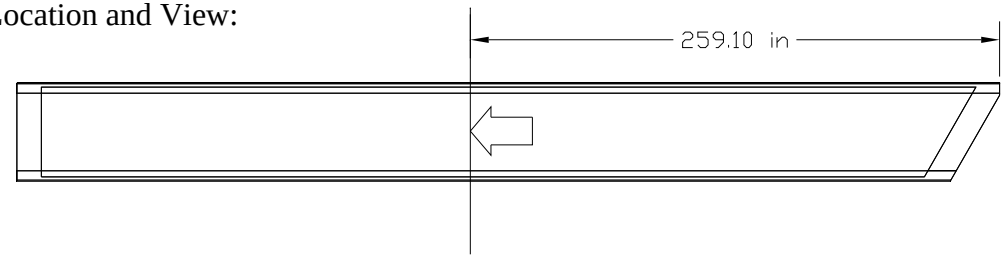


Figure A. 30: Picture BB08C4B

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C4B

Cut Location and View:

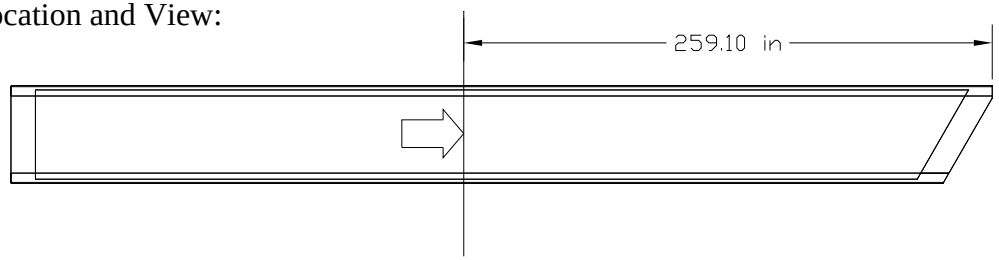


Figure A. 31: Picture BB08C5A

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C5A

Cut Location and View:

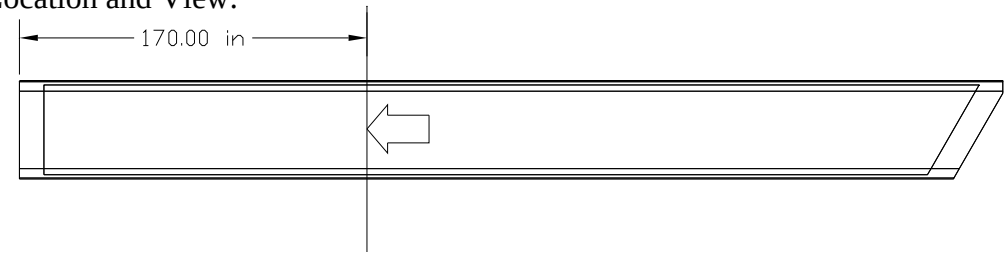


Figure A. 32: Picture BB08C5B

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C5B

Cut Location and View:

Figure A. 33: Picture BB08C6A

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C6A

Cut Location and View:

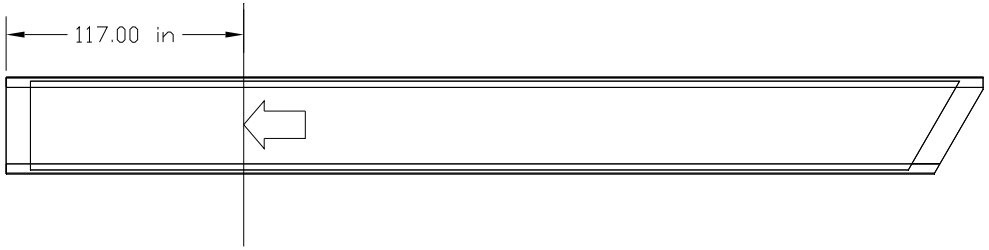


Figure A. 34: Picture BB08C6B

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C6B

Cut Location and View:

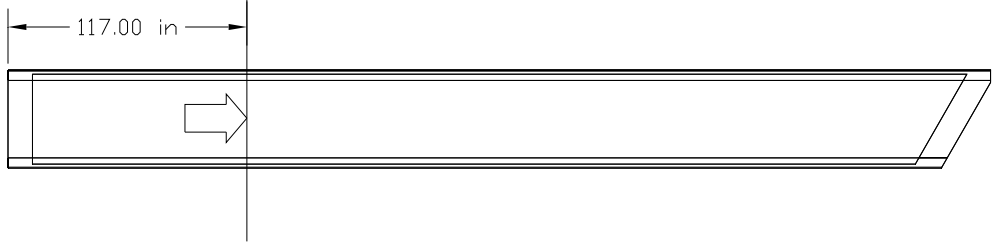
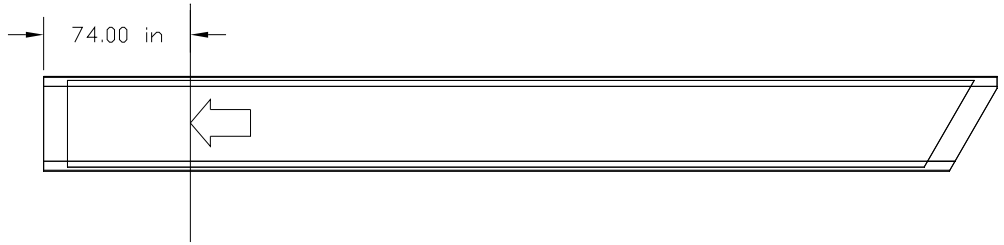


Figure A. 35: Picture BB08C7A

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C7A

Cut Location and View:



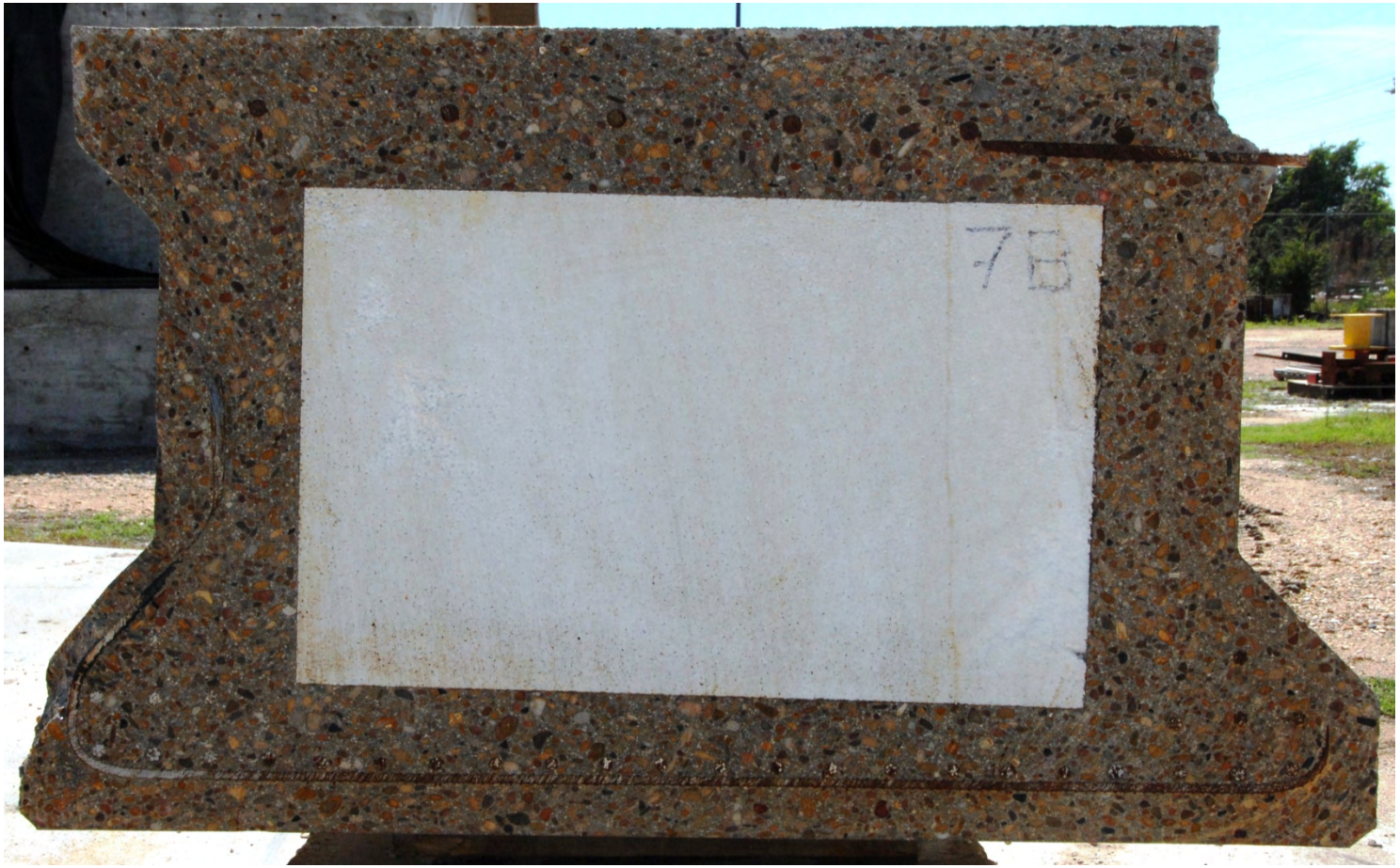


Figure A. 36: Picture BB08C7B

Beam Mark:	BB08
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB08C7B

Cut Location and View:

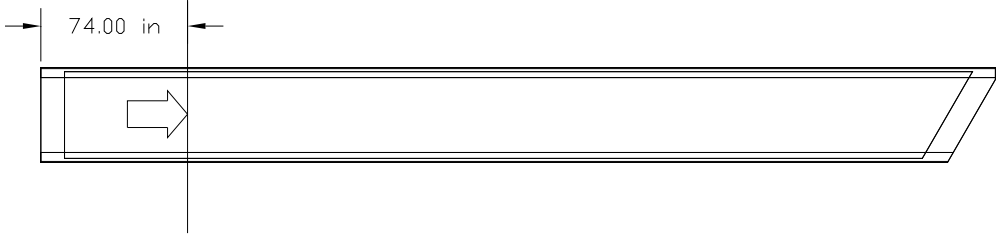


Figure A. 37: Picture BB09C1A

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C1A

Cut Location and View:

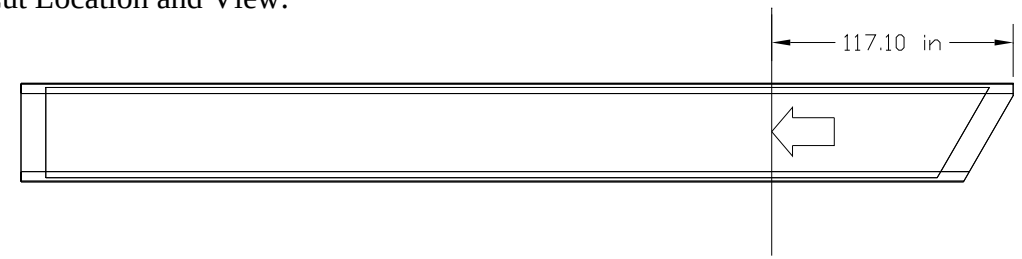


Figure A. 38: Picture BB09C1B

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C1B

Cut Location and View:

Figure A. 39: Picture BB09C2A

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C2A

Cut Location and View:

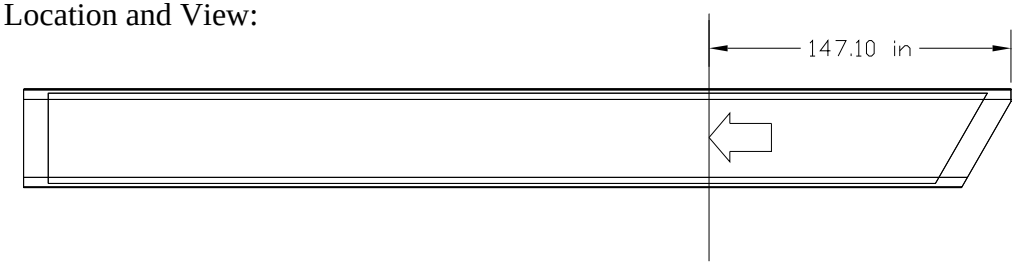


Figure A. 40: Picture BB09C2B

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C2B

Cut Location and View:

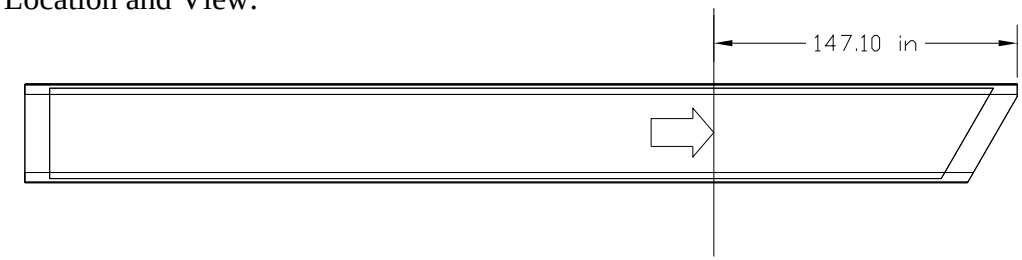


Figure A. 41: Picture BB09C3A

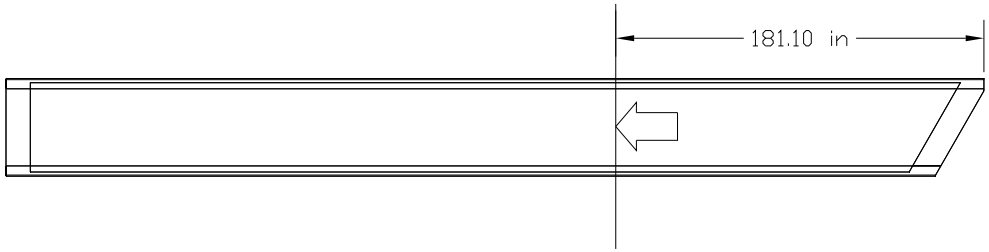
Beam Mark: BB09	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB09C3A	
Observations: This cut coincided with the joint between two Styrofoam blocks. The fabricator tapes together the top and sides of the blocks but since nothing is done to keep the bottom of the blocks together, concrete is able to flow up into the space between the blocks. This creates a thin layer of concrete (about ¼ inch) as it is observed in this picture.	

Figure A. 42: Picture BB09C3B

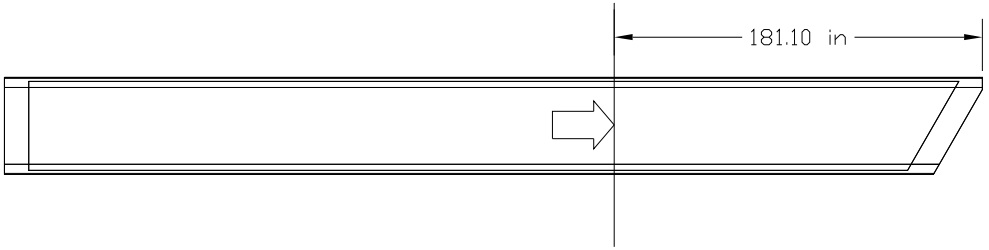
Beam Mark: BB09	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB09C3B	

Figure A. 43: Picture BB09C4A

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C4A

Cut Location and View:

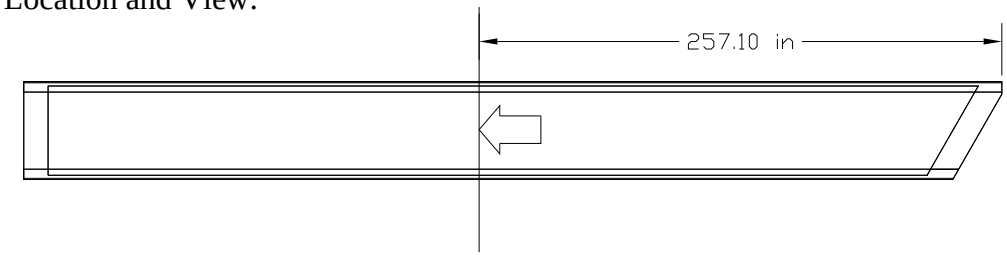


Figure A. 44: Picture BB09C4B

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C4B

Cut Location and View:

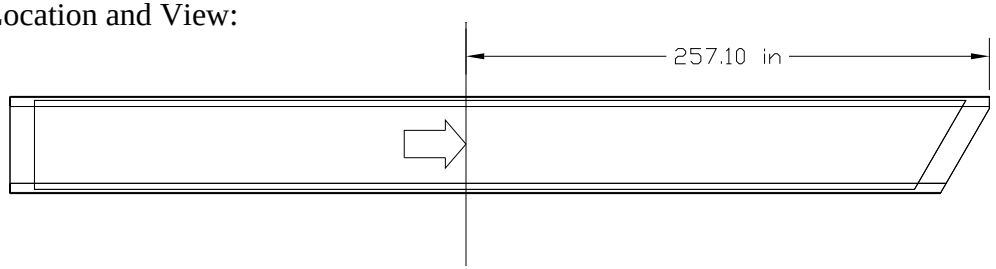


Figure A. 45: Picture BB09C5A

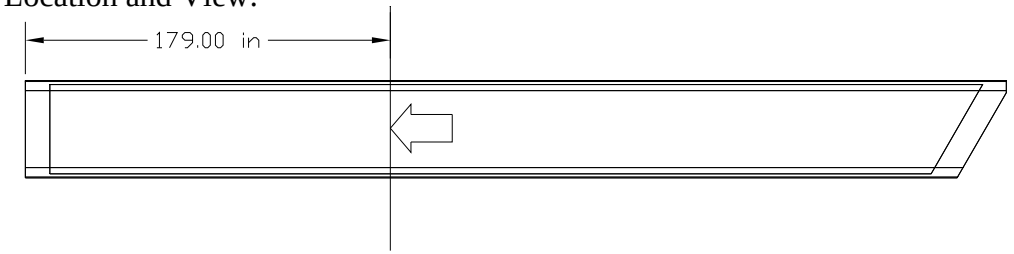
Beam Mark: BB09	Cut Location and View: 
Concrete Type: Self consolidating	
Aggregate: River Rock	
Cut ID: BB09C5A	

Figure A. 46: Picture BB09C5B

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C5B

Cut Location and View:

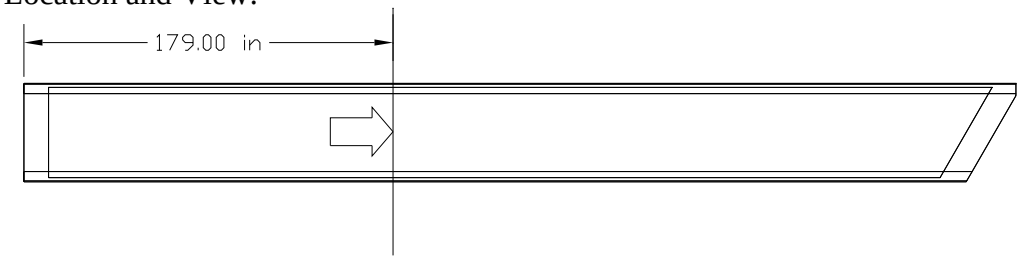


Figure A. 47: Picture BB09C6A

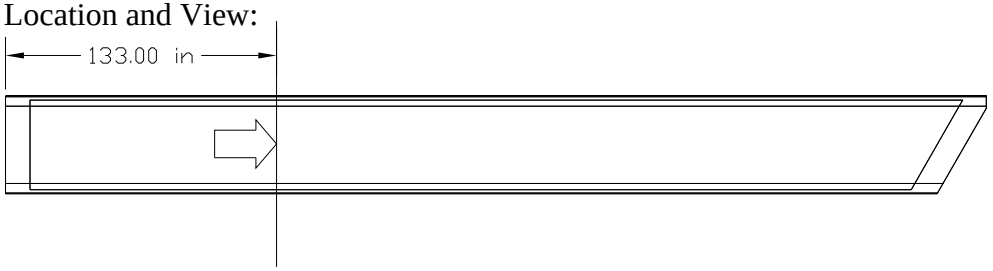
Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C6A

Cut Location and View:

Figure A. 48: Picture BB09C6B

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C6B

Cut Location and View:



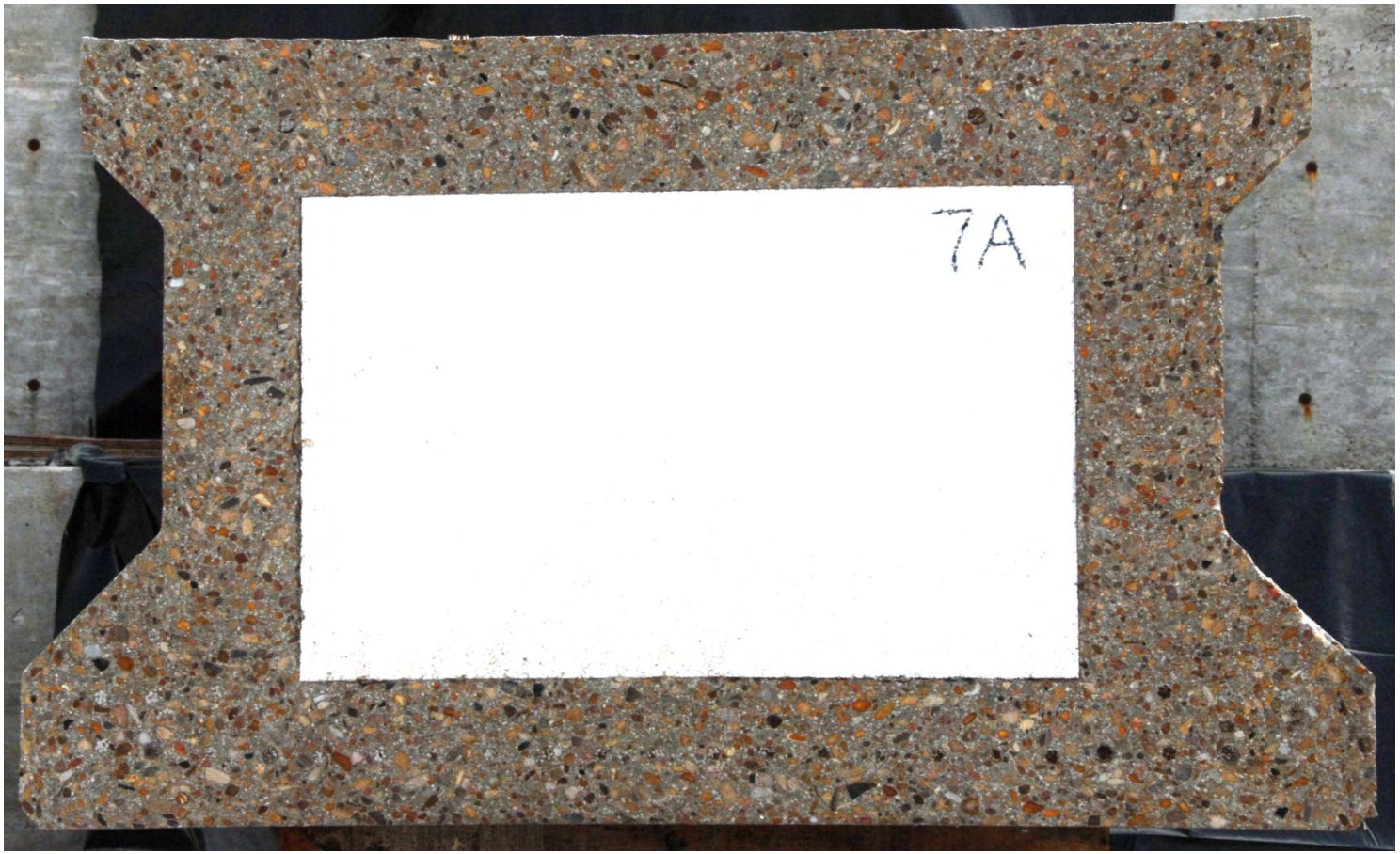


Figure A. 49: Picture BB09C7A

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C7A

Cut Location and View:

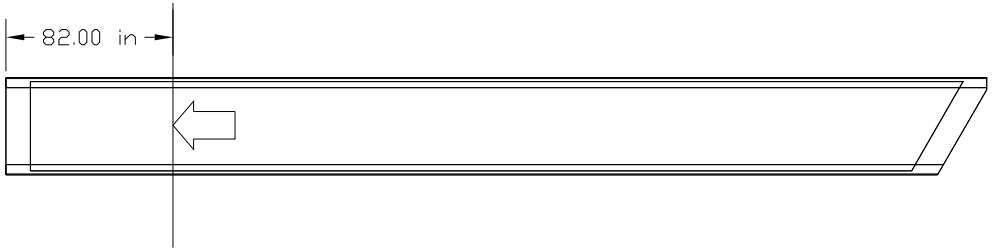


Figure A. 50: Picture BB09C7B

Beam Mark:	BB09
Concrete Type:	Self consolidating
Aggregate:	River Rock
Cut ID:	BB09C7B

Cut Location and View: