SD44/PLATTE-WINNER BRIDGE CORRIDOR STUDY AND ENVIRONMENTAL ASSESSMENT

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PROJECT MEMORANDUM

BRIDGE TYPE CONCEPT EVALUATION

To: Study Advisory Team (SDDOT, FHWA, SDGFP)

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Document Summary

This memorandum provides an overview of potential bridge types that are available for consideration on the SD44/Platte-Winner Bridge project and an initial bridge type evaluation. This evaluation includes recommendations regarding which major bridge types are feasible for this project, and among those feasible bridge categories, which types are recommended for further consideration.

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Introduction

The HR Green/Summit Engineering Group Bridge Engineering Task Team (Task Team) evaluated several major superstructure types to determine the feasibility of each class for the SD44 Project. The purpose of this evaluation was to determine those bridge types that are best suited for the SD44 corridor. In this manner, the Task Team can focus its energy and attention on these structure classes to present design concepts to SDDOT and all the project stakeholders for consideration.

Major Bridge Types Evaluation

The major bridge types that were examined for the SD44 Corridor include Suspension, Cable Stay, Arch, Truss, Girder/Slab, and Segmental. Special consideration was given to the typical span ranges of each bridge class with the goal of minimizing the amount of substructure and foundations for the new bridge. The Task Team also considered constructability, aesthetics, and cost.

Table 1 provides a comparison matrix for each bridge class, detailing the results of the evaluation for each structure class over the range of evaluation criteria. The Task Team concluded that the Girder/Slab and Segmental structure classes are best options the SD44 Corridor.

Figure 1. Representative Images of Bridge Types

Girder/Slab

Existing SD44 Platte-Winner Bridge – Missouri River

Segmental

Four Bears Bridge - Missouri River

New Town, ND

Arch

Highway 61 Bridge - Mississippi River,

Hastings, MN

Truss

I-70 Blanchette Memorial Bridge – Missouri River

St. Louis, MO

Cable Stay

US 82 Bridge – Mississippi River

Mississippi-Arkansas Border

Suspension

Golden Gate Bridge

San Francisco, CA

Table 1 – Major Bridge Type Comparison Matrix

Bridge Type	Aesthetics	Span Ranges	Construct-ability	Construction Cost	SD44 Corridor Feasibility	Relative Score
Girder/Slab	0 conventional girder slab look, variable depth girders add interest	0 / + 100ft to 450ft	+ Conventional materials, precast or steel girders with concrete deck	0 / + conventional materials and cost	+ **feasible** due to achieving longer spans with conventional materials	**+ 3**
Segmental	+ tapered box shape, variable depth adds interest	0 / + 150ft to 650ft	0 concrete, special forms and equip, simultaneous erection at multiple piers	0 / - somewhat expensive compare to conventional	+ **feasible** due to longer spans eliminating substructure	**+ 2**
Arch	+ long spans with open look	+ 200ft to 700ft	- critical / complex connections, temporary stability of arch ribs critical	- expensive, shipping/erection logistics for prefabbed or CIP arches	- **not feasible** due to high cost and complex construction	**- 1**
Truss	- boxy imposing shape with lots of chord members detract from landscape	+ 400ft to 800ft	- labor intensive / non-redundant connections	- expensive driven by labor to fabricate and erect all the connections	- **not feasible** due to high cost and labor intensive fabrication and erection	**- 3**
Cable Stay	0 / - tall towers that may look out of place	+ 500ft to 1200ft	- highly specialized erection requirements	- (2) very expensive	- **not feasible** due to very high cost and specialized construction	**- 3.5**
Suspension	0 / - tall towers that may look out of place	+ 1000ft to 4000ft	- highly specialized erection requirements	- (2) very expensive	- **not feasible** due to very high cost and specialized construction	**- 3.5**

Screened Bridge Types Comparison

After the major bridge type comparison was completed, the **Bridge Engineering Task Team moved forward with further consideration of structure types that were determined feasible: the Girder/Slab and Segmental categories**. In the Girder/Slab category, five bridge types were investigated: precast simple span made continuous girders, precast constant depth spliced girders, precast variable depth spliced girders, and two types of steel plate girders: constant depth and variable depth plate girders. For the Segmental bridge types the Task Team considered both span by span and balanced cantilever options.

Girder/Slab Bridge Types

Precast simple span girders made continuous for composite loading will have shorter spans and more substructure. This method can be very cost effective when substructure costs are not the primary driver of the overall economy of construction. The superstructure is made from conventionally, locally available materials. Erection can be completed by standard cranes mounted on barges. Spans of up to 185ft are feasible using pretensioned girders and conventional CIP slab construction. These span lengths are less than those of the existing bridge, meaning the amount of substructure would be increased by approximately 15%.

Precast concrete constant depth spliced girders can achieve spans up to 265ft. The girders are produced in lengths up to 190ft at a precast plant to fit the pier layout. The pier segments are erected first and tied down to the piers with a CIP diaphragm. After the pier girders are stabilized, the end girders are erected. They are supported by strongbacks hung from the pier girders at one end and the end bent at the other end. Finally, the drop-in girders in the interior spans are erected on strongbacks hung from the pier girders. After all of the girders in a superstructure unit are erected, CIP closure pours are cast to tie the girders together and post-tensioning is stressed and grouted. At that point the girders act as a continuous beam. Finally, the deck and bridge rails are place by conventional CIP construction. In this manner, the entire superstructure can be erected over the water without requiring temporary supports. The span configuration will achieve a reduction of approximately 7% in the number of piers required when compared to the existing bridge.

Precast concrete variable depth spliced girders can achieve span lengths up to 320ft using. This option is nearly identical to the precast constant depth girders, with the exception that the pier girders get deeper over the piers. This achieves a greater negative moment capacity and allows for longer span lengths. The pier girders match the typical section at the ends to facilitate the closure connections with the end and drop-in girders. However, they vary linearly in depth such that they are approximately 4ft to 4.5ft deeper over the piers. This requires additional forms for the precaster, increasing the girder cost. The construction methods are the same as described for the precast constant depth girders. The number of piers is reduced by 20% over the existing bridge.

Steel plate girder and slab construction also offers many of the same advantages of spliced precast girders. Both **constant depth and variable depth** girder arrangements are possible. Longer spans can be achieve, up to 320ft for constant depth and 400ft variable depth plate girders. Additionally, post tensioning is not required, simplifying the superstructure erection procedures. Due to piece length requirements for shipping, temporary falsework or additional cranes will be necessary to erect the plate girders. Cost of steel plate girders vs. precast concrete is a function of material availability, the relative location of steel/precast fabricators, fabrication cost, and labor cost. Steel prices are generally more volatile than precast concrete, making future price predictions more difficult. Past experience in Colorado and Texas indicates that precast girders are more economical relative to steel. Local South Dakota markets will be investigated by the Task Team to better understand the economy of local materials. For the constant depth plate girders the number of piers is reduced by 20% over the existing

bridge. For the variable depth plate girders, the number of piers is reduced by 35% compared to the existing bridge.

Segmental Bridge Types

Span by span construction can achieve span lengths up to 175ft, which would require a quantity of substructure similar to simple span precast. Superstructure erection would be completely out of the water. The segments are delivered to a gantry that spans between piers. As each span is completed the gantry launches forward and additional segments are delivered over the previously completed spans. This construction method is typically used in urban areas where sight conditions do not allow for falsework. The number of piers would increase by 20% compared to the existing bridge.

B**alanced cantilever construction**, span lengths up to 450 feet are achievable with precast segments. The Task Team recommends that precast segments be considered in lieu of CIP due to construction time. Precast segments can be produced and stockpiled at the same time as the foundations are being cast, shortening the overall project schedule. The segments are delivered by barge to the interior piers and erected by barge mounted cranes or segment lifters from on top of the previously erected superstructure. The pieces are erected in both directions out from the pier to balance the loads during construction. While the longer span lengths will limit the quantity of substructure, the substructure size will increase due to heavier structure loads. Construction costs are higher due to specialized erection methods, equipment, and large amounts of post tensioning. Additionally, the contractor must build a facility for the production and storage of the precast segments adjacent to the site. The number of piers would be reduced by 50% compared to the existing bridge.

Initial Bridge Types Screening Recommendation

Table 2 provides a comparison matrix for each of the superstructure types discussed above. The criteria considered include aesthetics, span length, minimization of substructure, minimization of bearings, minimization of expansion joints, constructability, and construction cost. The comparison results in a relative +/- “score” that provides a reference point for the feasibility of specific bridge types within the girder/slab and segment bridge categories.

The relative score should not be viewed as a definitive comparison of bridge types (a +3.5 score might not be clearly better than a +2.5 score). The results in Table 2 do serve as a guidepost in the evaluation of bridge types and help the project team narrow the range of bridges to consider in more detailed evaluation. For example, the construction cost criteria will be further refined moving forward, as the Task Team is able refine the analysis to estimate the size of the foundations and substructure required for each option.

At this time we recommend **eliminating** the **precast simple span girders made continuous** and the **span by span segmental** options from further consideration. Further refinement and evaluation of bridge types will be documented in separate technical memoranda.

Table 2 – Girder/Slab and Segmental Bridge Type Options Comparison Matrix

Bridge Type	Aesthetics	Minimize Substructure	Maximize Span Lengths	Minimize Bearings ("Brg")	Minimize Expansion Joints ("exp jts")	Constructability	Construction Cost	Reference Projects	Relative Score (Recommend-ation)
Precast Concrete Girder (Simple Span Made Continuous)	**-** conventional precast girder look	**-** Spans up to 185ft	**-** Spans up to 185ft	**0 / +** Brg @ exp jts, Integral diaph @ int piers	**-** 4 to 5 span units (700ft to 925ft) between exp jts	**+** conventional material and methods, erect from barges	**0** standard P/C forms, conventional methods	SR20 Methow River Bridge, WA	- 2.5 **(Eliminate)**
Spliced Precast Concrete Bulb-T (Constant Depth)	**-** conventional precast girder look	**0 / +** Spans up to 265ft	**0 / +** Spans up to 265ft	**+** Brg @ exp jts, Integral diaph @ int piers	**+** 4 to 5 span units (900ft to 1200ft) between exp jts	**+** conventional material and methods, erect from barges, no falsework	**0** standard P/C forms reusable on future projects, min PT on site, no falsework	Sylvan Avenue Bridge, TX	+ 3 **(Retain)**
Spliced Precast Concrete Bulb-T (Variable Depth)	**0** conventional P/C girder look, variable depth adds interest	**+** Spans up to 320ft	**+** Spans up to 320ft	**+** Brg @ exp jts, Integral diaph @ int piers	**+** 4 to 5 span units (1100ft to 1450ft) between exp jts	**+** conventional material and methods, erect from barges, no falsework	**0** standard P/C forms reusable on future projects, special haunch P/C forms, min PT on site, no falsework	Sylvan Avenue Bridge, TX Dallas Horseshoe Project, TX	+ 5 **(Retain)**
Steel Plate Girder (Constant Depth)	**-** conventional steel girder look	**+** Spans up to 320ft	**+** Spans up to 320ft	**-** Brg @ all supports	**+** 4 to 5 span units (1100ft to 1450ft) between exp jts	**0 / +** conventional material and methods, erect from barges w/ falsework	**0 / +** conventional methods, falsework	I-90 Missouri River Bridge, SD	+ 2 **(Retain)**
Steel Plate Girder (Variable Depth)	**0** conventional steel girder look, variable depth adds interest	**+** Spans up to 400ft	**+** Spans up to 400ft	**-** Brg @ all supports	**+** 4 to 5 span units (1500ft to 2000ft) between exp jts	**0 / +** conventional material and methods, erect from barges w/ falsework	**0 / +** conventional methods, falsework	Existing SD44 Platte-Winner Bridge SD	+ 3 **(Retain)**
Segmental Concrete (Span by Span)	**+** tapered box shape	**-** Spans up to 175ft	**-** Spans up to 175ft	**-** Brg @ all supports	**-** 4 to 5 span units (700ft to 925ft) between exp jts	**-** special forms, erection gantry, build fabrication plant, out of water for superstructure erection	**-** special forms, erection gantry, specialty contractor, build fabrication plant	I59/20 Bridge Replacement, AL (in progress)	- 5 **(Eliminate)**
Segmental Concrete (Balanced Cantilever)	**+** tapered box shape, variable depth adds interest	**+** Spans up to 450ft for precast and 650ft for CIP	**+** Spans up to 450ft for precast and 650ft for CIP	**-** Brg @ all supports	**+** 4 to 5 span units (1500ft to 2000ft) between exp jts	**-** special forms, specialty equipment, build fabrication plant, simultaneous erection at multiple piers	**-** special forms, special erection equip, specialty contractor, build fabrication plant	Four Bears Bridge, ND (P/C)	+ 1 **(Retain)**