

# Red Deer River Bridge

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## Introduction:

In planning extensions to north-south highway #36 located approximately 100 miles east of highway #2 joining Calgary and Edmonton, the Bridge Branch of the Alberta Provincial Department of Highways found it necessary to locate a bridge across the Red Deer River at a point 8 miles north of Duchess. At this bridge site the river runs at right angles to the highway. The requirements dictated a structure 750 feet long with a 30 ft. deck and a 2 ft.-6 in. wide curb on each side.

A complete study of the most economical structure for this site indicated that the bridge should be designed with five equal 148 ft. spans to minimize the number of interior piers. As these spans were considerably longer than any previous spans using precast prestressed girders, the Bridge Branch proceeded with the design of a continuous built-up steel girder section. These girders were approximately 7 ft. 6 in. deep with 4 girders per span spaced at 9 ft.-0 in. centers. The tenders called for the supply of all structural steel, bearings, diaphragms, f.o.b. jobsite. Con-Force Products Ltd. commissioned Structural Engineering Service Ltd.,

Consulting Engineers, to prepare a simple span alternate design using 4 lines of prestressed concrete girders set at 9 ft.-0 in. centers. (Fig. 1) When tenders were opened, the prestressed alternate was considerably lower than the lowest steel bid; and after revised quotations were obtained to include for supply and erection of all materials, the prestressed alternate still provided the most economical structure. Based on lowest initial cost and minimum future maintenance costs, the decision was made in favor of the prestressed girder alternate on June 1, 1959.

## Tender Data:

INITIAL TENDER—Supply only of girders, bearings and diaphragms, and horizontal bottom chord bracing, f.o.b. site.

Low steel fabricators . . . . \$206,476.  
Prestress alternate . . . . . \$178,000.

FINAL TENDER—Supply and erection of girders, bearings, diaphragm, and horizontal bottom chord bracing.

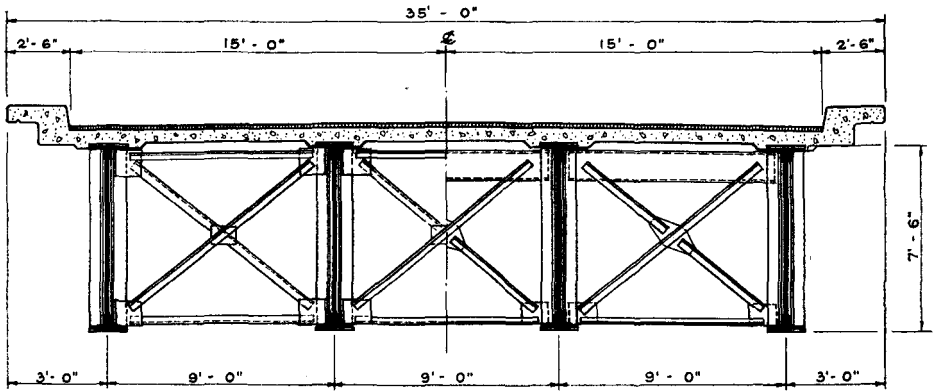
Low steel bid ..\$229,139. (17.6¢/ #)  
Prestress alternate \$223,000. (\$198./ yd.<sup>3</sup>)

## Design:

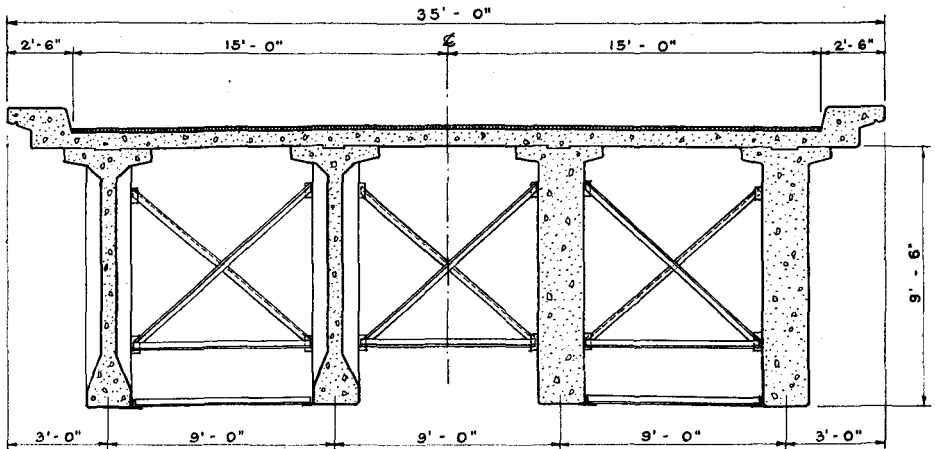
With span and spacing determined, and the design live load of AASHO H20-S16 specified, the de-

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• CROSS SECTION • STEEL GIRDER DESIGN •



• CROSS SECTION • PRESTRESSED CONCRETE ALTERNATIVE •

Fig. 1—Bridge alternates—cross sections.

sign of the girders was routine.

For the trial section, the depth was selected on the basis of a depth-span ratio of 1:15, this ratio having been determined by previous experience with similar requirements. From the trial depth and the required ultimate resisting moment, based on 2 (MDL + MLL), it was determined that 14, 12/0.276 in. diameter wire Freyssinet cables would be required. A web thickness of 7 in. was selected as being the practical minimum.

The bottom flange was proportioned to suit the desired arrangement of cables keeping in mind the practical requirements for concreting a slim section of this depth.

The width of the top flange was selected from a width-span ratio of 1:42 in keeping with proportions of previously built long members.

Minor adjustments were made in the proportions of the trial section as the analysis proceeded with the final cross-section being as shown. (Fig. 2)

Principal tensile stresses at working loads were very low, but under the ultimate loading, shear was a consideration. The shear reinforcing used was  $\frac{5}{8}$  in. diameter two leg stirrups at a maximum spacing of 18 inches.

Due to the considerable height of the girder, deck, and curb, and to conform with clause 1.6.67 of the current AASHO specifications, it was necessary to consider the effects of transverse wind loading. A system of lateral bracing in the plane of the bottom chord of the girders was designed to resist one half the total wind force. Both this lateral bracing and the transverse diaphragms, which were located at 24 foot centers consisted of light rolled steel shapes.

In keeping with the original steel design, typical rocker bearings were designed for a reaction of 259 kips.

#### Construction Schedule:

Tenders for the general contract on this project were then called based on the supply and erection of the girders; bearings and diaphragms were to be by others. On July 2, 1959, a contract was awarded based on the following construction schedule:

(a) July to October, 1959—Girders cast and stressed at jobsite.

(b) July 1959 to January 1960—Approach fill, piers and abutments completed.

(c) January to March 1960—Girders, bearings and diaphragms erected in place.

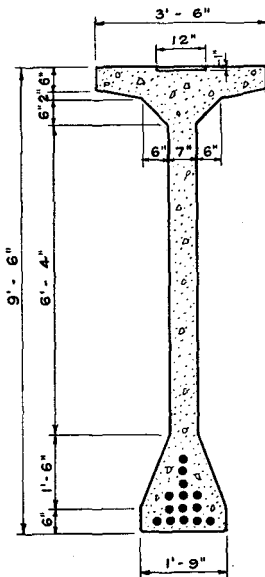
(d) April to August 1960—Deck and superstructure completed.

This schedule enabled the general contractor to drive piles and construct piers and abutments under minimum river flow conditions. It also made it possible for erection

crews to handle the girders during the winter months when ice and frozen ground permitted transportation of almost unlimited loads with a minimum of problems.

#### Manufacturing Girders:

Production crews were faced with the problem of casting 20 girders 148 ft.— $2\frac{1}{4}$  in. long, 9 ft.—6 in. high and weighing approximately 112 tons each. Also included in the girder were the mild steel reinforcing cage, cast-in shoe plates, inserts, weld plates, and 15 Freyssinet 12 wire 0.276 cables. Two 12 ft. sample sections of a typical girder were cast in new metal forms at our Calgary plant using aggregates hauled in from the jobsite to provide information on the most satisfactory method of handling the forms, reinforcing cages, and concrete. These trial sections confirmed that cross-sectional dimensions could be kept within  $\pm \frac{1}{8}$  in. of detailed dimen-



• GIRDER CROSS SECTION •  
Fig. 2—Typical prestressed beam cross-section.

sions and that concrete poured with a 3 in. slump could be vibrated to provide a dense concrete around all of the post-tensioned cables in this girder. As these 112 ton girders were to be erected with two sixty ton cranes, accurate control of the overall weight of each girder was extremely important. In addition, to confirm that normal grouting procedures were satisfactory, a standard 150 ft. long cable complete with wires and metal tubing was assembled and pressure grouted at our Calgary plant.

At the site, construction crews cleared several acres of land situated above summer flood levels 2,000 feet south of the bridge site. A concrete slab 160 ft. x 120 ft. with heavy edge beams on the 120 ft. side and with sleepers placed in the long direction was prepared to serve as a casting bed for the 20 large girders required in this project. Short lengths of 2 x 4's were then nailed to adjacent sleepers to support a 2 in. thick timber base, complete with chamfer strip, running in the 160 ft. direction. The first half of the metal form was set up tight against this wood base, wedged in place, and securely braced to the front edge of the slab using steel bars with adjustable turnbuckles. Shoe plates at ends of girders and connection plates were set in place and the reinforcing steel cage, previously fabricated in sections, was assembled. The cage was then tack welded together, and supported in the correct location on this base. A one yard dragline on tracks was used to handle metal forms and sections of reinforcing steel cage. Lengths of flexible tubing complete with 12-0.276 in. diameter wires were then inserted at the end of the cage and guided through accurately located control stirrup loops

attached to reinforcing steel cage. End bulkhead units containing anchorage cones were then set in position, and hose connections to cones were completed with standard Freyssinet sleeves. The high tensile wires extended through the anchorage cones at each end of the girder. The outside form was then set up tight to the base. Steel clamps were used at the top and bottom of the girder form to insure that girder cross section dimensions remained constant during the entire casting cycle.

The 56 yards of 5,000 psi concrete used in each girder was mixed at the jobsite using 2-16S drum type mixers fed by standard bin and batch field type equipment. A front end loader delivered aggregates to the storage bins, and a tractor shovel with extended arms was used to deliver concrete from the mixer to the forms. Temporary working platforms were set up, cantilevered from the forms at the most suitable height for production crews. The concrete was poured commencing at one end and kept on about a 20° slope as the form was filled. When pouring was complete and the top surface finished the entire section was covered with tarps for at least one night. Production crews poured two girders the first week and three girders each week thereafter until all twenty girders were cast (see Fig. 3). Curing was obtained by keeping the girders covered and water soaked for 5 to 10 days after pouring. Test cylinders were taken to determine standard 7 day and 28 day strengths on all girders.

The two top cables in each girder were stressed with hand equipment as soon as possible after casting to prevent shrinkage cracks from forming. Later a special crew moved in

to the jobsite from the manufacturer's Calgary plant to complete the stressing and grouting of the 14-12 wire 0.276 Freyssinet cables in each girder. The use of a portable generator and power stressing equipment enabled this special crew to complete stressing, grouting and pouring of protective concrete end cap around the exposed ends of the anchorage cones in 25 working days. The grout injected around the stressed wires in each cable was composed of high early cement and water with no other additives. The girders initially cambered about 1 in. rising clear of the wooden base at the centerline and compressing the base at each end. After stressing, the entire dead weight of the girder was carried by the heavy edge beam cast with the poured-in-place casting bed.

#### **Erection:**

While the methods and procedures used in casting these girders in the field were comparable with normal plant practice, the problems associated with lifting, transporting and erecting these girders in the most economical manner required

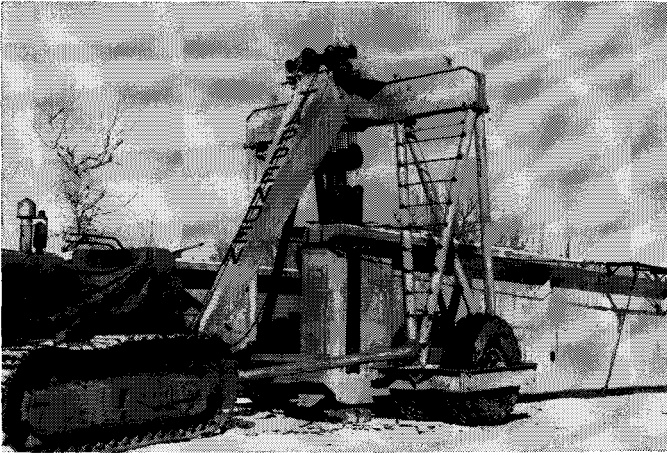
careful planning and the use of special equipment.

During the casting of girders in the field, rectangular holes were formed in the top flange two feet in from each end on both sides of the end block. Directly under these holes a 4 in. diameter pipe section was cast horizontally in the end block. It was a simple matter to fabricate a short lifting bar with long channel straps. This was dropped through the rectangular deck holes and accepted a horizontal lifting pin which went through the reinforced bottom ends of the straps and through the cast-in 4 in. pipe section. An initial lift on each girder was made with a mobile 60 ton crane to remove the girder from the form base and line it up in the general direction of the bridge.

Specially fabricated frames were then used to lift the girder and transport it over the frozen ground and ice to a point where the girder could be erected in place on its bearings. These frames straddling each end of the girder rolled on two 18 x 24 scraper tires on each side of the girder on a pair of



**Fig. 3—Completed girders awaiting prestressing.**



**Fig. 4—Specially fabricated transporting frames straddling end of a girder.**

**Fig. 5—Preparing a girder for movement with transporting frames and dozers at each end.**



**Fig. 6—Moving a girder into position for erection.**

axles. (see fig. 4) To achieve stability in this lifting and travelling frame, horizontal pipe braces from the axles on each side of the girder and a heavy rigid connection from the top of the frame were all attached to the front of a TD-24 dozer. A multi-pulley fixed block was attached to the top of each frame and a movable block complete with lift hook was suspended over the girder from a 14 part line. This line led from the top pulley to the power winch on the dozer enabling each dozer to raise one end of the girder approximately 16 in. The dozers and lifting frame units were used to move the girders from the casting slab to locations beside the piers. (see fig. 5) To provide the girder with additional lateral stability, a 10 ft. wide pipe truss was fastened to the top flange while it was moved over 2,000 feet of rough terrain to the bridge site. (fig. 6)

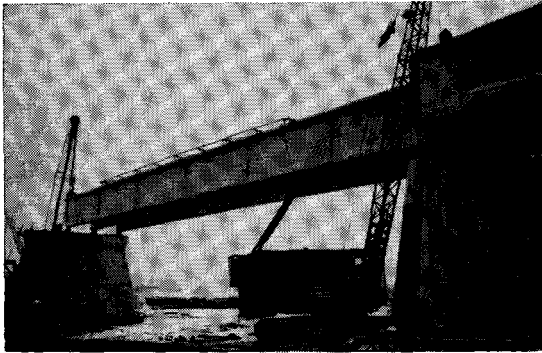
Girders were cast in the required order and orientation to permit each girder to be moved to the site and erected in place. This was done working from east to west, with the furthest span of the bridge first, and progressively completing the structure one span at a time. After the girders had been moved to the base of the piers they were lowered onto temporary supports while the dozer units and travelling frames returned to the casting yard. The girders were then placed on metal fixed and expansion bearings using 2 cranes each with 60 ft. booms and a rated capacity of 60 tons (fig. 7) As the cranes were operating very close to their maximum capacity, some girders had to be moved again and placed on temporary blocking to enable the equipment to get close

enough to the piers to complete erection with a single lift from the last storage point.

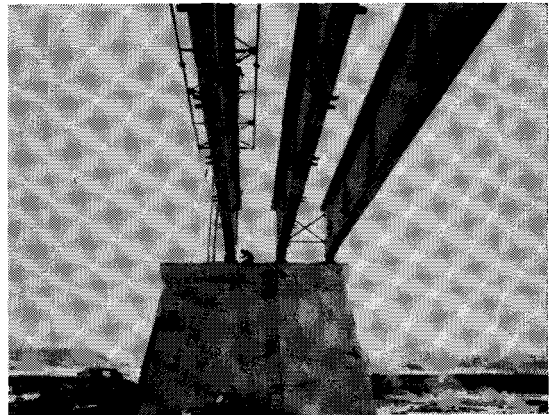
Diaphragms were made up of two vertical  $3\frac{1}{2}$  in. x  $3\frac{1}{2}$  in. x  $\frac{5}{16}$  in. angles securely fastened to the girder. Two diagonal angle cross braces and a horizontal bottom angle were bolted together during erection to stabilize girders and were finally welded after all the girders were erected in place. In addition, lateral bracing was provided to tie bottom chords of girders 1 to 2 and 3 to 4 (equivalent to the bracing shown for steel girders in the original tender drawings. (fig. 9) These 4 in. structural tees were also initially bolted and finally welded in place after girders were all erected. All bearings, girders, diaphragms and bottom chord bracing members were erected in place by March 10, 1960.

#### **Observations:**

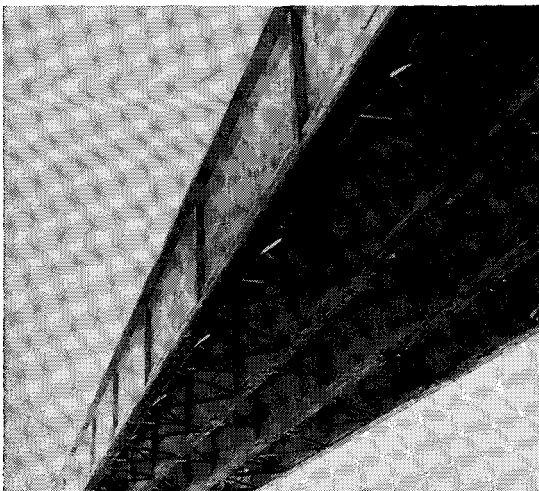
As transportation of prestressed concrete girders exceeding 120 ft. by road or rail is either expensive or impossible, many design engineers fail to consider the possible advantages to be gained in considering girders cast in the field. Excellent members can result by using competent plant personnel with years of experience in the efficient production of post-tensioned concrete girders. When local terrain will permit the movement of heavy loads and high capacity mobile cranes are available, and bridge foundation conditions are reasonably good, prestressed girders can, for many bridge projects, provide all of the advantages normally associated with short span girders used in North America.



**Fig. 7—Erecting the 112 ton girder with two 60 ton cranes.**



**Fig. 8—Special lateral stabilizing frame used during erection is seen in this view.**



**Fig. 9—Lateral bracing and diaphragms are shown here.**



**Fig. 10—Graceful lines of completed structure are emphasized in this photo.**