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Hollow Core Beam Bridge #20 over Broad Creek on SR 1124 in Carteret County, North Carolina

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Review of Hollow Core Beam Bridge #20 over Broad Creek

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Executive Summary

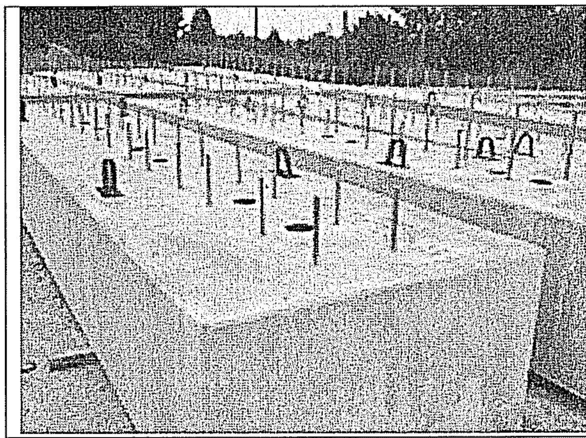
This report examines the project to replace Bridge #20 on SR 1124 over a branch of Broad Creek in Newport, NC. The replacement project employed a diamond-grind, hollow cored slab with precast barriers and approaches. The goal of the report is to document the construction process and to analyze the aspects of the project which worked well and those which merit examination for improvement.

In preparing this report, the construction team at the New Bern resident engineer's office was interviewed and the project site was visited. This bridge replacement method received positive comments for its potential to provide a durable replacement bridge with a shortened construction interval. However to realize this potential, several issues should be examined.

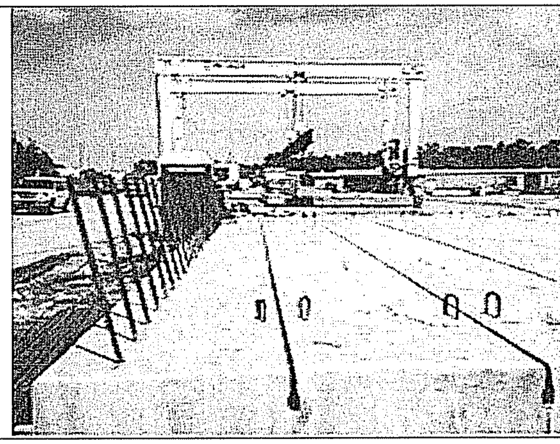
- First, availability of the precast materials and components delayed the project. It is essential for future projects that the precast supplier verifies manufacturing capability sufficient to meet the construction schedule. In addition, the manufacturing process demonstrated fit and finish issues which may have resulted from rushed manufacturing.
- Second, the project experienced inconsistent grout failures in several applications. These appear to be potentially related to either grout mixture / material issues or design.
- Third, there are transverse cracks evident on several of the cored slabs. Once again these are inconsistent and appear to be related to either the fabrication or material handling of these items.

Introduction

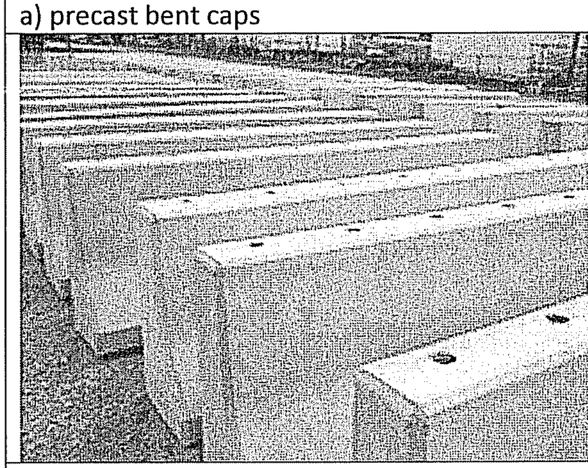
The project documents indicate that bids on this project (Contract ID C202081, TIP No. B-3625, and Federal –AID No. BRSTP-1124(3)) were opened on May 20, 2008. Major contract items on this proposal involved replacement of an aged bridge on a busy two lane road with a structure comprised primarily of pre stressed concrete and cored slab components. An advantage of this approach was that it was anticipated to reduce the period of road closure and public inconvenience. Figure 1 depicts typical steps in this construction approach[1].



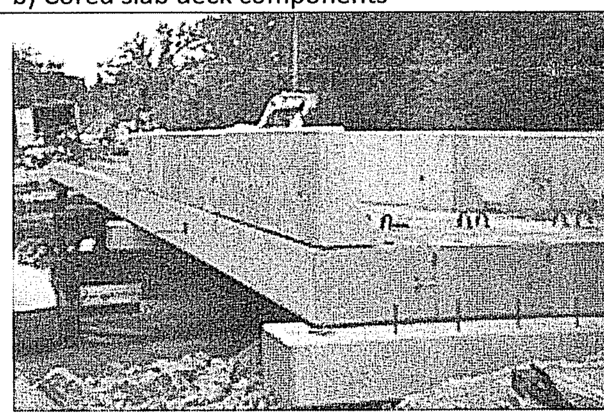
a) precast bent caps



b) Cored slab deck components



c) Guard rail components



d) Integrated structure

Figure 1 Cored Slab Bridge Construction Example

The specifications for this project did not stipulate asphalt overlay and grout was used to fill voids in the cored slab shear keys, dowel holes, and space in the joints between the spans. Without the overlay, the bridge deck had to be longitudinally diamond ground (planed) to obtain a smooth riding surface true to the grade and cross section requirements. Hairline transverse cracks appeared in some of the deck components and concern had been expressed that this may be related to the grinding process potentially damaging the grout and causing de laminations between the grout and the cored slab units. It had also been identified that holes left by the void hold-down systems were also uncovered by the

[1] Pictures from http://www.utilityprecastinc.com/exampleproducts.html

grinding process. The goal of this paper is to examine these previously identified issues and to identify any additional suggestions or ideas related to this project.

Project Review Meeting

A meeting was held on January 13, 2011 at the New Bern Resident Engineer's office with staff involved in the project. The staff reviewed project specifications and construction items they perceived to be noteworthy with this project compared to traditional methods including:

- Use of the precast deck and grinding of the bridge surface compared to topping with pavement.
- Use of precast approach slabs with jack screws contrasted to cast in place approaches.
- Precast bridge rails and use of anchor bolts versus rebar.
- Precast, crowned pile caps contrasted to cast in place methods

Appendix A contains selected pictures related to the construction of the project.

In general the resident engineer's staff expressed support for the potential benefits of the construction methods applied to this project as both feasible and presenting potential to produce durable replacement structures with reduced construction time. However, several issues were identified as important to improve:

- Manufacturing time table: Suppliers of the precast components did not appear to have sufficient production capability and there were delays in delivery. Apparently the precast beam supplier only had one form to produce the bridge spans for example. This resulted in loss of a month on the project and greatly reduced the potential construction time savings.
- Fit and finish: Component interfaces, fit, and end finish were not as thoroughly and precisely completed as would be expected. The picture in Figure 8 provides an example of this issue related to the finish of the bridge rails.
- Surface coat compared to diamond grinding: This project did not indicate that diamond grinding presented time saving over surface coating. Considering the current issues noted above related to concern about the impact of grinding, this should be reviewed as a future specification.

Site Visit

Subsequent to the project review meeting, a site visit was conducted and this section summarizes items reviewed and discussed. The following paragraphs examine these points by topical area.

Transverse Cracks on Hollow Core Beams

Inspection of the bridge highlighted the inconsistent nature of the occurrence of these cracks, transverse to the longitudinal beam dimension. In general, there did not appear to be identifiable patterns based on exterior issues such as placement of the beam, traffic load, grinding pattern or other factors. For example, a slab displaying this issue would be next to a slab with no indication of cracks. Figure 2 is a close up picture depicting a transverse crack in a precast deck slab. As seen in the picture, this crack occurs only in one slab and cracks are not evident in the adjacent slabs. This picture was taken in January and the cracks may well appear smaller in the summer. Nevertheless, it is important in the long term to identify the source of this phenomenon since it does not appear to be related to the grinding process.

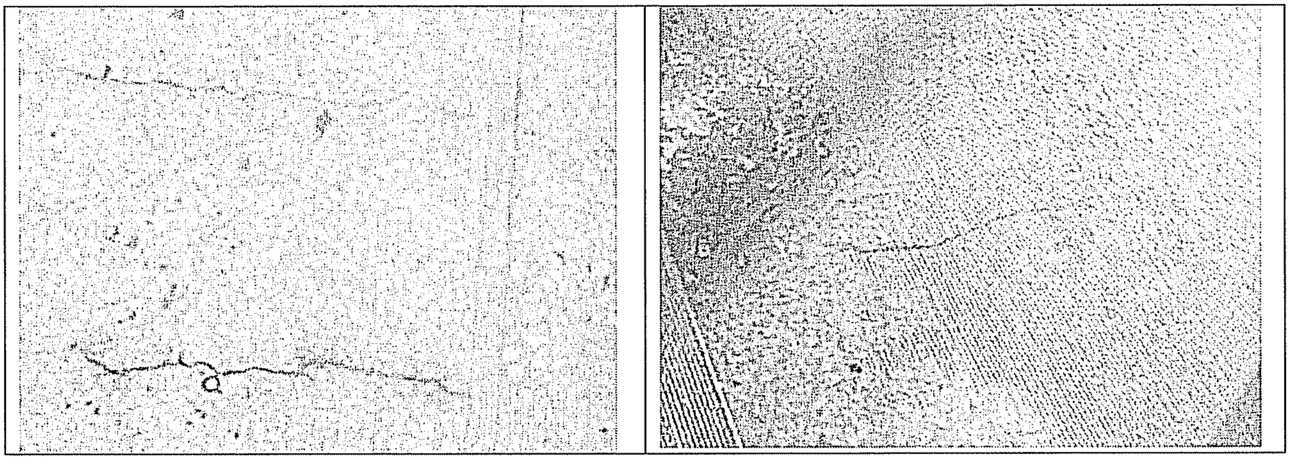


Figure 2 Examples of Transverse Cracks

There are a number of possible root causes which could explain the beam by beam occurrence of these cracks. Figure 3 provides information from a publication from the Prestressed Concrete Institute (PCI, 1983) and indicates a range of potential causes for the beam by beam occurrence of these cracks. The highest potential areas involve:

- The individual manufacturing process: It is possible that aspects of production of these beams relate to the formation of these cracks on an individual beam basis. Causes may relate to variation and quality control in the original manufacturing / fabrication steps, including shrinkage due to mix issues, curing / heat issues, and excessive top fiber tension, among others.
- Mishandling of the beams: This issues examines cantilever loading by misplacement of dunnage, and related activities which would result in an excessive cantilever condition.

Transverse crack

This is a crack across the member, predominantly occurring in the top, but can extend completely through the member in severe cases.

Cause	Prevention	Effect	Repair
A. Longitudinal shrinkage 1. Excess water in concrete 2. Rapid moisture loss 3. Heat applied too early 4. Excessive curing temperatures 5. Uneven heating along length of bed	**A. Proper mix and curing** 1. Reduce water content. 2. Cover product completely and as soon as possible (especially in windy, hot, or dry exposures). In extreme cases, spray product with mist or curing compound before covering. 3. Increase preset time before curing temperatures rise begins. 4. Reduce curing temperatures. 5. Check heat distribution system.	Potential shear capacity reduction if crack occurs at end. Can have a significant effect on shear and moment capacities of cantilevers. Reduction of moment of inertia in center of member can cause camber differentials and excessive deflections.	For minor cracks epoxy can be effective, and shear capacity can be increased by grouting voids solid at crack. Minor cracks in the top flange at areas of positive moment or in bottom flange at areas of negative moment may not require any repair. When a severe crack occurs in a member, cracked section should be cut out and resulting member placed in stock.
B. Contraction due to delayed detensioning after uncovering heat cured product	**B. Detention as soon as strength is verified, before product cools**		
C. Excessive top fiber tension 1. Cantilever loading by misplacement of dunnage 2. Inadequate or misplaced tension reinforced in cantilevers 3. Strand pattern too low 4. Low release strength	**C. Reduce top fiber tension.** 1. Maintain proper dunnage location. 2. Install adequate reinforcement at proper position. 3. Check placement of strand and consider debonding at end of members. 4. Increase release strength to accommodate top fiber tension.		
D. Insufficient cover on transverse reinforcing bar (when required for special designs)	**D. Increase reinforcing bar cover.**		

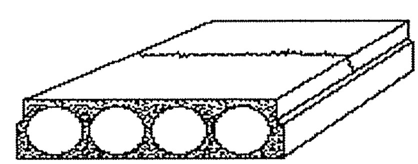


Figure 3 Causes of Transverse Cracks in Prestressed Hollow Core Slabs (PCI, 1983)

Grout Performance

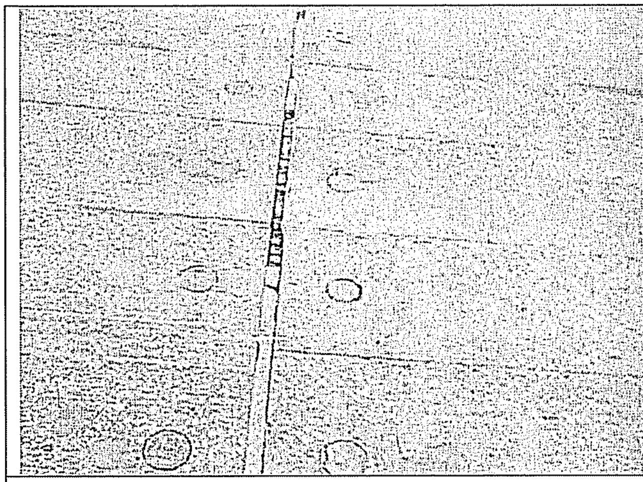
Issues are evident related to performance of the grout used both for filling voids longitudinally between beams and at the transitions between the approach and over the pile caps. Once again, the performance of grout was inconsistent.

- Figure 4 (a) and (b) show issues with the transverse joints between the beam slabs.
- Figure 4 (c) and (d) show issues with the transverse joint where the approach meets the beam slab and also with a longitudinal joint between beams.
- Figure 4 (e) shows a similar joint to 4(d) with no cracking evident.

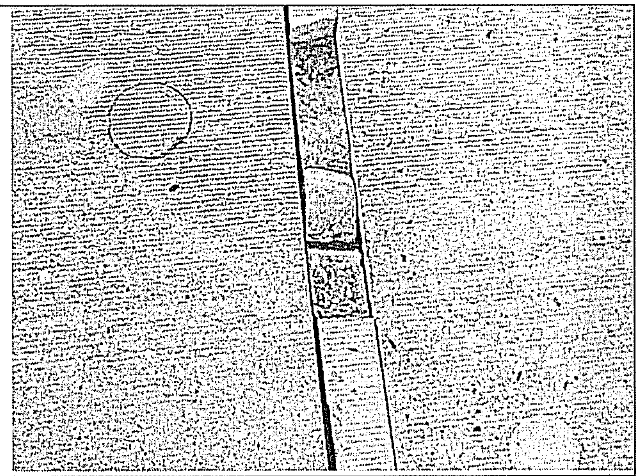
The inconsistency of the cracking in the longitudinal joints between beams may indicate an issue with mix or material consistency. As far as the transverse joints, root cause issues appear to relate to joint design, material specification or both.

Other Issues

Figure 5 illustrates a final issue observed during the site visit and relates to the potential implications of the late delivery of materials. The figure shows a concrete spall on the bridge shoulder. Delays in slab delivery forced the contractor to pour this segment early, before the approach was installed. The height ended up above the approach and it appears the grinding process may have produced a hairline crack which eventually resulted in this spall. Once again this highlights the importance of component availability to assure appropriate sequencing of tasks.

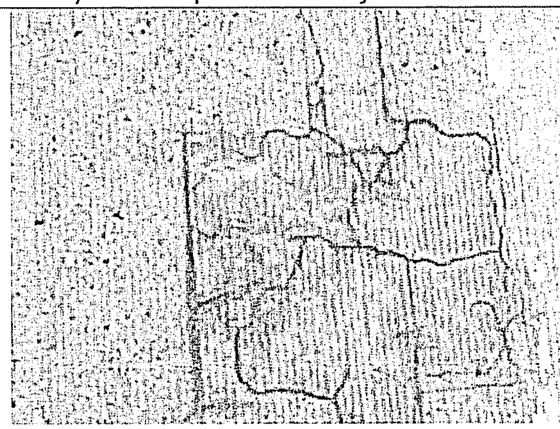


a) Deteriorated joint above bent



b) Close up- Transverse joint above Bent

c) Longitudinal joint between Beams and Transverse Joint at Approach



d) Close up of Grout between Beams

e) Beam Grout with No Cracks

Figure 4 Grout Pictures

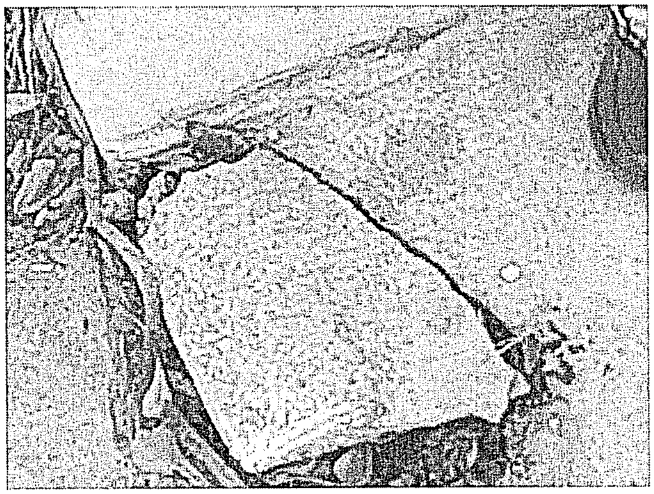


Figure 5 Concrete Spalling

Summary

This report reviewed the installation of hollow core Beam Bridge #20 over Broad Creek near Newport, NC. Project personnel involved in this replacement project believe that use of the pre stressed concrete components employed has the potential to provide a bridge renewal alternative with reduced construction time and a quality result. Experience in this case indicates that it is essential to have well prepared and qualified sources for the bridge components if these goals are to be accomplished.

A second area of concern involves visible and serious failure of grout used for a variety of voids. Both longitudinal and transverse grout joints showed evidence of failure. Design of these joints, material consistency, application quality, and the value of eliminating an overlay should be investigated relative to this issue.

Finally, the report documented several examples of transverse cracks visible in some of the longitudinal beams. These cracks are inconsistent and may be related to fabrication issues noted above or improper handling of the beams which resulted in excessive cantilever forces.

The issues noted above led to other construction issues involving work scheduling and the related quality of tasks which were performed out of sequence as a result of component delivery delays. This project highlighted the key point that the potential of promising new technologies can be hindered by poor vendor performance and possible quality issues.

Bibliography

Journal of the (PCI) Prestressed Concrete Institute. Fabrication and Shipment Cracks in Prestressed Hollow-Core Slabs and Double Tees. V. 28, No. 1, Jan-Feb. 1983

PCI- Prestressed Concrete Institute. PCI Manual for the Design of Hollow Core Slabs. 1998.

Appendix A: Select Pictures from Bridge Construction

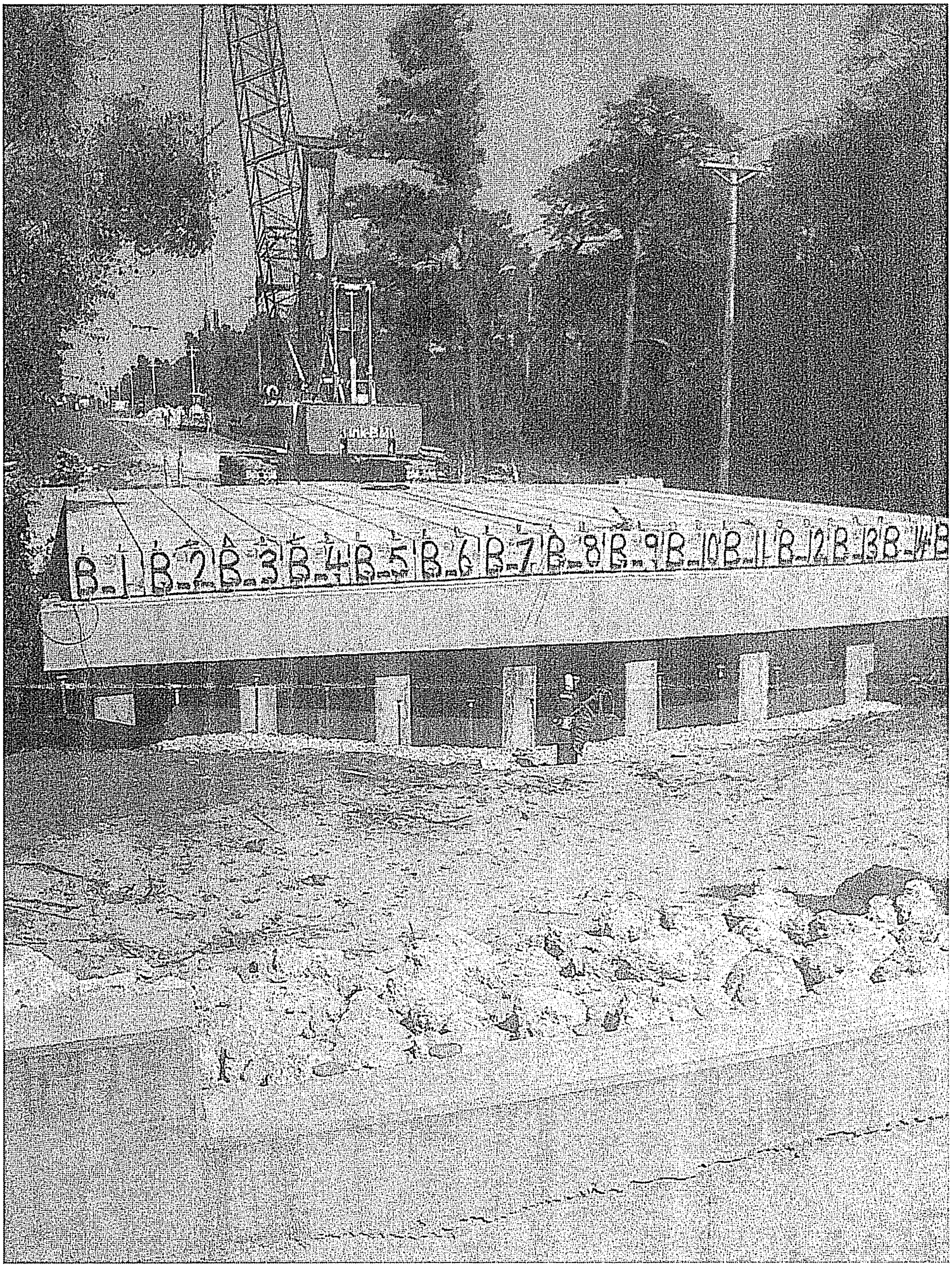


Figure 6 Hollow Core Beams and Bent

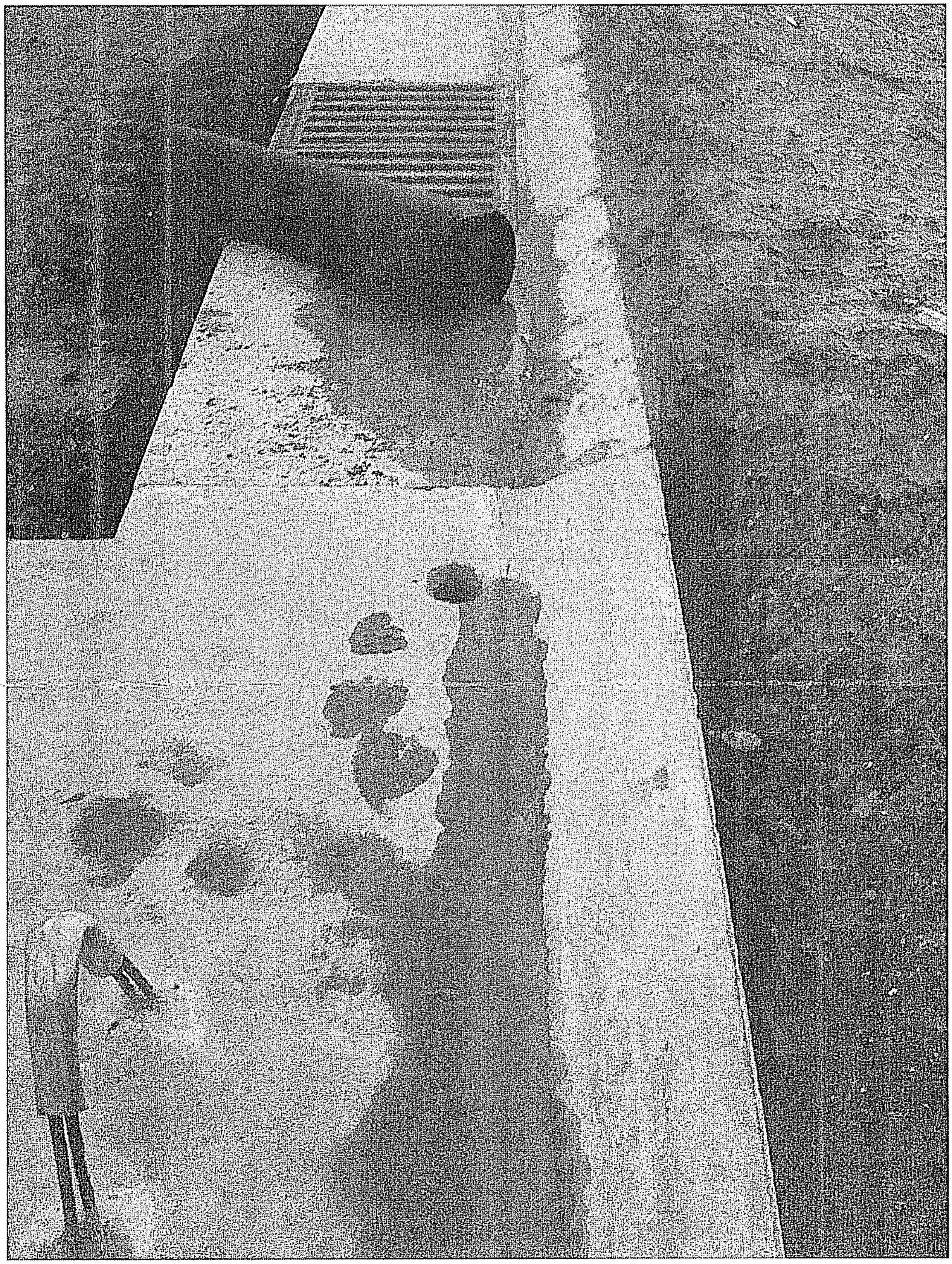


Figure 7 Approach and Poured Shoulder

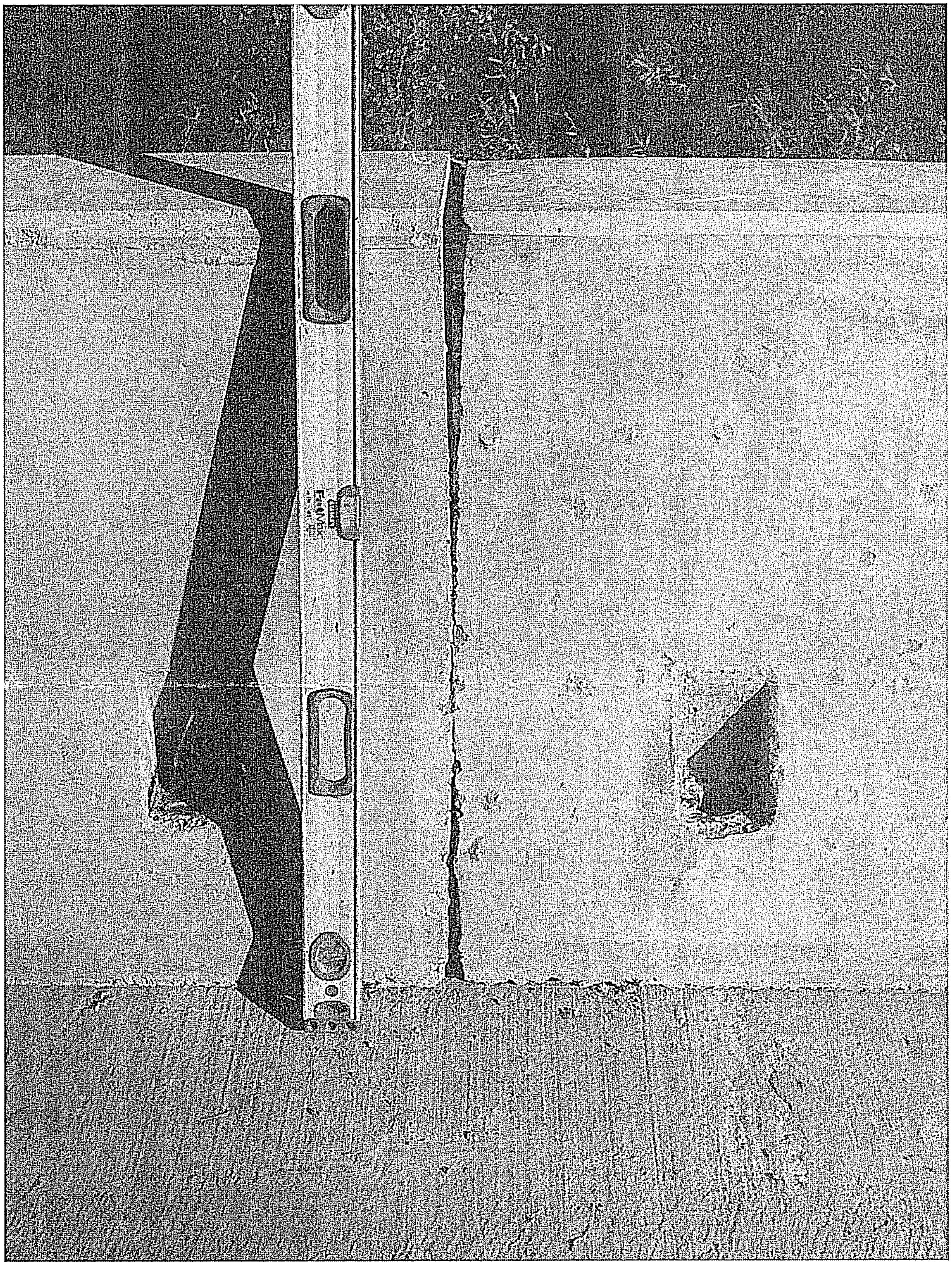


Figure 8 Bridge Rails and Finish Issue Example