SR-35 Columbia River Crossing Feasibility Study

Bridge Construction Assumptions

Working Draft

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Table of Contents

SITE CONSTRAINTS 1

PROPOSED BRIDGE TYPES 2

EXISTING BRIDGE DEMOLITION AND STAGING 5

SUBSTRUCTURE 7

FOOTING CONSTRUCTION 11

PIER CONSTRUCTION 13

SUPERSTRUCTURE 15

SR-35 Hood River Bridge

Bridge Construction Assumptions

This memorandum identifies the construction issues and operations required for building a steel or concrete girder/box bridge supported on concrete piers, with a possible sub-option of utilizing a Steel Tied Arch Type Span over the Navigation Channel for the SR-35 Hood River Bridge Replacement Study over the Columbia River in Hood River, Oregon / White Salmon, Washington.

Site Constraints

Land Uses

The bridge site is largely located over an existing navigable waterway. There are limitations on the contractors' construction activities imposed by existing and proposed land uses adjacent to the alignment, as well as environmental considerations. Shoreline development is anticipated on both banks of the river, and could occur within the anticipated bridge construction timeframe. This development could have an influence on bridge construction by restricting contractor access. In addition, an in lieu fishing site exists along the north bank approximately 200 feet upstream of the existing bridge. The contractors' access could be limited, by having to maneuver barges and equipment to the proposed bridge site while leaving the Native American access to the river unimpaired. Two of the proposed bridge alignments, EC-2 and EC-3, lie between the two Native American fishing sites. The south bank development would occur from the implementation of the Port of Hood River master plan, which would develop a majority of close available land. If this land remains undeveloped, it could be used for the contractors' staging yard.

Staging Areas

There are limited potential staging areas directly adjacent to the bridge site. The most promising existing area is available land that is owned by the Port of Hood River. A minimum of 1 acre would be necessary to facilitate the contractors' storage and staging area. Floating staging areas on barges could be used where on-shore space is not available nearby. The historic industrial land uses along this reach of the Columbia River shoreline suggest that larger staging areas exist at locations in close proximity to the project site. It is anticipated that the majority of the construction materials will arrive at the project site by water.

Navigation

There is one navigation channel in the vicinity of the proposed bridge locations. Navigation needs to be maintained at all times during construction. This will constrain the contractors' use of equipment and superstructure (deck and girder) erection techniques. Temporary lighting will likely be required for equipment in the river. Existing horizontal and vertical navigation clearances on this reach of the Columbia River do not appear to present a problem to contractor access by water. According to the *SR-35 Bridge Feasibility Study, Navigation Baseline Report*, dated October 6, 2000, the vertical navigation clearance under the existing bridge in the closed position is charted at 67 feet with a XX horizontal clearance. For the new bridge, the revised *SR-35 Bridge Feasibility Study, Navigation Baseline Report*, dated January 2003 recommends the following:

- The navigation channel under the bridge should have horizontal clearance equal to or greater than 450 feet.
- The recommended vertical clearance under the bridge is 80 feet above the full pool elevation of 77 feet MSL. At a minimum, the vertical clearance could be measured relative to normal pool elevation of 73 feet MSL.
- Channel alignment should allow tugs and barges to be aligned with the westerly winds that now hit on the diagonal and cause control problems, especially for tows with empty barges.
- Design proposals should be reviewed by commercial river users to ensure that their navigability issues are addressed. These discussions should be preliminary to the U.S. Coast Guard permitting process.

Bridge Lighting (Navigation and Roadway Level)

Navigation lights with photocell control will be placed on the new bridge. The installation will be according to the U.S. Coast Guard requirements.

Roadway illumination will be provided on the sidewalk along the western edge of the bridge. Further study and public outreach is necessary to determine the requirements and needs for traffic lighting.

Hydraulics

The Columbia River near the SR-35 Bridge, Columbia River Mile 169.6, is heavily regulated by federal dams upstream and downstream. The dams upstream of the project modify the flow in the river, decreasing the natural flow during flood events by holding back water and increasing the natural flow during drought events by releasing additional water. The dam downstream of the project site, Bonneville Dam at Columbia River Mile 145.1, modifies the stage of river at the SR-35 Bridge by controlling the volume of water released through the dam and subsequently controlling the elevation of the river upstream of the dam.

The forebay or pool elevation of Bonneville Dam is the level of water upstream or behind the dam. The forebay can fluctuate from the minimum operating pool elevation of 70.0 feet, NGVD to the maximum operation pool elevation of 82.5 feet, NGVD. The normal pool elevation is 73.0 feet, NGVD and the full pool elevation is 77.0 feet, NGVD.

Floodplain Information

The floodplain of the Columbia River near the SR-35 Bridge is designated as Zone A (approximate). The 100-year floodplain is identified, but base flood elevations and flood hazard factors are not determined. Unofficial flood profile elevations and flows were obtained, however, from the Floodplain Management Section of the Portland District, U.S. Army Corps of Engineers, and are shown below.

Flood Levels and Discharges

SR-35 Bridge, Columbia River Mile 169.6

Recurrence Interval (years)	Discharge (cfs)	Water Surface Elevation (feet, NGVD)
2	360,000	81
10	515,000	85
50	635,000	88
100	680,000	89
500	800,000	92

Note: Water surface elevations based on Bonneville Dam full pool elevation of 77.0 feet, NGVD.

If work is performed within the 100-year floodplain, potential flood rise issues must be evaluated. A floodway is not designated on the Columbia River near the SR-35 Bridge, therefore, a "no-rise" certification will not be necessary. According to FEMA Region X, FEMA does not have specific guidelines in the Code of Federal Regulations limiting flood rise in floodplains designated as Zone A. FEMA does have an agreement with the Federal Highways Administration that any new structure within the floodplain must cause less than one foot of rise in the base flood elevation.

In-Water Work Windows

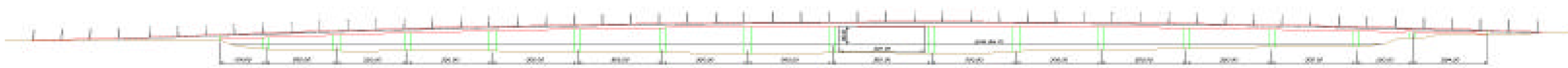
Fish migration places significant restrictions on periods when work can be done in the river below the water level. The available schedule window is between mid November until mid-March. Outside of these timeframes, all work must be done within cofferdams, in dry condition (work above water line). This is a major constraint on the contractor's foundation construction schedule, a critical path activity.

Construction Time

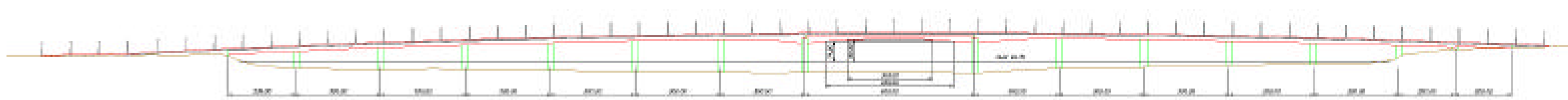
Depending on the crossing location, length, and type of bridge, a construction period between three to five years should be expected from notice to proceed for the first site contractor, to opening of the new bridge, to removal of the existing bridge. Major time constraints include in-water construction periods, existing adjacent developments, and proposed developments. Many factors need to be determined, such as construction contract packaging and structure type, before a firm schedule can be established. If time is a major issue, there are methods for speeding up the entire design/construction process.

Proposed Bridge Types

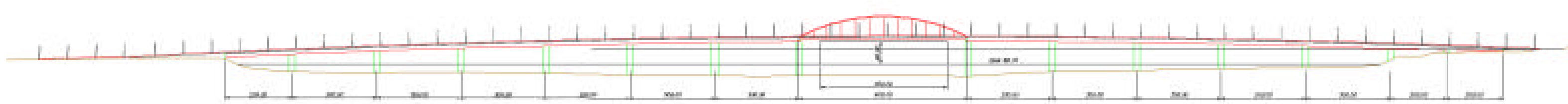
- Girder Segmental with 300' Typical Span
- Girder Segmental with 600' Parabolic Span Over Navigation Channel
- Girder Segmental with 600' Tied Arch Span Over Navigation Channel



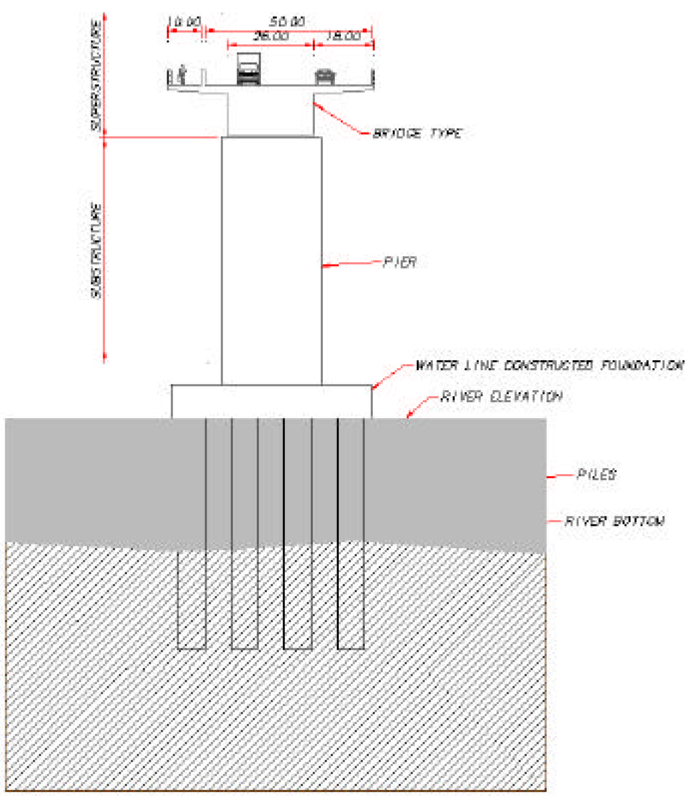
Girder Segmental with 300-foot Typical Span



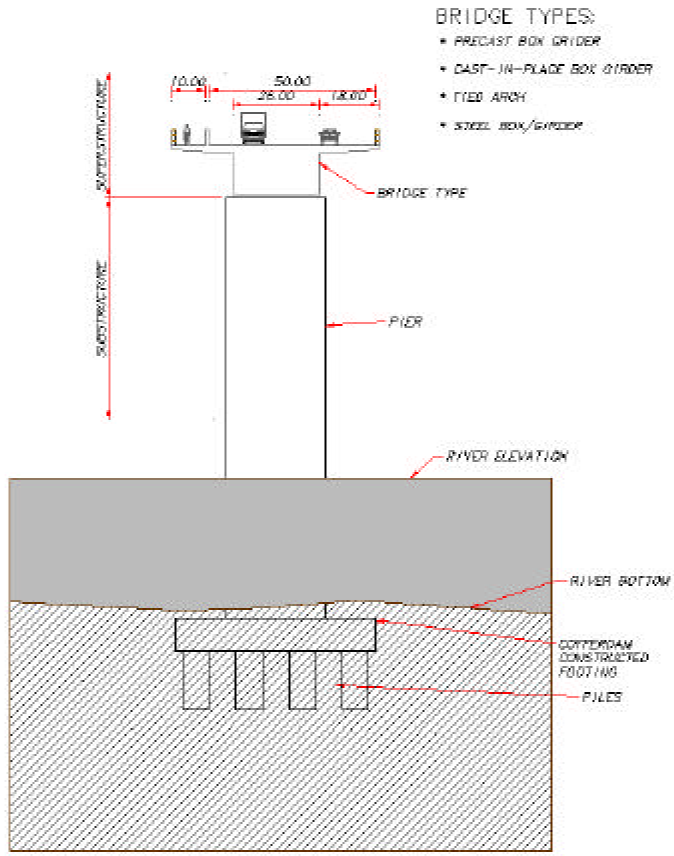
Girder Segmental with 600-foot Parabolic Span over the Navigation Channel



Girder Segmental with 600-foot Tied Arch Span over the Navigation Channel



Waterline Footing



Cofferdam Dam Footing

Typical Superstructure/Substructure Configuration

Existing Bridge Demolition and Staging

Major Bridge Foundation Removal

- Cofferdam being constructed around an existing pier to facilitate removal

Major Bridge Truss Superstructure Removal

- Truss span being maneuvered in river by a system of barges

There are no significant existing structures that need to be demolished during the site clearing. The existing bridge is proposed to remain open during construction of the new bridge. Once all traffic has been switched over to the new bridge, demolition of the existing bridge can begin. The existing bridge is most likely painted with a lead-base paint. As such, care will have to be exercised in its removal to prevent paint debris from entering the river. The contractor could begin by removing the lift span portion of the bridge. The bridge would be lowered into a down position, and electrical, mechanical, and other components associated with the lift towers would be removed. Note that on older movable bridges, there could be a considerable amount of electrical gear containing asbestos that will need to be removed. The contractor could then proceed to remove the deck, railings, lights, etc. from the truss.

This work could start at the lift span and work to each shore, utilizing the bridge as a haul and work bridge. Once the trusses are stripped of non-essential weight, barges could be moved in and the trusses picked off the piers and shipped to an appropriate site to begin the process of lead paint removal.

In-Water Pier Removal

- Track excavators working on removal of a concrete pier along a shoreline

Major Bridge Truss Superstructure Removal

- Truss span being removed from existing pier by system of barges

Once the paint is removed, the steel could be salvaged. With the entire truss now removed, the pier removal would be next. One method would be to construct a cofferdam around the existing piers and footings, dewater, and demo the pier to the existing mud line. The cofferdams would need to be constructed and removed during the fish windows.

Substructure

Pile Alternatives

Two alternative pile systems are under consideration at this time: steel pipe piles and drilled shafts. A detailed geotechnical exploration program is necessary to determine applicable pile types and installation methods. In general, the ground conditions consist of ten's of feet of loose alluvium underlayed by rock. Depending of the depth of rock, this may make driven pile foundation not applicable, but for general discussion purposes, both driven and drilled pile systems will be presented.

Major Waterway Bridge Foundation Construction

- Work bridge connecting cofferdams
- Cofferdams constructed to allow dry foundation installation
- Barge-mounted cranes used to construct cofferdams and bridge footings

Abutment Pile Options

Bridge Foundation Construction
- Land-based, drilled-shaft installation

Bridge Foundation Construction
- Abutment footing excavation
- Drive steel pile installation and layout

The foundations for the abutments are anticipated to be 4 to 6 feet in diameter drilled shafts or a series on driven piles. As with the river piles, these piles will need to be spliced. These piles could be installed with small land-based equipment or barge-based cranes if water depths on the south shore allow. Drilled shaft construction for the abutment foundations will most likely use ground-based equipment. Access is not anticipated to be a major issue, due to the size of the equipment necessary to construct the smaller diameter shafts. The contractor will likely use casings at the abutments, and it is anticipated that the casings will be withdrawn during tremie concrete placement.

Driven pile foundations will require a slightly larger footing footprint, with multiple rows of piles.

Both types of abutment foundations are common construction to this area.

River Pier Pile Options

Driven Steel Piles

The major advantages of steel pipe piles are the speed of installation (about 2-3 days maximum per pile versus 5 [very dependant on drilling conditions which are unknown at this point] days for drilled shafts). In addition, there is no excavated underwater material to be removed from the site and disposed of.

It is anticipated that large diameter piles will be required for the river piers. Welded splices will be required for these pile lengths due to limitations on pile handling and shipping. It is anticipated that the piles would be shipped in 60-foot lengths. A hydraulic hammer would likely be required to drive the piles into the ground. The actual hammer will have to be barge-mounted, and during preliminary engineering an assessment will have to be made as to the availability of barge-mounted, pile-driving hammers when selecting a pile size, length, and type for construction.

Drilled Shaft Option

Bridge Foundation Construction

- Water-based, drilled-shaft installation

Drilled shafts are a common type of construction in the northwest United States, and are suitable for use on river crossings. The major advantages of this pile type are familiarity by local contractors and relatively easy access to equipment.

Drilled shafts for the pier foundations will require barge-based cranes and steel casings. Excavated material will need to be removed and disposed of at an appropriate location, which may result in environmental permitting issues and corresponding construction schedule impacts. The casings would remain in place below the mud line. Drilling slurry will likely be required and will require precautions by the contractor to prevent the slurry from accidentally spilling into the river.

Drilled-Shaft Construction

- Water-based, drilled-shaft installation

Bridge Foundation Construction

- Water-based, drilled-shaft installation
- Steel form around drilled shafts to facilitate pier cap construction
- Existing water line foundations in background

Bridge Foundation Construction

- Water-based, drilled-shaft installation
- Barge-mounted cranes constructing drilled shafts

Footing Construction

Two alternative pier-footing schemes are considered: cofferdam construction and water line foundations. Both schemes would require the use of barge-mounted equipment.

Water Line Footings

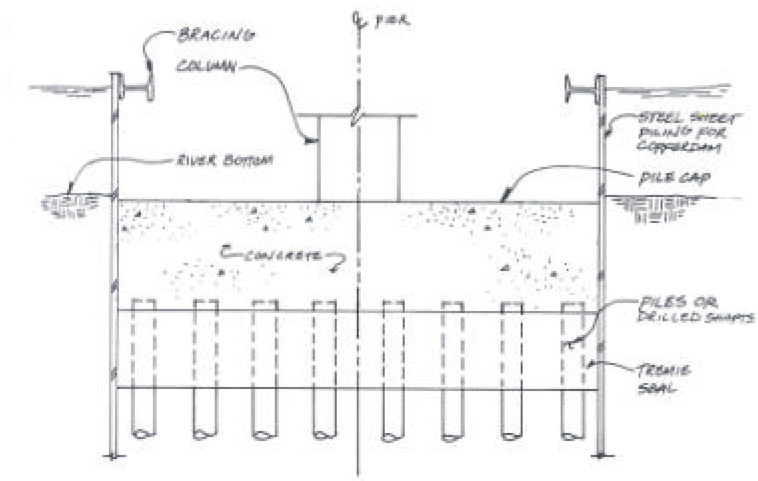
Water Line Footings in Completed Form

The preferred scheme is the water line foundation using a precast concrete lost form. This scheme consists of constructing the precast footing shell off-site, floating the forms into the final position, and anchoring the forms with spud piles. The lost form also acts as a template for driving or drilling the piles. Following pile placement, a thin tremie pour is placed, and the form is dewatered to permit placement of the footing reinforcing steel. This scheme eliminates the necessity for driven cofferdams in the river.

INSERT SKETCH OF FOOTING SECTION

Cofferdam Footings

An alternative to the water line foundation scheme is the construction of a sheet pile cofferdam. In this scheme, the sheet piling is placed in a perimeter around the excavation; steel pipe piles or drilled shafts placed; a tremie seal placed; and the cofferdam dewatered to allow for footing rebar and concrete placement in the dry. This scheme will need verification by geotechnical analysis to confirm sheet piles for the cofferdam are feasible. Driven cofferdams are also assumed for the removal of the existing bridge piers.



Cofferdam Footing

- Steel sheets are installed around the perimeter of the proposed footing
- Pile installed and Tremie Concrete is place to allow de-watering
- Footing and Pier Constructed
- Cofferdam removed

Cofferdam Installation around an Existing Pier

- Steel template is installed around the perimeter of the existing pier and footing
- Pile installed and Tremie Concrete is place to allow dewatering
- Footing and Pier Constructed
- Cofferdam removed

Pier Construction

Piers are constructed above the footings. They provide vertical support to the bridge superstructure. In navigable waterways, they must also be designed to withstand potential barge or ship impacts. Fenders may be constructed to reduce these impact forces and to protect ships and barges.

Pier construction begins once the footings are in place. Steel or plywood forms can be used for frequent reuse and rapid advancement of a cast-in-place pier. The forms are typically constructed to cast/build segments of the pier vertically, and moving the forms upward as the pier construction takes place. Many different shapes of the piers are possible; the most economical shape would have a consistent cross-section. The size and frequency of piers depends on the type of superstructure and spans they are supporting. Concrete is the most likely construction material to be used but they could also be built of steel.

Concrete Pier for Segmental Construction

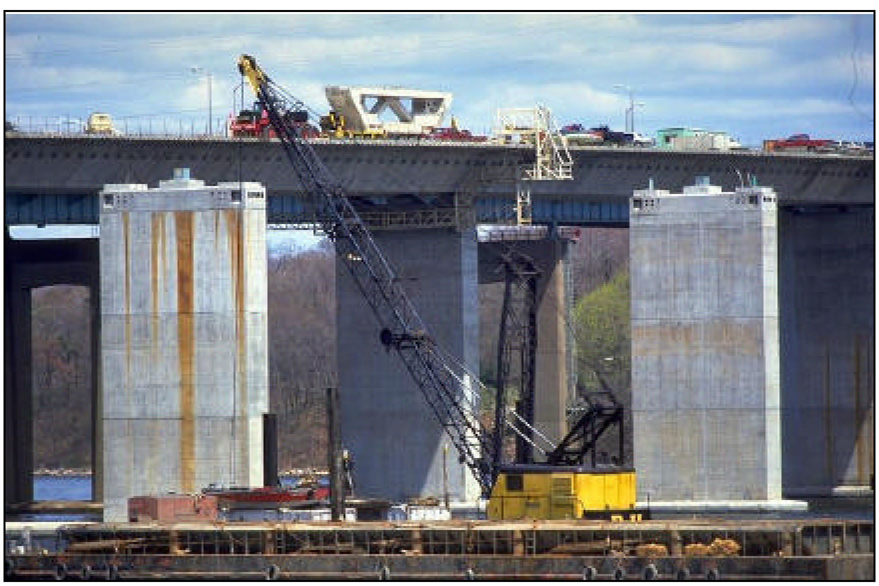
- Twin Piers to facilitate balanced cantilever construction technique
- Steel form used to construct oblong pier shape

Concrete Pier

- Steel rebar extending from drilled shaft
- Steel form for to be place around rebar cage to cast concrete

Concrete Piers

- Cable Stay tower construction for Delta Frame
- Approach spans on waterline foundations with single concrete pier



Concrete Piers

- Single Rectangular Pier
- Cast in 3 segments with slip forms
- Constructed on water line foundations
- Construct from barges

Superstructure

Bridge Construction Over Land and Small Waterways

Falsework Placement

- ➢ Temporary steel falsework constructed along slope to support Cast-in-Place Concrete Bridge Construction

Conventional construction entails typical highway bridges constructed of concrete and steel. Each of these materials employs various construction techniques and has different applications depending on if it is over land or water.

In conventional construction for cast-in-place concrete bridges, once the piers are constructed a temporary bridge structure (falsework) is built from the ground up to support construction of the bridge span. This structure consists of falsework piers topped by forms into which the concrete for the bridge span will be poured. This approach is used because the final bridge structure cannot support its own weight until the concrete has hardened. Conventional construction results in significant on-ground impacts caused by the extensive construction area needed to build the falsework. This type of construction is most appropriate for bridges over land in primarily undeveloped areas or where there are no ground obstructions or sensitive environmental areas. Constraints to this approach include construction over water, urban environments, and sensitive environments where construction impacts could be significant. If this is the case, precast girders and/or steel girders can be used to avoid the landside disruption and span from pier to pier.

Falsework Placement

- ➢ Temporary timber falsework constructed to support cast-in-place concrete bridge construction

Steel Girder Placement

- No falsework required for bridge construction
- Barge-mounted crane positioning girder on pier located in river

Steel Box Girder Placement

- No falsework required for bridge construction
- Girder being placed onto piers by cranes

Bridge Construction Over Large Waterways

Concrete Segmental Construction

In segmental superstructure construction, the primary load-supporting portions of the bridge are made up of segments, which are then post-tensioned together using steel cables.

Cast-in-Place (CIP) Segmental

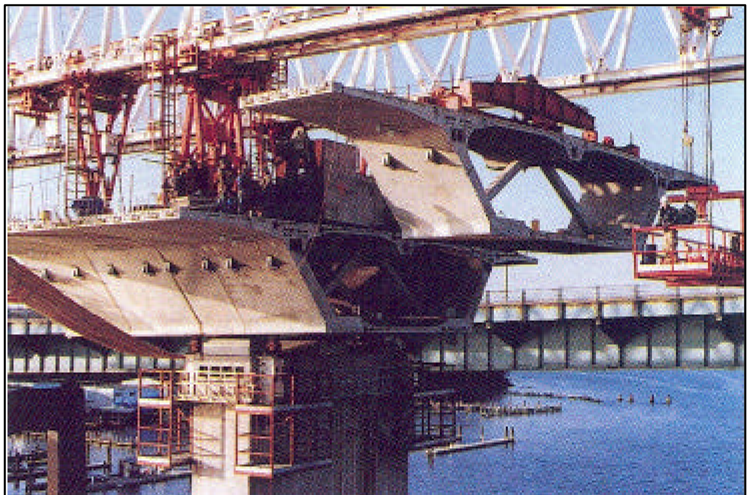
- Balanced Cantilever Construction
- Variable depth CIP section
- Formwork pushed out after each segment is cast and tensioned

Cast-in-Place Segmental Construction

In cast-in place segmental construction, segments are cast one after the other in their final location in the structure. The segments are supported from the adjacent completed segments by travelers for balanced cantilever construction or by formwork units moved along a supporting gantry for span-by-span construction. A traveler is a structure, usually a covered form structure, that is first supported on the piers, then moved forward as each segment is completed.

A gantry is a temporary overhead steel structure supported on the bridge piers. Each segment is then post-tensioned longitudinally, or from end to end, along the span of the bridge. The size of each segment is limited by the capacity (weight and dimensional) of the traveler used to move the forms along the bridge span or the overhead gantry.

Precast Segmental Construction



Precast Segmental

- Overhead gantry positing precast box
- Balanced Cantilever Construction
- Constant depth precast section

In precast segmental construction, bridge segments are constructed offsite. They may then be trucked or barged to the bridge site and lifted into place with a crane or gantry, as described above. The size of the segments is affected primarily by the method of transport available. For example, a bridge location near a navigable waterway could use larger segments because they can be transported by barge.

Precast Segmental

- Overhead gantry positing precast box
- Balanced Cantilever Construction
- Constant depth precast section
- Precast segments transported to site by barge

If segments must be transported by truck, they are generally limited to widths able to travel within a roadway lane.

Precast Segmental

- Bridge superstructure segment transported by truck

Steel Bridges

Plate Girder

Steel Plate girders would be approximately the dame depth or slightly shallower than concrete segmental box girders. Deflection and economy of steel design requirements, rather than steel material costs, typically control depth to span ratios. Large steel elements could be transported to the site on a barge or by

Steel Girder Placement

- No falsework required for bridge construction
- Barge-mounted crane positioning girder on pier located

truck, lifted into place, and bolted into continuous spans. Erection time would be faster with steel girders compared to concrete segmental types, but the deck construction for the steel girder would be much slower. Another Steel Structure type is a Steel box. Steel box spans would be fabricated off-site, and could either be transported by barge of truck to the project area. Then erected into positions be barge-mounted cranes.

Steel Box Girder Placement

- No falsework required for bridge construction
- Girder being placed onto piers by cranes

A third steel structure type an arch for the main navigation span of the river could be combined with either the concrete or girder segmental bridge approach spans. It is likely the contractor would fabricate units as large as crane capacity would allow, barge the unit to the site and lift them into place. As an example, the 900-foot main span of the Fremont Bridge was lifted into place after being assembled on barges in the Willamette River at an accessible site. Depicted below is the Fremont Bridge main span being lifted off barges into its final position.

Fremont Bridge
- 900-foot Arch span being placed
- Fabricated off-site and barged