

A newly developed prestressed concrete I girder, capable of spans up to 164 ft (50 m), played a key role in the winning concrete alternate design for a 1345 ft (410 m) long, sharply curved nine-span bridge.

Annacis Channel East Bridge

This precast prestressed concrete bridge is a nine-span 1345 ft (410 m) long sharply curved and superelevated structure with a complex geometry. The bridge, situated on Annacis Highway just south of Vancouver, British Columbia, spans a busy shipping channel of the Fraser River—a major coastal estuary.

Although precast concrete girders are commonly used in bridge construction in Western Canada, this bridge represents the latest development in the trend toward having longer bridge spans using precast I girders. Prior to this project, the Department of Highways was using six standard precast I girders, ranging in depth from 3 to 7.6 ft (0.91 to 2.30 m).

A new prestressed I girder section, 9 ft (2.75 m) deep, was specially developed for this project. This section allowed for the use of 164 ft (50.0 m) prestressed simple spans in the land portion and 197 and 233 ft (60.0 and 71.0 m) spans in the river portion of the bridge, resulting in substantial savings to the owner. The Ministry of Transportation and Highways examined bids for two alternate designs, steel and precast concrete. The bid price for the concrete alternative, utilizing the new 9 ft (2.75 m) deep prestressed concrete I girders, was 26 percent lower than that for a steel bridge. The concrete alternative was selected for construction.

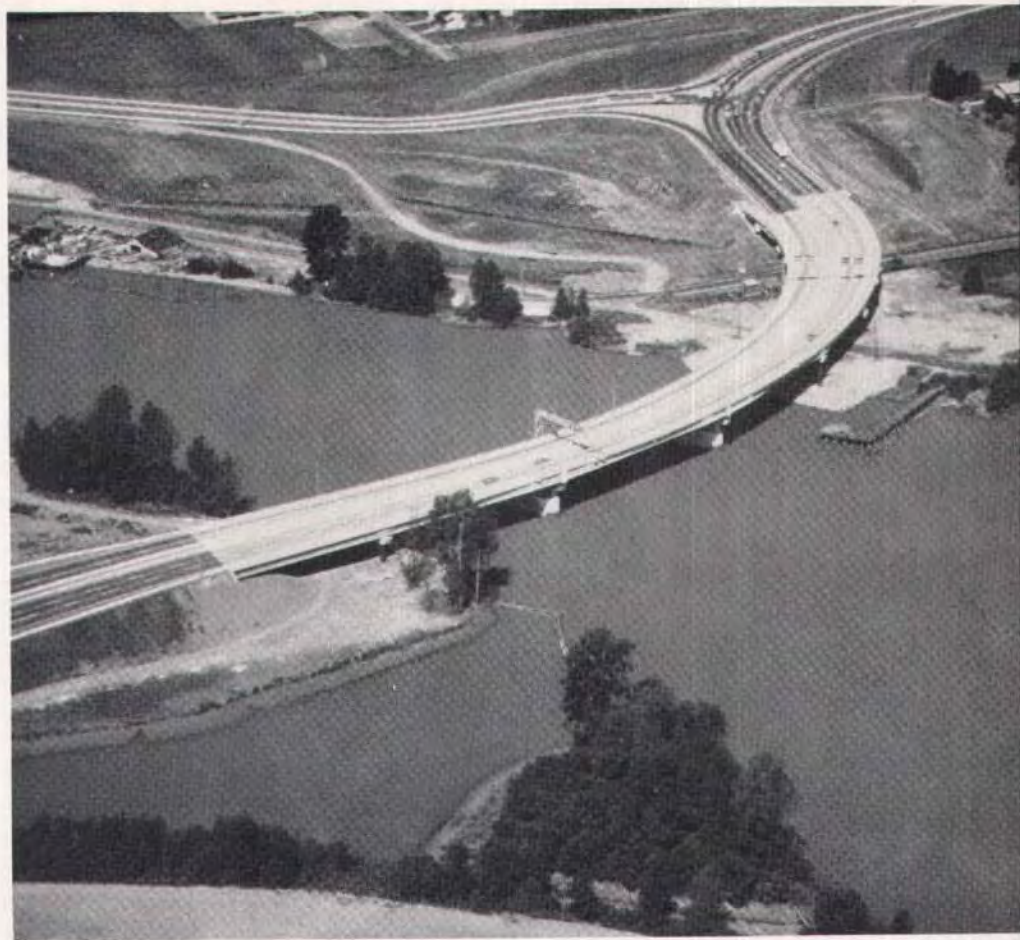
Development of New Section

The conceptual design of the bridge called for a ten-span structure, consisting of six land spans and four river spans. All spans were simple spans from 115 to 148 ft (35.1 to 45.1 m).

Geotechnical investigations revealed very poor soil conditions. Preliminary calculations indicated that the land piers would consist of 5 ft (1.52 m) diameter steel piles up to 230 ft (70.1 m) long. The size of the river piers was governed by a large ship impact force specified by the Ministry of Transportation and Highways. Preliminary cost estimates indicated that a net saving of \$1,000,000 (Canadian) could be achieved if the length of spans could be increased, thus eliminating one river pier.

A new span arrangement, using a long center span of 233 ft (71.0 m) and two flanking spans of 197 ft (60.0 m), was proposed for the river portion of the bridge (see Fig. 1). The largest precast I girder available could not be used to span 233 ft (71.0 m) as required by this new arrangement, prompting development of a new I girder section (see Fig. 3).

With the cooperation of the Portland Cement Association and local precast fabricators, a new I girder section was developed. A 9 ft (2.75 m) deep section was



selected with the top flange 5 ft (1.50 m) wide. This section allowed the main river span to increase to 233 ft (71.0 m) and the two adjacent river spans to 197 ft (60.0 m). It was also beneficial by allowing greater lateral spacing between girders in the land spans, which resulted in fewer girders and, therefore, a lower cost of the superstructure.

Design Considerations

After consultations with the Department of Highways and local precast fabricators, a 9 ft (2.75 m) deep girder was designed. Due to the complex geometry of the bridge almost every girder had a different length. Due to the variable width of the superstructure the girders were generally not parallel to each other, thus creating a variable loading along the girder. To overcome this problem, computer programs were used extensively in the design.

Ten to twelve girders per span were used (see Fig. 4). The design of the girders was based on a maximum compressive strength at release of 5400 and 7250 psi (37 and 50 MPa) at 28 days.

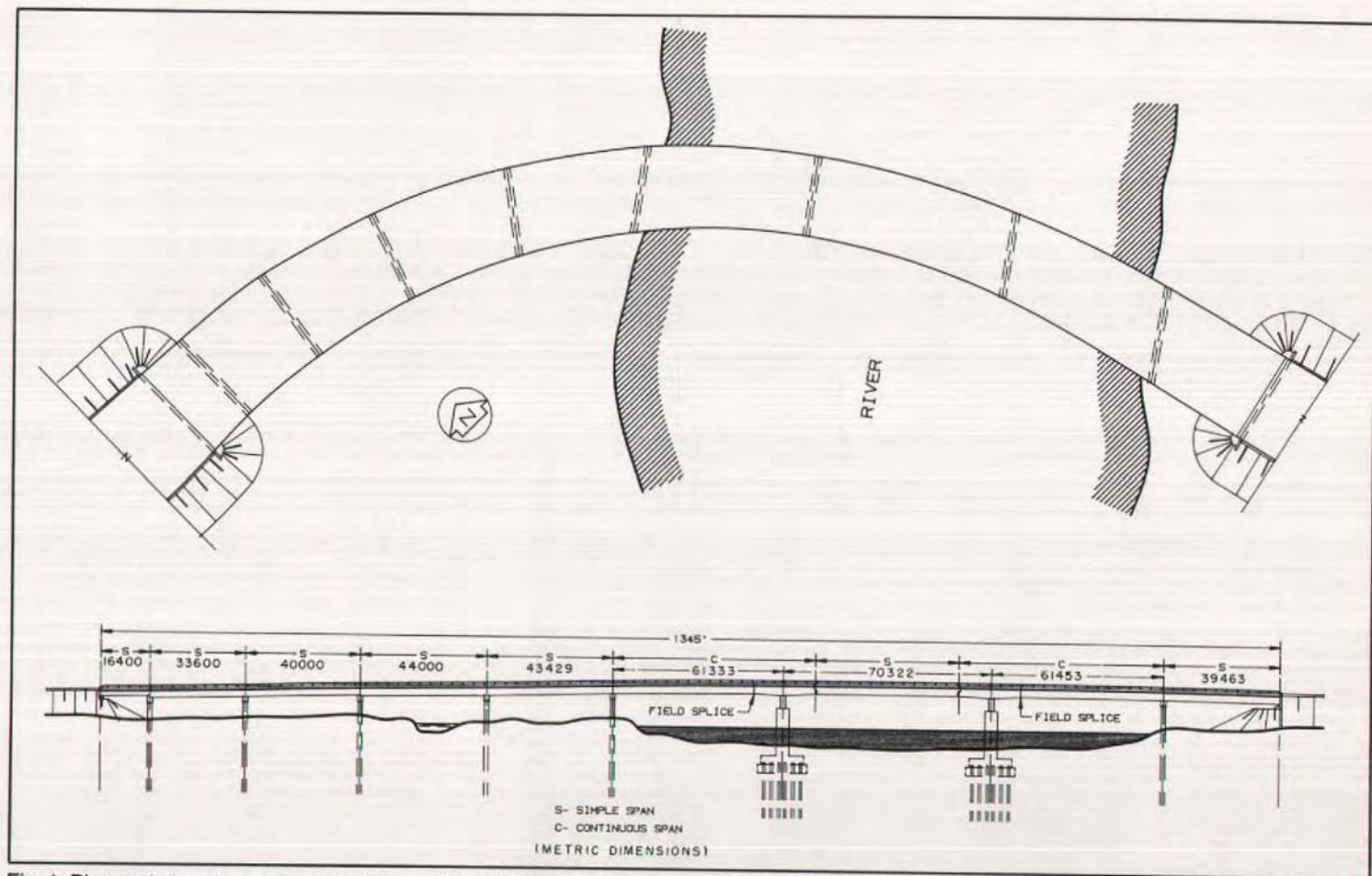


Fig. 1. Plan and elevation of Annacis Channel East Bridge.

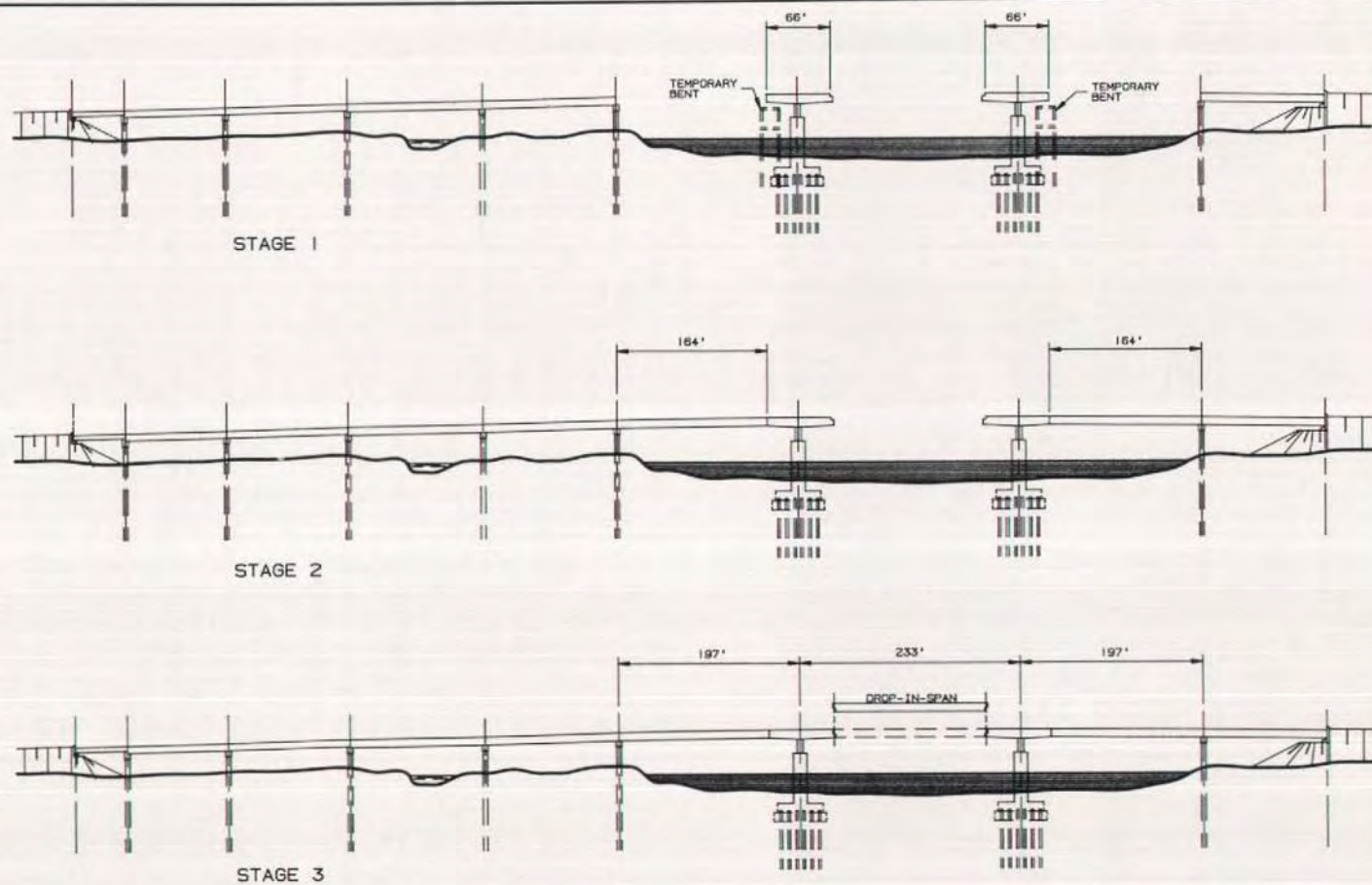


Fig. 2. Erection scheme for construction of Annacis Channel East Bridge.



Every effort was made to have as much repetition between girders despite the complex horizontal and vertical geometry. All girder ends (except for the field splice) have no vertical or horizontal skew. The angle difference caused by the curvature of the bridges is taken up in the cast-in-place end diaphragms. The location of prestressing hold-downs was standardized at 15 ft (4.57 m) from the centerline of all girders.

The long river spans were analyzed as a grillage formed by individual girders and cast-in-place concrete diaphragms, with each phase of the staged construction modeled separately. The 233 ft (71.0 m) main span was created by placing 66 ft (20.2 m) long girders on both river piers cantilevering approximately 33 ft (10.1 m) on either side of the pier, as shown in Fig. 2.

The ends of the cantilever were field spliced with 164 ft (50.0 m) long girders, thus creating 197 ft (60.0 m) side spans. The horizontal angle (approximately 9 degrees) between the two girders to be spliced varied, due to the variable width of the superstructure. A temporary pile bent supported the field splice until post-tensioning cables were stressed.

After completion of the deck pour over the pier and side spans, the main span was completed by installing a 164 ft (50.0 m) drop-in girder between the two cantilevers to give the total length of 233 ft (71.0 m) for the middle span. Post-tensioning at the land ends was designed to be tensioned through the girder top flanges to avoid delays in the installation of adjoining spans.

Attention to long-term deflection calculations resulted in a superior riding surface.

Erection Considerations

The installation of the land spans was relatively straightforward. Two 230 ton (209 t) crawler cranes, each picking one end, could easily handle the installation;



however, the soft ground and sloping site required careful planning and construction of crane pads and areas to spot steering rigs. Installation of all the land spans was completed by mid-December 1985. The river spans were installed using the same two crawler cranes. Because the slender girders are relatively flexible, the contractor made provisions to brace the girders immediately on installation.

Summary and Concluding Remarks

A new and significantly larger girder section, 9.0 ft (2.74 m) deep, was developed for this project. The new girder section made possible the use of 164 ft (50.0 m) long approach spans in the bridge. These girders are the largest plant-cast single-piece precast prestressed sections ever made and erected in the Vancouver area.

Field splices and post-tensioning, in combination with girders deepened locally to 10.0 ft (3.05 m) at the two main piers, were used to achieve continuous spans of 197 ft — 233 ft — 197 ft (60.0 m — 71.0 m — 60.0 m) for the river portion of the bridge.

The bridge demonstrates that, given the encouragement of an owner who recognizes the merits of alternative designs, and given the expertise of bridge engineers working together as a team with industry, significant capital cost savings can be achieved with alternative designs. During the design stage, advantages may arise from the careful evaluation of the specific site constraints and their relationship to the production, transportation and installation of major precast concrete components.

The finest capabilities of the precast prestressed concrete industry were mobilized to produce a bridge that is extremely competitive in the bridge construction market. The end result is an aesthetically pleasing and functionally efficient river bridge that can be expected to serve the travelling public for generations.

The total cost of the bridge (including materials supplied by the British Columbia

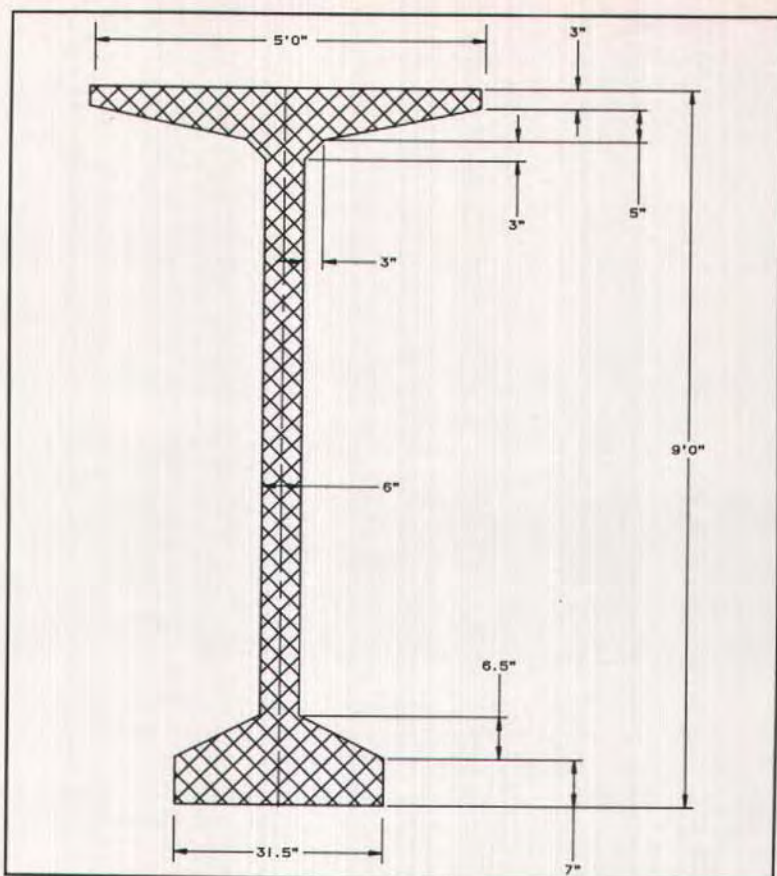


Fig. 3. Newly developed precast prestressed concrete girder section with 9 ft (2.75 m) depth.

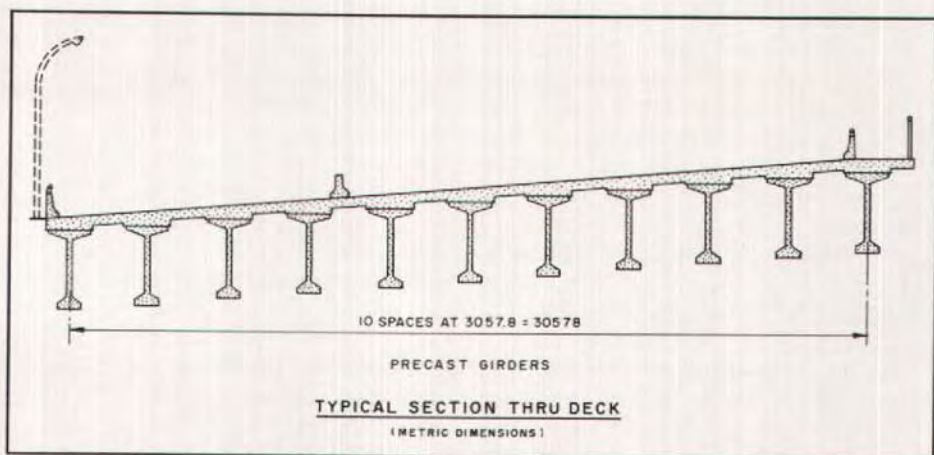


Fig. 4. Typical bridge cross section.

Bridge Characteristics and Number and Size of Precast Prestressed Concrete Components.

Bridge Details

Total length: 1345 ft
Spans: nine spans varying from 230.7 to 110.2 ft
Deck width: varies from 128 to 92 ft
Deck area: 139,000 sq ft
Radius of curvature: 820 ft
Maximum superelevation: 8 percent
Vertical curve: 4 percent

Precast Prestressed Components

85 girders, 9.0 ft deep
23 girders, 7.5 ft deep
12 girders, 5.67 ft deep
Total: 120 precast prestressed girders with length varying up to 164 ft

Note: 1 ft = 0.305 m; 1 sq ft = 0.093 m².

Ministry of Transportation and Highways) was \$15 million (Canadian) with the precast prestressed portion amounting to about \$3 million (Canadian). The unit cost came to about \$108 per sq ft based on the precast work.

The river bridge was opened for traffic in September 1986 and has been performing with total satisfaction.

Acknowledgment

This article was submitted with the permission of Mr. Peter Brett, P. Eng., Director of Bridge Engineering, Ministry of Transportation and Highways, British Columbia.







Credits

Owner: Ministry of Transportation and Highways, Victoria, British Columbia.

Consulting Engineer: Delcan Corporation, New Westminster, British Columbia.

Design Team:

Ota J. Nykl, P. Eng., Project Manager.

Ron Pelkey, P. Eng., Chief Bridge Engineer.

Don McCulloch, P. Eng., Senior Bridge Engineer.

Peter Fairbridge, P. Eng., Senior Bridge Engineer.

General Contractor: Dillingham Construction Limited, North Vancouver, British Columbia.

Precast Prestressed Concrete Manufacturer: Con-Force Structures Limited, Vancouver, British Columbia.

★ ★ ★