Innovative Bridge Design/Construction Techniques to Expedite Construction

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This project examined various methods of innovative bridge design and construction techniques to expedite construction.

1. The following method have been identified as possible method of reducing the time needed for bridge construction:
   a. Precast substructures.
   b. Prefabricated composite bridge units.
   c. Prefabricated superstructure units, such as adjacent boxes, which do not need a separate wearing surface.
   d. Full depth precast concrete decks.
   e. Stay-in-place concrete or steel forms.
   f. Completely prefabricated bridges.
   g. Rapid curing concrete materials.

Items 1-6 have been tried in various states and the results of these trials can be found in an AASHTO Technology Implementation Group (TIG) report at www.ashtotig.org.

2. In order to find additional information on barriers to rapid construction, a survey of contractors was conducted. This survey showed that the main obstacle to fast bridge construction is the forming of the deck. The contractors also indicated that the best way to build bridges faster was to allow the entire bridge to be closed and the reconstruction to occur all at one time.

3. One possible solution to the deck forming problem is the use of stay-in-place steel deck forms. A survey of states showed that approximately 34 sta...
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CHAPTER 1

INTRODUCTION

Construction related lane closures, lane restrictions and detours cause significant safety risks, costs and inconvenience to the traveling public. The Ohio Department of Transportation has attempted to alleviate some of these problems by using contract incentives to have the work completed in fewer calendar days\(^1\). For the most part, these incentives are aimed at getting the contractor to condense the time schedule by adding workers, adding shifts, working weekends and eliminating dead time in the schedules. Even with incentives, there are limits to how quickly the job can be completed as there are tasks which cannot be done more quickly without possibly compromising the quality of the work (e.g. curing of concrete).

Bridges present major problems in scheduling. Unlike pavements, bridges usually cannot be temporarily widened to provide extra lanes during construction. Bridge work tends to be more complicated than pavement work due to the presence of substructure and superstructure elements. The work on bridges is also more linear. A contractor can have several different crews working on different parts of a pavement at the same time but in a bridge, a specific sequence must generally be followed: substructure elements first, then the super structure and finally the deck. Bridge elements are often made of concrete, which must be cured, adding more time the work.

The time needed for bridge construction/repair could be greatly reduced by reducing the amount of time needed to complete a particular task or by shifting the task to a location where traffic restriction is not needed (e.g. a precast member is cast and cured off site so there is no need to restrict traffic during these operations). To this end, ODOT created Strategic Initiative Five: Build Bridges Faster, Smarter, Better. The stated goals of Strategic Initiative Five were:

1) Conduct a literature search and surveys of manufacturers, contractors and state DOTs to determine which rapid repair/construction methods are available, along with methods which have been successful.

2) Collect cost and feasibility information on each method.
3) Initiate sample projects with the most promising expeditious construction techniques and processes.

4) Develop best practice guidance for the most expeditious/cost effective bridge construction techniques.

5) Complete the initiative by June 2002.

A committee was formed made up of ODOT personnel, contractors and consultants. The University of Cincinnati was retained to provide help with literature searches and surveys. This reports details the findings of the literature searches and surveys.
CHAPTER 2
INFORMATION SEARCH

Authors note: This section describes certain products and processes found in a search of available literature. As it is ODOT policy not to recommend specific manufacturers or products, all the information presented here is in a generic form and specific manufacturers and/or product names are not mentioned.

2.1 INTRODUCTION

In looking for product or process information, the normal sources, archival journals, were not a good source. Journal articles tended to focus on theory and rarely related case studies or information on product performance. The information on methods and products for rapid construction was collected by searching the Internet, as this was thought to have the most up-to-date information. Two excellent summaries of rapid construction methods/products were found. One is a paper by Ralls, et. al. summarizing the work of an American Association of State Highway and Transportation Officials (AASHTO) Technology Implementation Group (TIG)\(^2\). The second is the AASHTO TIG website (www.aashtotig.org). This website has the report of the TIG\(^3\). Although much of the relevant information was found on the internet, germane papers from journals are summarized at the end of this chapter.

2.2 RAPID CONSTRUCTION METHODS

2.2.1. Prefabricated Substructure Elements

Several references were found on the use of prefabricated substructure elements\(^4\). Texas Department of Transportation (TxDOT) used prefabricated columns and pier caps for the Louetta Road Overpass on Highway 249 near Houston. These columns were match cast, that is, previously cast sections were used as part of the formwork for new sections. This assured precise alignment of the sections in the field, thus expediting the construction process. The sections were connected by using post-tensioning bars.

Prefabricated pile bent caps were used in Texas (US 290 – Route “G” in Austin) and Tennessee (Route 57 over Wolf River in Fayette County). In Texas, the ramp closure time was reduced from 42 days to 8 hours\(^2\). The prefabricated bent caps in Tennessee\(^3\) were used to avoid placing equipment in an environmentally sensitive area.

A supplier of mechanical reinforcing bar connectors references the use of precast substructures in several states\(^5\). In Florida the contractor was able to erect 6 columns and 3 pier caps each day Edison Bridges in Ft. Meyers. These bridges were 1 mile long and consisted of 10
spans each. Contractors were able to erect the footings, abutments and wingwalls for a single span bridge in New York (Route 9N over Sucker Creek) and a three span bridge in Massachusetts (Great Road over B&M Railroad) in one day. This supplier reports that precast substructure units have also been used in Nebraska, Washington State and Indiana.

### 2.2.2 Prefabricated Composite Bridge Units

Another system for increasing the speed of construction is the use of prefabricated composite bridge units. These systems consist of steel or precast concrete girders with concrete decks precast on top. This eliminates the need to cast the composite deck. These systems have been successfully used in several bridges:\(^3\):

- I-95/James River Bridge in Virginia
- Lions Gate Suspension Bridge in Vancouver BC
- Main Street Bridge over Metro RR North in New York

Many of these systems are proprietary.

### 2.2.3 Prefabricated Superstructure Units

Prefabricated superstructure units have been used for decades as adjacent member structures. These structures usually consist of adjacent box girders or adjacent bulb “T” systems. In these systems, a separate wearing surface of cast-in-place concrete or asphalt is added. This increases construction time. Some states use adjacent units without a separate wearing surface. Three states bordering Ohio, Kentucky, West Virginia and Indiana, use adjacent box girder systems without separate wearing surfaces.

One problem with adjacent systems is leakage of the grout joints between the adjacent girders. When a separate wearing surface is installed, it provides a additional barrier to water penetrating these joints. To stop leakage in systems without a wearing surface and to improve the integrity of the grout joints, several states laterally post-tension adjacent structures. An explanation of the procedure can be found in a report from West Virginia\(^6\).

### 2.2.4 Precast Full Depth Deck Panels

National Co-operative Highway Research Program (NCHRP) Report #407\(^7\) discussed various ways to increase the speed at which decks could be replaced. One task in this research was to develop a precast deck system. The system developed consisted of 8.1” (206mm) thick, ribbed deck panels which were 7’-10” (2.4 m) wide and their length was such that a single panel would span over all the girders for the entire width of the bridge. To minimize depth, the panels were longitudinally pretensioned. These panels were set to the correct height through leveling screws and a grout bed was cast between the panels and girders. The panels were connected to
the girders by threaded studs, which could be welded onto steel girders and cast into (or, in the case of a rehabilitation, drilled and grouted) into concrete girders. Grouted shear key joints were used to transfer shear between adjacent panels. The panels were also laterally post-tensioned.

The AASHTO TIG³ reports that precast, full depth deck panels have been used in various projects:
I-45 Pierce Elevated in Texas
SH66/Lake Ray Hubbard in Texas
Cross Westchester Expressway Viaducts in New York
Route 7 over Route 50 in Virginia.

2.2.5 Stay-in-place Forms

Several manufacturers sell stay-in-place (SIP) deck forms. Steel forms predominate the market although, according to the AASHTO TIG, precast forms are being used more and more. Precast SIP forms were used in the 1960s, but they fell out of favor when cracking problems developed. These problems have been blamed on improper support conditions for the panels⁶,⁸. Because precast concrete SIP forms are heavier and thicker than steel SIP forms, they are often designed to act as a composite structure with topping. This also lead to concerns about cracking and if the composite action could be maintained. However, studies have shown that these panels can be used successfully, without cracking and will maintain composite action⁶,⁹

The AASHTO TIG found two cases where SIP concrete forms were used:
Route 57 over Wolf River in Tennessee
I-5/South 38th Street Interchange in Washington State

TxDOT uses SIP concrete forms for their “U” or “bathtub” girders. Nebraska and Florida DOTs use these forms with inverted “T” section bridges.

SIP steel forms are used in many states. In 1995, the Federal Highway Administration (FHWA) conducted a survey on the use of SIP steel forms. This survey is presented in Chapter 4 along with an update done for this project.

2.2.6 Completely Prefabricated Bridges

By combining the technologies given above, it is possible to create a completely prefabricated bridge unit. The AASHTO TIG identifies the following bridges as being completely prefabricated:
Baldorioty de Castro Avenue Overpass in San Juan, Puerto Rico
Cross Winchester Expressway Viaducts in New York, New York
Linn Cove Viaduct in North Carolina
Reedy Creek Bridge in Florida
Route 9/Metro North Pedestrian Bridge in New York

2.2.7 Rapid Curing Concrete

Another way to speed bridge construction is to use rapid curing concrete. Precasters have been able to attain strengths of 4 – 8 ksi (28-56 MPa) overnight by using Type III cement, low water/cement ratios and steam curing. Some high performance concretes will attain high strengths when only a few days old. Several manufacturers sell rapid curing, polymer or latex modified concrete materials. However, these materials are usually used for rapid repair of concrete or for pavements, rather than for casting entire concrete structures. No specific instances of rapid curing concrete for structural applications were found.

2.2.8 Foundations and Highway Embankments

The Federal Highway Administration sent a scanning team to Europe to examine accelerated construction of highway embankments and bridge foundations\textsuperscript{10}. The SCAN team identified the following items:

List of Technologies:

1. Embankment on column
2. Lightweight aggregate
3. Deep mixing (lime/cement) columns
4. Mass stabilization
5. Geotextile encased columns
6. Rapid impact compaction
7. Vibro-Jet sheet pile driving
8. Load transfer mat concrete slab
9. Load transfer mat – caps and geosynthetics
10. Automatic controlled variable roller compaction
11. Reinforced soil sound barriers
12. Self drilling hollow nail bars and micropiling
13. Screw piling
14. Combined soil stabilization (CSV) systems
15. Accelerated site investigation
16. Continuous flight auger piles
17. Bored Piling-Cased Secant Piles
18. Berlin Wall (micro-pile wall)
19. Continuous diaphragm wall
20. Hydro-Millä Diaphragm walls
21. Reinforced protective umbrella method glass reinforced plastic rebar
22. Pretunneling
23. Micropiling Rod Carousels
24. Rock saw
25. Computer controlled consolidation grouting
26. Turbo-jets
27. Horizontal vacuum consolidation
28. AuGeöä (piling)
29. Dynamic stiffness gage
30. Higher energy compaction impact roller

Processes and Approaches for Fast Track Construction:

A. Public Relocation during Construction
B. Communication with the Public
C. Designer on Board during Construction
D. Contractor Involved in Design
E. Contractor/Designer QC/QA Required ISO 9000
F. Real-Time Lab Testing and Data Storage
G. Real-Time Design (e.g., ADECO-RS (Analysis of Controlled Deformation)
H. 10-Year Warranties/Insurance
I. Pile Load Test Program/Certification for Screw Piling (Recommendations)
J. Self-Compacting Concrete
K. Prefabricated Bridge Parts (Bayonet Pipe Pile Connection)
L. Moving Completed Bridges on Site
M. Automated GPR for Pavement
N. Maintenance-based Payment Procedure
O. Automated Control QC Documentation of Installation
2.3 PAPERS RELATED TO RAPID CONSTRUCTION/INNOVATIVE CONTRACTING

Summarized below are several papers/reports on rapid construction and innovative contracting. These papers do not concentrate on specific products, but offer general guidance.

Jaraiedi, Plummer and Aber\textsuperscript{11} discussed ways to ensure the successful completion of the accelerated projects. They noted that it is important for the contracting agency to do everything possible to eliminate delays and disruptions in the construction and that the contracting agency needs to anticipate potential trouble spots and develop methods for dealing with them. The following points must be carefully considered in the preparation and execution of contracts.

1) Extra time and effort must be given to project development so as to avoid costly field changes once the project begins. Pre-design field reviews are important at this stage as the actual construction at the site may be different from that indicated on old construction plans.

2) It is important that the contract clearly specifies the procedures that will be in place should any changes in the scope of the work take place. Additionally, the contract should state under what circumstances the completion date will be extended and under what circumstances the contractor is responsible for delay.

3) The contract must clearly define when the incentive/disincentive (I/D) time will begin and end, as it may be different from the start and completion date of the rest of the project. It is important that the contract defines in detail what is expected of the contractor to earn the incentive payment. This would include a detailed list items that may be completed after the I/D completion date, such as shoulder and cleanup.

4) All parties that will be involved with the construction, including the local officials and police, should participate in preconstruction meetings. This will help uncover any unusual features of the project, as well as any restrictions that may affect the construction such as a restriction on jack hammering at night due to noise problems.

5) Prior to awarding the contract, there should be a written agreement between the contracting agency and utility companies addressing what work needs to be done and when it will be done. This should minimize delays once the construction begins and reduce the potential for conflicts between the contracting agency and the contractor.

6) Prior to construction, arrangements for the moving of right-of-ways must be confirmed and completed. Failure to do this could result in a lengthy delay in the construction process.
O’Connor and El-Diraby\textsuperscript{12} presented a case study on the Mockingbird Bridge BCP (Bridge Construction Project). They identified these key elements:

1) Awareness of the critical contribution of the BCP to the overall success of urban freeway reconstruction projects; the sooner this occurs, the greater the likelihood of overall project success.

2) Integration of traffic safety, traffic control planning, construction sequencing, and constructability into one initiative.

3) Importance of generating several BCP approaches and not being complacent with the first scheme developed.

4) Importance of a team approach, particularly with contractor participation in the process.

Texas Department of Transportation published a set of guidelines for accelerated construction\textsuperscript{13}. A brief summary follows:

Design considerations:

1) Solve all right-of-way issues and utility issues before construction. If this is not possible, sequence work around conflicts.

2) Resolve environmental issues before construction starts.

3) Be sure plans and specifications are complete before construction. Have accurate estimates of quantities.

4) Have a realistic time schedule. Allow enough working days.

5) Consider effects of weather on allotted time. Also consider weather effects on the construction process (e.g. some processes cannot be done in hot or cold weather). Adjust let dates to avoid weather related conflicts.

6) Allow long lead times, as needed, for material procurement so all materials are available at start-up.

7) Consider the effects of third parties. If local governments, utilities, etc. must participate, funding problems may delay construction.

8) Have a constructability review.

Construction Considerations:

1) Review, analyze and monitor CPM schedule.

2) Work with contractor to solve problems proactively.

3) Process change orders in a timely manner.

4) Make contract administration decisions in a timely manner.

5) Be open to suggestions from the contractor.
6) Work with the contractor to revise the schedule to show the effect of sequencing on the overall project. It may be that accelerating a task does not help the project finish earlier.

The remainder of the report discusses contracting methods, such as incentive/disincentive, A+B, lane rental, etc.

Transportation Research Board Committee on Construction Management (AFH10, formerly A2F05) published a millennium paper on innovative practices in highway contracting. This paper summarized the benefits and barriers to using warranties, transfer of quality control, multi-parameter bidding, constructability reviews, design-build, quality based contractor pre-qualification and electronic bidding. However, the most useful part of the paper was a survey of state DOT’s on contracting practices.

A survey was sent to 50 state DOTs and 4 Canadian DOTs to determine their experience with innovative contracting practices. The DOT’s were asked to identify innovative practices that have been tried, and to rate the benefit and the difficulty of its implementation. A total of 24 DOT’s responded and some these respondents were interviewed. The benefit perceived from each innovation was rated from 1.0 (low) to 5.0 (high). The difficulty of implementing the innovation was rated from 1.0 (easy) to 5.0 (very difficult). The report state that “All of the methods tried are believed to be beneficial, but it is believed that most will be somewhat difficult to implement”

The following table is taken from the report:

<table>
<thead>
<tr>
<th>Contract Innovation</th>
<th>% of Respondent Use</th>
<th>Benefit Received</th>
<th>Difficulty of Implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partnering</td>
<td>89.7</td>
<td>3.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Quality Control by Contractor</td>
<td>93.1</td>
<td>3.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Warranties</td>
<td>20.7</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Lane Rental</td>
<td>Design Build</td>
<td>A+B(Cost + Time)</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------</td>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>52.0</td>
<td>48.3</td>
<td>69.0</td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>2.8</td>
<td>3.3</td>
<td>2.4</td>
</tr>
</tbody>
</table>

As seen from the table above, many states use incentive/disincentive types of contracts. Shr and Chen\textsuperscript{15} summarized the caps on I/D contracts used by the various states. The following table is from this work:

**Incentive/Disincentive cap rates for different states**

<table>
<thead>
<tr>
<th>State</th>
<th>Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>None</td>
</tr>
<tr>
<td>Arizona</td>
<td>+30 days</td>
</tr>
<tr>
<td>Arkansas</td>
<td>None</td>
</tr>
<tr>
<td>California</td>
<td>Dollar amount\textsuperscript{a}</td>
</tr>
<tr>
<td>Colorado</td>
<td>None</td>
</tr>
<tr>
<td>Delaware</td>
<td>None</td>
</tr>
<tr>
<td>Florida</td>
<td>Varies</td>
</tr>
<tr>
<td>Georgia</td>
<td>None</td>
</tr>
<tr>
<td>Idaho</td>
<td>Varies</td>
</tr>
<tr>
<td>Illinois</td>
<td>N/A</td>
</tr>
<tr>
<td>Indiana</td>
<td>Dollar amount\textsuperscript{c}</td>
</tr>
<tr>
<td>Iowa</td>
<td>None</td>
</tr>
<tr>
<td>Kansas</td>
<td>Dollar amount\textsuperscript{a}</td>
</tr>
<tr>
<td>Maine</td>
<td>Dollar amount\textsuperscript{c}</td>
</tr>
</tbody>
</table>
Maryland 5%
Massachusetts None
Michigan 5%
Minnesota None
Missouri 10%
Montana Varies
Nevada Varies
New Hampshire None
New Jersey Dollars 100,000
New York 10%
North Carolina Varies
North Dakota 5%
Ohio 5%
Pennsylvania 5%
South Dakota None
Tennessee None
Utah Dollar amount<sup>c</sup>
Virginia Dollar amount<sup>b</sup>
Washington 5%
Wisconsin Varies
Wyoming 6–8%

<sup>a</sup>Fixed.
<sup>b</sup>Fixed except the A+B contracts.
<sup>c</sup>Fixed or negotiated not available.

Chan et. al. 16 studied partnering. Although partnering can be applied to any contract, the above references show the critical importance of partnering in accelerating construction. Chan et. al. identified 10 factors which have the most impact on a successful partnering project:

1) Establishment and communication of a conflict resolution strategy.
2) Commitment to win-win
3) Regular monitoring of the partnering process.
4) Clear definition of responsibilities.
5) Mutual trust.

6) Willingness to eliminate non-value added activities.

7) Early implementation of the partnering process.

8) Willingness to share resources among participants.

9) Ability to generate innovative ideas.

10) Subcontractor involvement.

Of the 10 items listed above, items 1, 8, 4, 2 and 3 (in that order) were found to be the most critical.

Some references were found on fast-tracking. Fast-tracking is not the same as accelerating. Accelerated construction follows the traditional linear path of planning, design and then construction, but the construction phase is compressed. In fast tracking, there is an attempt to have planning, design and construction proceed simultaneously, with offsets in the start time of each phase. As a result, construction on a fast-track project starts before the final design is complete. Often, final design is less than ½ finished when construction starts. Fast-tracking is favored by industries where delays in opening a plant may result in lost profits or market share.

Williams\textsuperscript{17} stated that “ideas of control and suspicion and minimizing risks must be replaced by trust, empowerment, openness, customer focus, and taking smart risks.” He listed the following pros and cons of fast-tracking:

1) Schedule: There is no time for optimization and there is little time for studies and surveys. As a result, mistakes may occur.

2) Design: Because the design process is accelerated, the engineers and planners may not have the opportunity to consider future outcomes (e.g. the design may prevent a facility from being able to produce a second or third line of products as efficiently). The structure/facility may not be as well suited for future expansion as it would have been had there been time to carefully consider all possibilities.

3) Materials: In fast tracking, teams focus on overall value rather than just on material savings. Some material wastage is accepted in favor of more effectively utilizing the design-build team labor force.

4) People: Politics and “turf wars” must be set aside to allow the team to reach quick decisions. There is no time for indecision or petty disputes. Fast-track projects work best when a well lead, empowered team is in place.
5) Cost: Conventional wisdom holds that a fast tracked project costs more, but it could cost less depending on the size, complexity, the level of overhead, the expected duration, and the size of the project team. For example, if a project is completed in a fraction of the time, there is only that fraction of the time for which overhead can be applied.

### 2.4 COSTS OF ACCELERATING CONSTRUCTION

No cost data on any method or product used for accelerating construction was found. Part of the reason may be that most of the projects found were pilots. Pilot projects tend to have high costs, which come down as the method or product becomes more mainstream. It may be that costs are not published to avoid giving an inaccurate portrayal of the eventual cost of the method or product. Construction cost data is, in general, difficult to find. Construction is a highly competitive industry and prices change frequently in response to market demand. Contractors normally do not want anyone publish costs for fear of being “locked in” to these costs.
CHAPTER 3
CONTRACTOR SURVEY

3.1 INTRODUCTION

The previous chapter identified several methods of speeding up bridge construction. However, there is some question as to whether applying these methods would actually result in a time savings. For the contractor to save time on a job, he/she must reduce the time it take to complete items on the critical path. Reducing the time required to complete items not on the critical path result in no net time saving. To this end a survey was conducted of Ohio contractors to determine what areas were most likely to be on a critical path and, therefore, showed the most promise to reduce construction time.

3.2 SURVEY

The following survey was sent to contractors in Ohio.

Contractor’s Survey

In conjunction with The Ohio Department of Transportation, we are surveying a limited group of Contractors. The objective of this survey is to examine where the Department should focus its efforts to increase the speed of bridge construction with the goal of reducing disruption to the traveling public.

This survey asks about the following type of bridge:

Mainline Interstate
An average deck Area of 24,000 SF
Multiple spans with a total length of 150' to 400'

The typical existing structure is a steel superstructure with a reinforced CIP concrete deck.

Typical projects will be: deck replacements, widenings, total structure replacements, or overlays.
Consider an existing bridge with deck replacement only:

Please consider the following steps. We need information on how these steps are a significant contributor to the reduced traffic capacity/closure of the bridge.

1) Removal of the existing deck.
2) Forming the new deck.
3) Placing the rebar.
4) Pouring the new deck.
5) Curing the new deck.
6) Parapet/barrier placement.
7) Backwall replacement and approach slab work.

Q1: Of the steps listed above, which single step is the greatest contributor to lane or bridge closures? Which is second?

Q2: Which of the steps above contribute the least to lane or bridge closures either because they take little time to complete, can be completed with the bridge open or can be completed simultaneously with another step?

Q3: Would any of the following technologies significantly reduce lane or bridge closures?

a) Precast, full depth, post-tensioned deck slabs.
b) Stay in place forms (steel or concrete).
c) Replacing the rebar with wire mesh.
d) The use of larger diameter shear studs.

Q4: Is there a technology or construction technique which you believe would significantly lessen the lane or bridge closures for the bridge construction?

Widening an existing bridge.

Please consider the following steps. We need information on how these steps are a significant contributor to the reduced traffic capacity/closure of the bridge.

1) Substructure work (ie. piles, footings, piers, abutments, MSE walls)
2) Placing the superstructure
3) Forming the new deck.
4) Placing the rebar.
5) Pouring the new deck.
6) Curing the new deck.
7) Parapet/barrier placement.
8) Closure pours - if used.
9) Approach slab work.
Q1: Of the steps listed above, which single step is the greatest contributor to lane or bridge closures? Which is second?

Q2: Which of the steps above contribute the least to lane or bridge closures either because they take little time to complete, can be completed with the bridge open or can be completed simultaneously with another step?

Q3: Would any of the following technologies significantly reduce lane or bridge closures?

1) Precast, substructure elements.
2) Single span steel members with integral piers made continuous for live load.
3) Replacing the rebar with wire mesh.

Q4: Is there a technology or construction technique which you believe would significantly lessen the lane or bridge closures for the bridge construction?

**Superstructure Replacement:**

Q1: Which method of construction would most likely result in the shortest reduced traffic capacity/closure of the bridge?

   a) partial width reconstruction with closure pours.
   b) move all traffic to the adjacent bridge and completely reconstruct the bridge.
   c) both options would take about the same amount of time.

Q2: Is there a technology or construction technique which you believe would significantly lessen the lane or bridge closures for the bridge construction?

**Overlays - Concrete:**

Please consider the following steps. We need information on how these steps are a significant contributor to the reduced traffic capacity/closure of the bridge.
1) Removal of the existing concrete surface.
2) Sounding the deck for other bad concrete and removing it.
3) Cleaning or replacing corroded rebar.
4) Placing the overlay.
5) Curing the overlay.

Q1: Of the steps listed above, which single step is the greatest contributor to lane or bridge closures? Which is second?

Q2: Which of the steps above contribute the least to lane or bridge closures either because they take little time to complete, can be completed with the bridge open or can be completed simultaneously with another step?

Q3: Would lane or bridge closures be less if the complete deck replacement was done as opposed to an overlay (i.e. does it take less time to remove and form a deck as opposed to removing bad concrete and rebar)?

Q4: Would overlay work go faster if the bridge were completely closed and traffic routed to an adjacent bridge or if partial lane closures were used?

Q5: Is there a technology or construction technique which you believe would significantly lessen the lane or bridge closures for the bridge construction?

3.3 RESULTS OF THE SURVEY

NOTE: To preserve the privacy of the respondents, contractor names are NOT used in the following tables. In the tables, contractor number is the same contractor in all tables.

EXISTING BRIDGE WITH DECK REPLACEMENT
Steps involved are as follows.
   a) Removal of existing deck.
   b) Forming the new deck.
   c) Placing the rebar.
   d) Pouring the new deck.
   e) Curing the new deck.
   f) Parapet/barrier placement.
   g) Backwall replacement and approach slab work.

The most significant step that contributes to lane/bridge closure is

FORMING THE NEW DECK – with a contractor score of 77.7%
BACKWALL REPLACEMENT AND APPROACH SLAB WORK – 44.44%
REMOVAL OF EXISTING DECK – 44.44%
CURING THE NEW DECK – 22.22%.
The steps that least contribute to lane/bridge closure are.

**PLACING THE REBAR – 55.55%**

**POURING THE NEW DECK – 33.33%**

**REMOVAL OF EXISTING DECK – 22.22%**

**CURING, BACKWALL REPLACEMENT & APPROACH SLAB WORK AND PARAPET PLACEMENT – 11.11%**

Comments:

<table>
<thead>
<tr>
<th>No</th>
<th>Greatest Contributor to Lane/Bridge Closure</th>
<th>Least contributor to lane/bridge closure</th>
<th>Construction Technology proposed to reduce lane/bridge closure</th>
<th>Contractor proposed Construction technology</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Curing the new deck &amp; abutment work</td>
<td>Pouring the new deck (and forming the new deck &amp; placing the rebar.)</td>
<td>------</td>
<td>Use crossovers.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Forming of new deck &amp; Back wall replacement and approach slab.</td>
<td>Removal of existing deck</td>
<td>Stay in place forms.</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Curing the new deck &amp; forming the new deck.</td>
<td>Removal of the existing deck.</td>
<td>Stay in place forms (steel)*</td>
<td>Tool to tie rebar instead by hand.#</td>
<td>*-ODOT doesn’t allow. #-cant use epoxy coated wire.</td>
</tr>
</tbody>
</table>
### WIDENING AN EXISTING BRIDGE

Steps involved are as follows.

- **a)** Substructure work (i.e. piles, footings, abutments, MSE walls)
- **b)** Placing the superstructure.
- **c)** Forming the new deck.
- **d)** Placing the rebar.
- **e)** Pouring the new deck.
- **f)** Curing the new deck.
- **g)** Parapet/barrier placement.
- **h)** Closure pours if used.
- **i)** Approach slab work.

The most significant step that contributes to lane/bridge closure is

**FORMING THE NEW DECK – 55.55%**

**SUUBSTRUCTURE WORK – 33.33%**
CLOSURE POURS IF USED AND PLACING SUPERSTRUCTURE – 22.22%

PLACING REBAR AND POURING THE NEW DECK – 11.11%

The steps that least contribute to lane/bridge closure are.

POURING THE NEW DECK – 33.33%

SUBSTRUCTURE WORK – 33.33%

PLACING THE REBAR & FORMING THE NEW DECK – 22.22%

PARAPET/BARRIER PLACEMENT – 22.22%

APPROACH SLAB WORK – 11.11%

**Comments**

<table>
<thead>
<tr>
<th>No</th>
<th>Greatest Contributor to Lane/Bridge Closure.</th>
<th>Least contributor to lane/bridge closure.</th>
<th>Construction Technology proposed to reduce lane/bridge closure.</th>
<th>Contractor proposed Construction technology.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Closure pours and Curing the new deck.</td>
<td>Pouring the new deck and forming the new deck &amp; placing the rebar.</td>
<td>Replacing rebar with wire mesh.</td>
<td>TBC</td>
<td>Precast substructure doesn’t work well. No anticipated stiffness.</td>
</tr>
<tr>
<td>3</td>
<td>Forming of new deck.</td>
<td>Substructure work- If median widening doesn’t affect traffic.</td>
<td>TBC</td>
<td>TBC</td>
<td>Wire mesh isn’t feasible.</td>
</tr>
<tr>
<td>4</td>
<td>Forming of new deck &amp; substructure work.</td>
<td>Parapet/barrier placement.</td>
<td>Precast, substructure elements.</td>
<td>TBC</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Closure pours.</td>
<td>Substructure work *</td>
<td>Replacing the rebar with wiremesh. #</td>
<td>Cure times.</td>
<td>*-Need to be designed without affecting traffic. Done without affecting traffic at all. #-Never heard of save time if possible.</td>
</tr>
<tr>
<td>7</td>
<td>Forming the new deck and placing the rebar.</td>
<td>Pouring the new deck.</td>
<td>Precast, substructure elements.* Replacing the rebar with wiremesh. #</td>
<td>------</td>
<td>*-If practically feasible. #-Restrictions in weight, maneuverability of cranes etc.</td>
</tr>
<tr>
<td>8</td>
<td>Placing the superstructure and forming the new deck</td>
<td>Parapet placement</td>
<td>Replacing the rebar with wire mesh</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Placing the superstructure and pouring the new deck</td>
<td>Substructure work</td>
<td>Replacing the rebar with wire mesh</td>
<td>Stay in place forms. Lump sum incentives for early completion</td>
<td></td>
</tr>
</tbody>
</table>

**SUPERSTRUCTURE REPLACEMENT**

Steps proposed that might result in shortest reduced traffic capacity/closure of the bridge.

a) Partial width reconstruction with closure pours.

b) Move all traffic to the adjacent bridge and completely reconstruct the bridge.

c) Both options would take about the same amount of time.

The step that contributes in significantly in reducing closure of bridges

**MOVE ALL TRAFFIC TO THE ADJACENT BRIDGE AND COMPLETELY RECONSTRUCT THE BRIDGE – 100%**
<table>
<thead>
<tr>
<th>No</th>
<th>Method of construction resulting in shortest closure of bridge</th>
<th>Contractor proposed Construction technology.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>Hybrid concrete, Composite form left in place.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>Precast super structure.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>Precast superstructure.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>Stay in place forms</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Move all traffic to the adjacent bridge and completely reconstruct the bridge</td>
<td>-------</td>
<td></td>
</tr>
</tbody>
</table>
OVERLAYS – CONCRETE

Steps involved are as follows

a) Removal of the existing concrete surface.
b) Sounding the deck for other bad concrete and removing it.
c) Cleaning or replacing corroded rebar.
d) Placing the overlay.
e) Curing the overlay.

The greatest contributor to lane closure is

SOUNDING THE DECK FOR OTHER BAD CONCRETE AND REMOVING IT – 77.77%
REMOVAL OF EXISTING CONCRETE SURFACE – 22.22%
CURING THE OVERLAY – 22.22%
CLEANING OR REPLACING CORRODED BAR – 11.11%

The step that contributes least to lane closure is

PLACING THE OVERLAY – 55.55%
CURING THE OVERLAY AND REMOVAL OF EXISTING CONCRETE SURFACE – 22.22%

BRIDGE/LANE CLOSURE SIGNIFICANCE -Over Lay Vs Complete Deck Replacement
OVERLAY IS QUICKER THAN COMPLETE DECK REPLACEMENT – 77.77%
DEPENDS ON EXTENT OF DECK REPLACEMENT – 22.22%
OVERLAY WORK IS DONE FASTER WITH – BRIDGE COMPLETELY CLOSED VS PARTIAL LANE CLOSURE
BRIDGE COMPLETELY CLOSED SPEEDS OVERLAY WORK THAN PARTIAL LANE CLOSURE – 88.88%

Comments

<table>
<thead>
<tr>
<th>No</th>
<th>Greatest Contributor to Lane/Bridge Closure.</th>
<th>Least contributor to lane/bridge closure.</th>
<th>Complete deck replacement VS overlay.</th>
<th>Partial lane closure VS complete bridge closure.</th>
<th>Contractor proposed Construction technology.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Removal of existing concrete surface and sounding the deck for other bad concrete and removing it.</td>
<td>Placing overlay. Hand removal with hydro demolition.</td>
<td>Just overlay will be quick.</td>
<td>Complete bridge closure.</td>
<td>Hydro demolition</td>
</tr>
<tr>
<td></td>
<td>Sounding the deck for other bad concrete and removing it.</td>
<td>Placing the overlay.</td>
<td>Overlay is quicker</td>
<td>Complete closure is quicker.</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------</td>
<td>----------------------</td>
<td>--------------------</td>
<td>------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>Curing the overlay</td>
<td>Removal of existing concrete surface.</td>
<td>Overlay is much quicker.</td>
<td>Complete closure is quicker and safer.</td>
<td>Stay in place forms would be used. (1/10 of total time saved) Saw stripping</td>
</tr>
<tr>
<td>3</td>
<td>Sounding the deck for other bad concrete, removing it, and placing the overlay.</td>
<td>Placing the overlay</td>
<td>Overlay is much quicker</td>
<td>Complete closure is quicker.</td>
<td>Hydro demolition equipments.</td>
</tr>
<tr>
<td>4</td>
<td>Curing overlay</td>
<td>Depends on condition of deck.</td>
<td>Not any quicker</td>
<td>Overlays expansion joints. Interval abutment - does away with expansion joints + deck replacement.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sounding the deck for other bad concrete and removing it.</td>
<td>Placing overlay.</td>
<td>Overlay is much quicker</td>
<td>Complete closure is quicker</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Removal of existing concrete surface.</td>
<td>Curing the overlay</td>
<td>Overlay is quicker</td>
<td>Complete closure is quicker</td>
<td>Hydro demolition equipment.</td>
</tr>
<tr>
<td>7</td>
<td>Sounding the deck for other bad concrete and removing it.</td>
<td>Removal of existing concrete surface.</td>
<td>Overlay is quicker</td>
<td>Complete closure is quicker</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Sounding the deck for other bad concrete and removing it.</td>
<td>Placing overlay</td>
<td>Depends on extent of deck replacement</td>
<td>Complete closure is quicker</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Cleaning or replacing corroded rebar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3.1 Conclusions

From the survey results, two main items have been identified:

a) Forming the deck is a major contributor to bridge down time.

b) The construction process could be most quickly completed if the contractor could completely close the bridge during construction.

The survey also shows that sounding a deck and removing old concrete is the most time consuming part of deck rehabilitation. If some of the previously identified methods of speeding up deck replacement (SIP forms, precast deck, deckles bridges) work, it may be more beneficial to replace, rather than rehabilitate, bridge decks.
CHAPTER 4
STEEL STAY-IN-PLACE FORM SURVEY

4.1 INTRODUCTION

The contractor’s survey in Chapter 3 identified deck forming as a major constraint to speeding up bridge construction. One alternative to deck forming is the use of stay-in-place (SIP) steel forms. In 1995, the Federal Highway Administration conducted a survey of the use of SIP steel form. The actual FHWA survey results are in Appendix A. A summary and an update of the survey is presented here.

4.2 FHWA SURVEY

PARTICIPANTS OF THE SURVEY

The survey was carried out with all of the transportation departments and the respective federal zones. The response of the survey is given below:

- Total number of responses – 37
- Total number of “No responses”- 17
- SIP forms users – 25
- SIP forms non users - 12

CONCERNS

The major concerns identified by the users of stay-in-place metal forms are:

- Inability to inspect the underside of the deck
- Hidden cracks or voids
- Effect of high metal temperature of the forms on the fresh concrete as it is placed
- Consolidation of concrete
- Deterioration and possibility of falling debris from ‘rust out’
- Corrosion of reinforcement due to the trapping of chloride contaminated water at the bottom of the deck
- Improper installation (Welding of forms to tension flange )

The major concern to many of SIP form users were about hidden deterioration, consolidation of concrete, corrosion and monitoring deck conditions especially when the top surface is not visible due to application of bituminous overlays and other water proofing membranes.
Rusting and Deterioration Sample – Photos obtained from Washington DOT
SUGGESTIONS FROM FHWA SURVEY

Hidden cracks and Voids:
Inspection by competent personnel during pouring, vibrating, and screeding in accordance with specifications and plans will avoid formation of voids.
Use of vibrators to help move and consolidate the concrete during the pour
Removal of sections to verify soundness
Partial removal of forms, and checking for soundness and bonding by sounding hammer

Deterioration:
Galvanization of permanent forms in accordance to ASTM
Painting with 2 coats of zinc oxide-zinc dust primer

Moisture entrapment:
Provision of drains (Field drilled drain holes ¼” at the bottom of the flute at any transverse construction joint)

Poor installation:
SIP forms attached to structural members by using saddles
Welding forms to a strap that is put across the top flange
Proper adherence to specifications and plans

RESTRICTIONS IN USE IDENTIFIED IN THE FHWA SURVEY
These forms are not used in marine sites.
There are problems related to design. Adds extra weight, restricts bar spacing.
Limitations in salting and additional deck dead load between girders
Not cost effective with beam spacing in excess of 15 feet
Attachment to steel beams in negative moment areas is a construction inspection problem.

MERITS IDENTIFIED IN THE FHWA SURVEY
Suitable for projects where form removal is impractical or extremely hazardous
Suitable for curved girder and large girder spacing structures
Less bridge closure time

CONCLUSIONS FROM THE FHWA SURVEY
The survey results show problems with respect to deck inspection, deterioration of forms and consolidation. However, many departments of transportation have successfully adopted procedures to counter these problems.
4.3 UPDATED SURVEY

PARTICIPANTS OF THE SURVEY

Number of DOT’s responded - 32
Number of “No Responses” - 16
Number of METAL SIP FORM user – 17
Number of METAL SIP FORM users under special conditions – 10
Number of METAL SIP FORM non users – 5

The results of the survey are provided in Appendix B

CONCERNS

- Monitoring the condition of the deck and the extent of the deterioration of deck is limited by the restricted visibility of the underside of the deck.
- Higher initial cost
- More expensive to demolish the deck when necessary to replace deck
- Weight of extra concrete to fill the flutes and end area
- Gets expensive with longer spans
- Deck deterioration accelerated from trapped moisture in the deck
- Installation concerns like right height to give proper slab thickness, properly welded angles to beams and not welded to beams in tension areas
- Consolidation of concrete

SOLUTIONS

The suggestions for all the concerns expressed remain the same as in FHWA SURVEY except for the weight issues. Kentucky and Louisiana DOT’s recommend the use of plastic foam to fill the flutes. This lowers the weight and provides a flat surface, thereby making it easier to maintain standard deck thickness. Idaho DOT uses cover plates to level flutes.

USERS UNDER SPECIAL CONDITIONS

The SIP FORM users who identified themselves as using SIP forms only under special conditions use them as follows:

- Time savings realized by the use of SIP forms will result in reduced traffic impact
- In general all bridges that go over railroad tracks and bridges that are difficult to access, such as bridges over high volume roads and also in on some bridges that are over water
- Inside steel boxes, where removal is an obstacle
Some Instances of bridge using metal stay in place forms

U.S.401 over the Neuse River Raleigh – HPC Bridge – North Carolina
SR20 over the Apalachicola River – FDOT – 8362’ long
Paper Mill Road Bridge – Winner: Long Span; National Steel bridge Alliance 2001 Prize Bridge Award
– MD Route 145.
Moorefield Section of the Corridor H Project 2001 – West Virginia division Of highways
The Sidney Lanier Bridge – Georgia

CONCLUSIONS

The updated survey confirms that the previous survey results are still valid. The main concerns about
the use of SIP deck forms are restrictions in the ability to inspect the decks, accelerated deterioration due
to moisture trapping, rusting (which may cause the forms to fall out) and additional weight. All the non
users and users under special conditions have these concerns in common. However, all the state DOTs
which use SIP forms have had no problems using these forms and are aggressive supporters of these
forms.

4.4 MANUFACTURES OF SIP FORMS

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-Mac Industries Inc</td>
<td>1880 D-MAC Drive, Alpharetta GA 30004</td>
<td>770 664-7120</td>
</tr>
<tr>
<td>Amico Stay Form</td>
<td><a href="mailto:stayform@amico-us.com">stayform@amico-us.com</a>, 885 Dunsmuir Street, Vancouver, BC, Canada</td>
<td>(800) 366-2642</td>
</tr>
<tr>
<td>Octaform Concrete Forming Systems</td>
<td>6808 Academy Parkway East NE, Bldg. C, 1-888-786-OCTA (6282)</td>
<td></td>
</tr>
<tr>
<td>American PolySteel</td>
<td>Albuquerque, NM 87109</td>
<td>1-800-977-3676</td>
</tr>
<tr>
<td>Metal Dek Group</td>
<td>4900 Hungerford Road • Memphis, TN 38118</td>
<td>(901) 365-0226</td>
</tr>
<tr>
<td>American ConForm Industries</td>
<td>Bldg. C, 1101 East Eighth Street, Wilmington, DE 19801-4356</td>
<td>1-800-CONFORM</td>
</tr>
<tr>
<td>S.I.P., Inc. of Delaware</td>
<td></td>
<td>(302) 654-4533</td>
</tr>
</tbody>
</table>

4.5 COST DATA

No published cost data could be found. This is attributed to the highly competitive nature of the
construction industry.
5.1 CONCLUSIONS

1. The following methods have been identified as possible methods of reducing the time needed for bridge construction:
   1. Precast substructures.
   2. Prefabricated composite bridge units.
   3. Prefabricated superstructure units, such as adjacent boxes, which do not need a separate wearing surface.
   4. Full depth precast concrete decks.
   5. Stay-in-place concrete or steel forms.
   6. Completely prefabricated bridges.

2. A survey of contractors showed that the main obstacle to fast bridge construction is the forming of the deck. The contractors also indicated that the best way to build bridges faster was to allow the entire bridge to be closed and the reconstruction to occur all at one time.

3. A survey of states showed that approximately 34 states use stay-in-place steel forms for decks. The main concerns about using these forms are the inability to inspect the underside of the deck, trapping moisture between the concrete and the form, deterioration of the form and additional weight due to the flutes in the forms. However, those states which use SIP steel forms contend that all of these concerns can be overcome.
5.2 FUTURE RESEARCH

This project identified 7 possible methods of reducing the time needed to construct bridges. The next step should be to choose several pilot projects and test each of these ideas. The pilot projects could be benchmarked against other projects to see if construction time is reduced. These pilot projects could be also be used to determine the cost of using rapid bridge construction methods.
References:

1. Innovative Contracting Manual – Ohio Department of Transportation, 2003
APPENDIX A

FHWA STAY-IN-PLACE FORM SURVEY
Courtesy of Curtis Monk – FHWA

A. 1
## SURVEY -- USE OF METAL STAY-IN-PLACE FORMS

<table>
<thead>
<tr>
<th>1) DOES YOUR STATE USE METAL S-I-P FORMS?</th>
<th>2) YES</th>
<th>A) WHAT TYPE OF GIRDER USED ON?</th>
<th>B) RESTRICTIONS?</th>
<th>C) WHO DECIDES USE?</th>
<th>D) CONCERNS REGARDING USE?</th>
<th>E) SUGGESTIONS?</th>
<th>NO</th>
<th>3) WHY NOT?</th>
<th>4) ADDITIONAL COMMENTS</th>
<th>NO RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Federal</td>
<td></td>
<td>Steel PPC Bot</td>
<td></td>
<td>DOT Contract or Option</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Can't inspect soffit of deck. Moisture entrapment.</td>
<td></td>
</tr>
<tr>
<td>Central Federal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No state spec. Not able to inspect bottom of deck.</td>
<td></td>
</tr>
<tr>
<td>Western Federal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No state spec. Not able to inspect bottom of deck.</td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td>X</td>
<td>X</td>
<td>Plans stamped by Alabama Prof. Engr.</td>
<td>X</td>
<td>1 2</td>
<td></td>
<td></td>
<td></td>
<td>Added wt limited &lt; 12#/sqft</td>
<td></td>
</tr>
<tr>
<td>Alaska</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Added 7/17/96 per M. Greer</td>
<td></td>
</tr>
<tr>
<td>Arkansas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Added 7/17/96 per M. Greer</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>X</td>
<td>X</td>
<td>No heavy salting. 10% addnl. deck dead load between girders.</td>
<td>4X</td>
<td>5X</td>
<td>Deterioration.</td>
<td>Forms could be galvanized.</td>
<td></td>
<td>Added 7/17/96 per M. Greer</td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>X</td>
<td>X</td>
<td>Added wt limited &lt; 12#/sqft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Added 7/17/96 per M. Greer</td>
<td></td>
</tr>
<tr>
<td>Connecticut</td>
<td>X</td>
<td></td>
<td>None.</td>
<td>X</td>
<td>Retains moisture, salts &amp; chlorides. Hides deterioration.</td>
<td>Develop a way to drain moisture from forms.</td>
<td></td>
<td></td>
<td>SIP forms used frequently--good, cheap &amp; fast. Problems are inspectability &amp; moisture drainage.</td>
<td></td>
</tr>
<tr>
<td>Delaware</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
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<td></td>
<td>SIP forms used frequently--good, cheap &amp; fast. Problems are inspectability &amp; moisture drainage.</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>1) DOES YOUR STATE USE METAL S-I-P FORMS?</td>
<td>2) YES</td>
<td>A) WHAT TYPE OF GIRDER USED ON?</td>
<td>B) RESTRICTIONS?</td>
<td>C) WHO DECIDES USE?</td>
<td>D) CONCERNS REGARDING USE?</td>
<td>E) SUGGESTIONS?</td>
<td>3) WHY NOT?</td>
<td>4) ADDITIONAL COMMENTS</td>
<td>NO RESPONSE</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------</td>
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</tr>
<tr>
<td>Georgia</td>
<td>X</td>
<td>X</td>
<td>Design related</td>
<td>X</td>
<td>X</td>
<td>Poor installation</td>
<td>Closer inspections.</td>
<td>X</td>
<td>Corrosion concerns.</td>
<td>Usage–75% SIP metal vs. 25% concrete deck panels.</td>
</tr>
<tr>
<td>Hawaii</td>
<td>X</td>
<td>X</td>
<td>Same as provided in specs</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Idaho</td>
<td>X</td>
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<td></td>
<td>X</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Indiana</td>
<td>X</td>
<td>X</td>
<td>Can’t use adjacent to longitudinal const. joints; use wooden forms.</td>
<td>X</td>
<td>X</td>
<td>Hidden deterioration.</td>
<td>None</td>
<td>X</td>
<td></td>
<td>Contractors like them.</td>
</tr>
<tr>
<td>Iowa</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>X</td>
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<td></td>
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<tr>
<td>Kansas</td>
<td>X</td>
<td>X</td>
<td>River spans; steel boxes; detail rebar pattern.</td>
<td>X</td>
<td>X</td>
<td>20-30 yr life. Can’t inspect.</td>
<td>Don’t use; remove to inspect.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kentucky</td>
<td>X</td>
<td>X</td>
<td>Cannot be used outside facia girder.</td>
<td>X</td>
<td>X</td>
<td>Hidden deterioration.</td>
<td>None</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Louisiana</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Future maint; effect on deck life.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Maine</td>
<td>X</td>
<td></td>
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<td></td>
<td>X</td>
<td>None.</td>
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<tr>
<td>Maryland</td>
<td>X</td>
<td>X</td>
<td>Cannot be used outside facia girder.</td>
<td>X</td>
<td>X</td>
<td>Hidden problems.</td>
<td>Provide easily removed knockout panels for insp.</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Massachusetts</td>
<td>X</td>
<td>X</td>
<td>None.</td>
<td>X</td>
<td>X</td>
<td>Hidden problems.</td>
<td>Provide easily removed knockout panels for insp.</td>
<td>None</td>
<td></td>
<td></td>
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<tr>
<td>Michigan</td>
<td>X</td>
<td></td>
<td>Only when safety is a concern.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not routinely used.</td>
</tr>
<tr>
<td>Minnesota</td>
<td>X</td>
<td>X</td>
<td>Special cases only based on difficulty of form</td>
<td>X</td>
<td>X</td>
<td>Rusting; hidden deterioration.</td>
<td>None.</td>
<td>X</td>
<td></td>
<td>Not common.</td>
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</table>

Notes:
- "X" indicates a positive response.
- "None." indicates no concerns.
- Additional comments for specific concerns or restrictions.
<table>
<thead>
<tr>
<th>State</th>
<th>Steel</th>
<th>PPC</th>
<th>Bot</th>
<th>B) RESTRICTIONS?</th>
<th>C) DO</th>
<th>Contract or Option</th>
<th>D) CONCERNS REGARDING USE?</th>
<th>E) SUGGESTIONS?</th>
<th>NO</th>
<th>3) WHY NOT?</th>
<th>4) ADDITIONAL COMMENTS</th>
<th>NO RESPONSE</th>
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<tbody>
<tr>
<td>Mississippi</td>
<td></td>
<td></td>
<td></td>
<td>Can't remove.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Missouri</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Only use on steel &amp; only when precast deck panels cannot be used.</td>
<td>X</td>
<td>Hidden deterioration; rusting.</td>
<td>Not to use.</td>
<td></td>
<td></td>
<td></td>
<td>Concord panel is std. Steel only used in curved girders &amp; large girders spacing</td>
<td>X</td>
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<tr>
<td>Montana</td>
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<tr>
<td>Nebraska</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Not much use.</td>
<td>X</td>
<td>X</td>
<td>None</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<td>Nevada</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Standard specs only.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contracrs always opt to use</td>
<td></td>
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<tr>
<td>New Hampshire</td>
<td></td>
<td></td>
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<td></td>
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<td>New Jersey</td>
<td>X</td>
<td></td>
<td>X</td>
<td>16</td>
<td>X</td>
<td></td>
<td>No welding is done to tension flange.</td>
<td></td>
<td></td>
<td></td>
<td>Have begun to use concrete deck panels</td>
<td></td>
</tr>
<tr>
<td>New Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>New York</td>
<td>X</td>
<td>X</td>
<td></td>
<td>NYS thruway authority doesn't use.</td>
<td>X</td>
<td>Rusting; hidden deterioration.</td>
<td>Quality deck concrete &amp; consolidation.</td>
<td></td>
<td></td>
<td></td>
<td>Use random removal &amp; sounding as QC</td>
<td></td>
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<tr>
<td>North Carolina</td>
<td></td>
<td></td>
<td>X</td>
<td>None</td>
<td>X</td>
<td>None</td>
<td></td>
<td></td>
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<tr>
<td>North Dakota</td>
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<tr>
<td>Ohio</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Can't inspect deck btm</td>
<td>X</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>X</td>
<td></td>
<td>X</td>
<td>None</td>
<td>X</td>
<td>Can't inspect btm deck. Trap moist</td>
<td>Epoxy rebar insulation forms</td>
<td></td>
<td></td>
<td></td>
<td>Changed from original on 7/15/96 Per B. Johnson and Terry Shike.</td>
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<tr>
<td>Oregon</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Can't inspect deck btm</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>Steel</td>
<td>PPC</td>
<td>Bot</td>
<td>Weight Restriction</td>
<td>DOT</td>
<td>Contract or Option</td>
<td>Concerns Regarding Use</td>
<td>Suggestions</td>
<td>Why Not?</td>
<td>Additional Comments</td>
<td></td>
<td></td>
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<tr>
<td>--------------------</td>
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</tr>
<tr>
<td>Pennsylvania</td>
<td>X</td>
<td></td>
<td></td>
<td>14.89 MPa (15# ft^2) - This forces the manufacturer to use a voided form for girder spacings greater than approx. 3 m (10 ft).</td>
<td>X</td>
<td>None. Used for 25 years.</td>
<td>Do not use under open medians (between bifurcated bridges) or on overhangs. State specifies when can’t use</td>
<td>Spec Book, but they are not used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>More expensive than wooden removable forms.</td>
<td>Allowed but not used. Used some in 1970s</td>
<td></td>
<td></td>
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<td>Rhode Island</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>South Carolina</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>None</td>
<td>None</td>
<td></td>
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<td>South Dakota</td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Tennessee</td>
<td>X</td>
<td>X</td>
<td></td>
<td>21 Can’t use in overhangs or under longit. jts</td>
<td>22X</td>
<td>25 None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Not allowed in harsh or corrosive environments.</td>
<td>X</td>
<td>25 Welding on tension flange</td>
<td>25 Train insp. random panel removal</td>
<td>26 Permits several alternatives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utah</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Can’t inspect deck soffit.</td>
<td></td>
<td>Quit using in 1989. Prior to that, allowed on both types of girders at contractor’s option.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermont</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>27 Trap moist. Can’t insp soffit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>X</td>
<td>X</td>
<td></td>
<td>26</td>
<td>26 X</td>
<td>Lack of inspectability of deck underside.</td>
<td>None. Currently using to replace or widen bridge decks and can evaluate performance.</td>
<td>Believe benefits exceed concerns.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1) DOES YOUR STATE USE METAL S-I-P FORMS?</td>
<td>2) YES</td>
<td>A) WHAT TYPE OF GIRDERs USED ON?</td>
<td>C) WHO DECIDES USE?</td>
<td>B) RESTRICTIONS?</td>
<td>D) CONCERNS REGARDING USE?</td>
<td>E) SUGGESTIONS?</td>
<td>NO</td>
<td>3) WHY NOT?</td>
<td>4) ADDITIONAL COMMENTS</td>
<td>NO RESPONSE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
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<td></td>
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<tr>
<td>West Virginia</td>
<td>X</td>
<td>Steel</td>
<td>DOT</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Wisconsin</td>
<td>X</td>
<td>PPC</td>
<td>Contract or Option</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyoming</td>
<td>X</td>
<td>Both</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
1. Hidden cracks or voids. Some have questioned the effect of high metal temperature of the forms on the fresh concrete as it is placed. No one has identified a problem from temperature.

2. Alabama DOT previously required the removal of them at first then decided that was not needed. Experience (typical girder deck) has shown that if an inspector will verify that the pouring, vibrating, and screeding are performed according to the plans and specifications, it is almost impossible to form a void. Hidden cracks are still a concern. They can be seen from topside if the deck is sprayed with water and given time to begin evaporating. Alabama DOT has removed many sections to verify soundness and still have that option today at the direction of the Engineer.

3. ADOL does not allow Concrete SIP forms. The other acceptable alternative is removable forms. One contractor in Alabama only uses removable forms; most use metal SIP forms.

4. For structures where vehicular traffic is expected to remain underneath during deck form removal, the areas where steel SIP forms are required will be detailed on the Typical Section sheet. In bays with longitudinal expansion joints, SIP’s will not be required.

5. For structures where the traffic will not remain underneath during form removal, no special details are required on the plans but the 10% additional weight will be added in. The special provisions will allow the contractor the option of using the SIP forms.

6. In nonaggressive environments, metal SIP forms are typically detailed on plans. Contractor may redesign for removable forms. In cases where removable forms detailed on plans, except where prohibited by environment, contractor may redesign for use of SIP forms.

7. So far Georgia DOT had a very good success with the SIP Metal Forms. We have encountered some problems where the contractors did not follow the installation procedures outlined in the approved shop drawings. We have not had problems with rusting since permanent steel forms have to be galvanized in accordance with ASTM Specifications.
8.  
(a) Adds extra weight.  
(b) Restricts bar patterns (spacings).  
(c) Best if not skewed.  
(d) Inspectors do not like.  
(e) Show option (or prohibition) on plans.  
(f) From Kansas DOT Bridge Design Manual.  “Steel stay-in-place forms may be considered where unusual construction conditions exist. Examples are high bridges and bridges over long expanses of water where form removal would be difficult. If forms are used, the extra dead load must be considered. Form inserts are available that cover the corrugations of the steel forms to provide a flat soffit which allows for easier rebar spacing and eliminates the extra concrete dead load. Rebar placement on curved or flared deck bridges is difficult and a smooth soffit is beneficial. Due to the possibility of falling debris from ‘rust out,’ steel stay-in-place forms should not be used over state highways or railroads. Maximum dead load deflection of stay-in-place forms shall be: Span/180 with a maximum of 0.5 inches. The use of stay-in-place forms should be determined at field check.

9.  Minnesota DOT Construction Specs. require removal of all forms. These specifications are modified if S-I-P forms are permitted. Projects permitting use are not common and use is limited to situations where form removal is impractical or extremely hazardous.

10. The precast deck panel is the State’s standard, but metal SIP forms will be specified for curved girder and large girder spacing structures. Cast-in-place conventional forming may be used as a contractor option on all structures.

11. Very little use because when concrete panels were let as an option, contractor was permitted to change to deck forms to permit MBE participation at greater extent in the project.

12. Nevada DOT has allowed the use of these forms for nearly 20 years and we have not had any deck failures or other problems. The Nevada DOT have had some concerns that contractors may tack weld the forms to steel girders if not watched closely but we haven’t found any instances of that yet. We also had concerns about consolidation of the concrete. We now have a requirement for “sounding” the deck and the option to remove panels to check if we suspect a problem.
13. New Hampshire DOT does not use metal SIP forms because of concern about hidden deterioration. All of our decks have waterproofing membranes and bituminous overlays, so the top surface is not visible. They are concerned about monitoring deck conditions if the bottom side were also hidden from view.

14. New Hampshire DOT has begun to use prestressed concrete forms (subdeck panels). When allowed, they are detailed in the contract plans, and the project usually involves a low-volume bridge crossing a high-volume road. They are using experience gained to judge the acceptability of the deck system for higher volume roads. Their concerns are cracking of the CIP concrete over panel joints, resulting leakage, etc. The advantages are no need to strip forms, underside of deck is visible, and no additional dead load as there is with metal SIP.

15. Standard details and specifications are included in the contract plans, otherwise there are no real restrictions with the exception that no welding of the forms to the tension flange is allowed. Also, it is my understanding that metal forms may not be cost effective with beam spacings in excess of say 15 feet. Our typical beam spacing in New Jersey is about 7 to 10 feet.

16. One form in every other bay/span (except over traffic) are removed. 1/4 of the forms are checked for soundness and bonding by sounding with a hammer. The North Carolina DOT metal s.i.p. forms specifications can be sent to you if you want.

17. The bridge engineers in Ohio, in general like to see the underside of the deck for inspection purposes. This is especially true if the deck is overlaid with an asphaltic wearing surface. On rare occasions SIP forms have been used. The county engineers use a heavy gage SIP steel overlaid with Asphalt.

18. Currently we are having a problem in Cleveland with the bottom of decks spalling off and falling on the roadway below. I think if SIP forms had been used this situation would be lessened. However, it is nice to see the underside of the deck for inspection. Ohio is not a big user of concrete girders.

19. (a) When we started using S-I-P forms Oklahoma DOT only required the top mat of reinforcing to be epoxy coated. Bridge decks tend to crack and that could allow chloride contaminated water to be trapped on the bottom of the deck and cause high levels of chloride contamination there. This would lead to
corrosion of the bottom mat of reinforcing. We started requiring both mats to be epoxy coated shortly after we started allowing S-I-P forms.

(b) We don’t do a very good job of protecting concrete in cold weather here and there is no way to tell if there is frost damaged concrete next to the S-I-P forms. You can’t check for bad consolidation either.

(c) We had some trouble with contractors field welding forms directly to steel beams in tension areas. Now they put a strap across the top flange and weld the forms to the strap. We still have problems with the welders over-running the strap and welding on the flange.

20. (a) Use epoxy coated rebar in both mats. They should do this anyway.

(b) Be sure to require these forms to be well insulated in cold weather. Require removal of some forms to check concrete consolidation.

(c) Don’t allow field welding, make the connection to steel beams some other way.

21. Remain-in-place forms are prohibited in slab overhang areas or in a bay where a longitudinal open joint is present. On projects involving stage construction where a construction joint may fall between beams, metal s-I-p forms may be prohibited if suitable splice or joint details are not furnished by the contractor. Also, metal s-I-p forms are to be attached to main structural members by other means than by welding (i.e. attached by saddles).

22. Other than the restricted areas as noted above, remain-in-place forms may be used as an alternate to removable forms at the contract’s option. The remain-in-place may be steel or prestressed concrete panels.

23. Tennessee DOT has no concerns, they require their forms to be galvanized after fabrication. Also, they require field drilled drain holes (1/4 in.) at the bottom of a flute at any transverse construction joints with the exposed metal form cleaned and painted with two coats of zinc oxide-zinc dust primer.
24. (a) Attachment to steel beams in negative moment areas is a continuing construction inspection problem. Details provide for hangers which do not require welding to flange in tension areas but historically the detail are not always followed by inspectors and welders.

(b) In the late 60s and early 70s fear of poor consolidation in bottom of slab under the SIP was a factor and we required that some panels be removed to inspect. Don’t remember that this ever produced any significant findings.

25. Make proper installation a matter of continuing education and training for DOT inspectors. If fear of corrosion and/or deterioration of concrete is a problem, initiate a program to remove a few of the panels that have been in place to see if the fear is justified.

26. Texas DOT prefers to permit conventional forming, precast concrete deck panels and Metal SIP as construction alternates. Districts will delete the Metal SIP alternate for work on the Gulf coast and in areas with heavy salt usage.

27. Concerns on 1) the condition of the deck during inspection. It is difficult to assess the underside and the top when it is overlaid with asphalt, 2) The moisture stays within the form and the asphalt overlay may affect the durability of the concrete.

28. YES, NOT PERMITTED for Cast-in-Place T-beam spans and old beam span/cast-in-place slab projects being updated where the beams are not redesigned, and on bridges to be maintained by Hampton, Newport News, Chesapeake, Norfolk, Portsmouth and Virginia Beach: also, bridges carrying railway traffic.
APPENDIX B
UPDATED SURVEY ON STAY-IN-PLACE FORMS
<table>
<thead>
<tr>
<th>State</th>
<th>Yes</th>
<th>No</th>
<th>Special Condition</th>
<th>Concern</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Alabama</td>
<td>No</td>
<td>No</td>
<td>No response</td>
<td>No</td>
<td>Response</td>
</tr>
<tr>
<td>Alaska</td>
<td>*</td>
<td>No</td>
<td>Deck inspection</td>
<td>Used in steel box girders.</td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td>*</td>
<td>No</td>
<td>Increase in weight due to concrete filling flutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arkansas</td>
<td>*</td>
<td>No</td>
<td>Deck inspection, construction joint in beams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>No</td>
<td>No</td>
<td>No response</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>*</td>
<td>No</td>
<td>Deterioration, moisture precast stay-in-place deck trapping, installation and forms are used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connecticut</td>
<td>*</td>
<td>No</td>
<td>Deck inspection, high initial cost</td>
<td>Used in areas where time savings realized by the use of SIP forms will result in decreased traffic impacts</td>
<td></td>
</tr>
<tr>
<td>Delaware</td>
<td>*</td>
<td>No</td>
<td>Deck inspection, Used widely</td>
<td>Moisture trapping</td>
<td></td>
</tr>
<tr>
<td>Florida</td>
<td>*</td>
<td>No</td>
<td>Deck inspection</td>
<td>Used widely</td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>*</td>
<td>No</td>
<td>Installation</td>
<td>Used widely</td>
<td></td>
</tr>
<tr>
<td>Hawaii</td>
<td>No</td>
<td>No</td>
<td>No response</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Idaho</td>
<td>*</td>
<td>No</td>
<td>Limit girder spacing, deck inspection</td>
<td>Cover plates on flutes are used to make a flat surface.</td>
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<tr>
<td>Illinois</td>
<td>*</td>
<td>No</td>
<td>Rusting, deck inspection</td>
<td>Used on project specific basis and chloride trapping</td>
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<tr>
<td>Indiana</td>
<td>No</td>
<td>No</td>
<td>No Response</td>
<td>No</td>
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<td>Iowa</td>
<td>No</td>
<td>No</td>
<td>No response</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>*</td>
<td>Extra weight, Deck inspection</td>
<td>No response</td>
<td></td>
<td></td>
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<td>---------</td>
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<td>-------------------------------</td>
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<tr>
<td>Kansas</td>
<td></td>
<td>Extra weight, Deck inspection</td>
<td>No response</td>
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<tr>
<td>Kentucky</td>
<td></td>
<td>Used mainly in special conditions, explained in summary.</td>
<td>No response</td>
<td></td>
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</tr>
<tr>
<td>Louisian</td>
<td></td>
<td>Widely used, STYROFOAM used to fill in the flutes to obtain a flat surface.</td>
<td>No response</td>
<td></td>
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</tr>
<tr>
<td>Maine</td>
<td></td>
<td>Deck inspection</td>
<td>No response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maryland</td>
<td></td>
<td>No response</td>
<td>No response</td>
<td></td>
<td></td>
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<tr>
<td>Massachusetts</td>
<td></td>
<td>No response</td>
<td>No response</td>
<td></td>
<td></td>
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<tr>
<td>Michigan</td>
<td></td>
<td>Used widely</td>
<td>No response</td>
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<tr>
<td>Minnesoa</td>
<td></td>
<td>Deck inspection, hidden deterioration in urban areas requiring speedier construction.</td>
<td>No response</td>
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<td>Mississippi</td>
<td></td>
<td>No response</td>
<td>No response</td>
<td></td>
<td></td>
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<tr>
<td>Missouri</td>
<td></td>
<td>Hidden deterioration, curved girders and large girders rusting, spacing structures.</td>
<td>No response</td>
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<tr>
<td>Montana</td>
<td></td>
<td>Deck inspection, moisture trapping and deterioration</td>
<td>No response</td>
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<tr>
<td>Nebraska</td>
<td></td>
<td>No response</td>
<td>No response</td>
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<tr>
<td>Nevada</td>
<td></td>
<td>No problem yet, used a lot, sounding and partial removal of forms for inspection.</td>
<td>No response</td>
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<tr>
<td>New Hampshire</td>
<td></td>
<td>No response</td>
<td>No response</td>
<td></td>
<td></td>
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<tr>
<td>New Jersey</td>
<td></td>
<td>Deck inspection, partial removal of forms and sounding</td>
<td>No response</td>
<td></td>
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</tr>
<tr>
<td>State</td>
<td>Notes</td>
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<tr>
<td>New Mexico</td>
<td>No response</td>
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<td>New York</td>
<td>No response</td>
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<tr>
<td>North Carolina</td>
<td>No response</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Dakota</td>
<td>* Deck inspection</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ohio</td>
<td>No response</td>
<td></td>
<td></td>
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<tr>
<td>Oklahoma</td>
<td>No response</td>
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<td>Oregon</td>
<td>No response</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pennsylvania</td>
<td>* Not used in overhangs or Widely used under open medians between bifurcated bridges</td>
<td></td>
<td></td>
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<tr>
<td>Rhode Island</td>
<td>* Both metal and concrete forms - refer summary notes. are being used</td>
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<tr>
<td>South Carolina</td>
<td>No response</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>South Dakota</td>
<td>* Moisture collection and deck inspection Not encouraged to use.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tennessee</td>
<td>* Panels to be designed according to the AISI Specifications for the Design of Cold-Formed Steel Structural Members along with the AASHTO Design Specifications</td>
<td></td>
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<tr>
<td>Texas</td>
<td>* Installation Not used in coastal areas and where there is heavy salt usage.</td>
<td></td>
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</tr>
<tr>
<td>Utah</td>
<td>* Deck inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermont</td>
<td>* Deck inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>* Deck inspection</td>
<td></td>
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</tr>
</tbody>
</table>

Notes:
- * indicates condition or usage
- Deck inspection is a part of the maintenance process.
<table>
<thead>
<tr>
<th>State</th>
<th>Deck inspection</th>
<th>Trap moisture</th>
</tr>
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<tbody>
<tr>
<td>Washington</td>
<td>*</td>
<td>Rusted and causes an unsightly appearance</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>*</td>
<td>Deck inspection, Trap moisture contaminated chloride; Corrodes, making any</td>
</tr>
<tr>
<td></td>
<td></td>
<td>corrosion problems in the deck, and looking unsightly.</td>
</tr>
<tr>
<td>Wyoming</td>
<td>*</td>
<td>Deck inspection, Almost half the bridges use them, its contractor option.</td>
</tr>
</tbody>
</table>