Innovative Bridge Designs that Accelerate Construction using Precast Concrete

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The use of precast concrete components in bridge construction in the United States has steadily advanced in response to a desire for greater economy, enhanced durability and lower maintenance costs. Precast concrete has primarily been used for conventional beam and deck slab bridges and segmental bridges. Other applications of precast concrete elements used for the construction of bridge projects include; full and partial depth deck panels, retaining walls, arches, pier columns and pier caps. Precast concrete bridge elements are typically designed as mildly reinforced, pre-tensioned or post-tensioned. Additionally, they may be designed with a combination of mild reinforcement, pre-tensioning, and post-tensioning for both temporary and final service conditions. Segmental and spliced girder bridges have been used to achieve span lengths suitable for almost all kinds bridge applications and curved precast has been recently used for complex interchanges.

The development of new methods and materials using precast concrete has enabled designers and constructors to explore innovative solutions that allow construction with difficult site constraints, increase economy, improve quality, and shorten the time necessary to construct projects. The popularity of Accelerated Bridge Construction has further stimulated engineers and constructors to develop additional creative solutions to reduce construction time and minimized interference to the travelling public during construction. Prefabricated Bridge Elements and Systems (PBES) made with precast concrete have been used to simplify and streamline construction operations and reduce the need for extensive temporary works and field operations. The use of PBES creates the opportunity to perform multiple operations simultaneously with the fabrication cycle of the precast elements. This enables contractors to shorten the duration of disruptive operations such as demolition, lane shifts and traffic detours.

This presentation will feature several case studies that illustrate several concepts where precast concrete PBES have been used to accelerate the construction process and reduce impact to the public. Projects using PBES as the primary methodology to achieve ABC are typically constructed by local Contractors using conventional means and methods without the need for specialized equipment or expertise. Further, the projects that will be presented were developed in Alternative Delivery System environments, such as Design/Build, CMGC, Contractor Alternate Design or Value Engineering Proposal. For this reason, the Contractor was instrumental in the development of design concepts with the Design Engineer. This process has created an approach to bridge design that will feature in this presentation. The design approach will be referred to as "Constructability Based Bridge Design."

Constructability Based Bridge Design

Constructability Based Bridge Design (CBBD) is an approach that focuses on design concepts that are developed around a proposed construction scheme and assumed means and methods. The primary focus of CBBD is to create designs that first concentrate on ease of construction and then hone in on material efficiency. The case studies in the presentation will feature bridge projects with a variety of different designs that used precast concrete elements to enhance constructability which resulted in more rapid construction and reduced impact on the traveling public.

Constructability Based Design relies on the following processes:

- Project requirements are considered.
- Input is sought from various Stakeholders.
- Key Objectives are identified which focus on how the bridge will be built before design begins.
- Reduced impact on existing traffic is considered as a valuable result of the process.

- Design solutions are developed through an iterative and collaborative process.
- Design concepts and details are finalized based on streamlined means and methods.
- Compliance with Project Design Requirements is satisfied.
- Design Documents are prepared.
- Design Engineering support continues through construction.

Constructability Based Design reflects the following principals:

- Design must incorporate the Construction Means and Methods.
- Design as many elements as possible that can be prefabricated.
- Create opportunities for simultaneous operations and avoid designs that create sequential operations whenever possible.
- Connections should be designed for ease of construction.
- Larger tolerances in connections result in more predictable and desirable outcomes.
- Keep it Simple. Complexity is sometimes necessary but should be avoided if possible.
- Repetition in design details and processes is advantageous.
- Avoid exotic materials unless they create construction advantages.
- Access for construction, fabrication or installation is essential.
- Issues such as shipping, handling, erection and demolition must be considered.
- Ease of Construction typically results in better quality in less time.

Precast Concrete Designs

The paper will present information on existing and completed projects where precast concrete elements, both simple and complex, have been used during construction to reduce time and impacts to existing traffic. Projects will feature innovative designs that use both common elements such as piers, pier caps and precast deck elements and more complex projects that feature spliced and curved precast girders or composite straddle caps to simplify erection and eliminate temporary shoring. Multiple projects representing a wide range of bridge designs will be featured to illustrate these concepts.

Substructure Construction is typically performed on or near existing roadways. By designing precast concrete with a Constructability Based Bridge Design approach, critical operations can be done off the roadway or during specific and limited lane closures. This creates an opportunity to perform critical operations which minimize the impact to existing roadways and/or delay demolition of structures that are to be replaced.



Precast Straddle Bents Eliminate Temporary Shoring and Ramp Closures

Precast substructure and superstructure elements can be prefabricated and stockpiled prior to being needed for construction. Constructible Designs can enable the Contactor to begin operations with an accelerated erection scheme that reduces time necessary for detours or roadways closures in order to

erect areas the substructure and superstructure. The staging of both substructure and superstructure construction is considered during the design process in order to create an efficient sequence of events where one operation is rapidly followed by the next until the new structure is completed. This approach also seeks to limit interference between areas of the project and creates the opportunity for multiple, simultaneous operations which greatly optimizes the overall construction process.



All Bridge Piers are Precast at Job Site Prior to Start of Phased Construction



Simultaneous Construction of Precast Elements Streamlines Bridge Erection

This presentation will feature completed projects that were successfully constructed on time and under budget using precast concrete in different situations and PBES methods to achieve ABC results. The presentation will also feature projects that are currently under construction and design concepts that were developed to maximize the use of precast concrete, PBES and Constructability Based Bridge Design.