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ERECTION OF FRENCH RIVER BRIDGE—CANADIAN PACIFIC RAILWAY.

By C. N. MONSARRAT, M. Can. Soc. C. E.

(To be read before General Section, April 16, 1908.)

The new branch line of the Canadian Pacific Railway, extending from Romford, Ont., a point about six miles east of Sudbury, on that Company's main Trans-continental line, southerly to Bolton Junction, where it connects with the Owen Sound Section, about 21 miles north of Toronto, includes a number of important bridges, one of the largest of which is that crossing the French River, about 43 miles south of Romford.

This bridge is located at a point where the river has a width of approximately 550 ft., while the depth of the water for about three-fifths of the crossing averages 90 ft. The character of the bottom is rock, with about 10 ft. of soft mud overlying it. The current is, however, very slight, being only about 3/10 of a mile per hour.

In order to avoid the great expense of building a pier in the deep water, it was found necessary to locate the first pier 415 ft. south of the north abutment, where a good foundation was obtained in about 48 ft. of water. The dimensions of this pier are 9' 0" x 30' 0" at the top under the coping, which is 2' 0" thick, with an overhang of 4½" on all sides, and has a batter of 1 in 12 on each side for a depth of 30' 0", making the bottom of the shaft on the footing 14′ 0″ x 30′ 0″, the ends being vertical. The foundation, or footing, is 21′ 0″ x 33′ 10″ long by 40′ 0″ high; the total height of the pier is 72′ 0″, and it was designed to resist the tractive forces from the spans supported by it. There is a second and smaller pier located 67′ 2″ farther south in about 15 feet of water, the shaft of which has a batter on each side of 1 in 24, the total height of this pier is 44′ 0″, and the dimensions at the top are 6′ 0″ x 16′ 0″ under the bridge seat, or coping, which overhangs 3″ on all sides. The abutments at both ends are located at the water's edge. The north abutment could not be built farther south on account of the rock at this point, which is very steep on the west side.

In laying out the substructure three independent triangulations were made. Reference points were located on the tops of the hills on either side of the river, on three parallel lines, one along the centre line, and one at each end of the piers; these points were high enough to permit of an instrument being set up on one side and a foresight being taken on the opposite shore at any time during the progress of the work.

After the abutments and piers were located, they were checked by steel tape rigged as follows: A ring bolt was set in the rock at the north shore of the river directly on the centre line of the bridge, and from this a ⅜″ diameter steel cable was stretched across to the south shore and made taut by block and tackle. To prevent sagging of the cable, floats, having their tops at exactly the same level as the ring bolt, were anchored in the river at frequent intervals to support it. Rings were attached to this cable every four feet and a 600-foot steel tape passed through them.

The difficulties encountered in getting plant and material for the substructure to the site were exceptionally arduous. Everything had to be brought in from French River village on Georgian Bay, at the mouth of the French River. First, rapids had to be overcome, then a portage of a mile and a half, then the plant was again floated up the Pickerel River (which had its difficulties too) a distance of 23 miles to what is called the Horse Shoe Falls. There the outfit was elevated some 25 feet, loaded again and transported some 12 miles over a swift and rough course to the bridge site.

Broken stone and sand used in making the concrete was hauled a distance of twelve or fifteen miles through a wilderness by teams in winter. The contractor's plant consisted of the usual concrete outfit of picks, shovels, concrete mixer, blacksmithing outfit, and other things incidental thereto; one submarine drill, complete for preparing the foundations; several sets of drill steel averaging 45 feet in length, one 30-foot high steel frame with sliding carriage for drill, truck wheels, and operating platform.

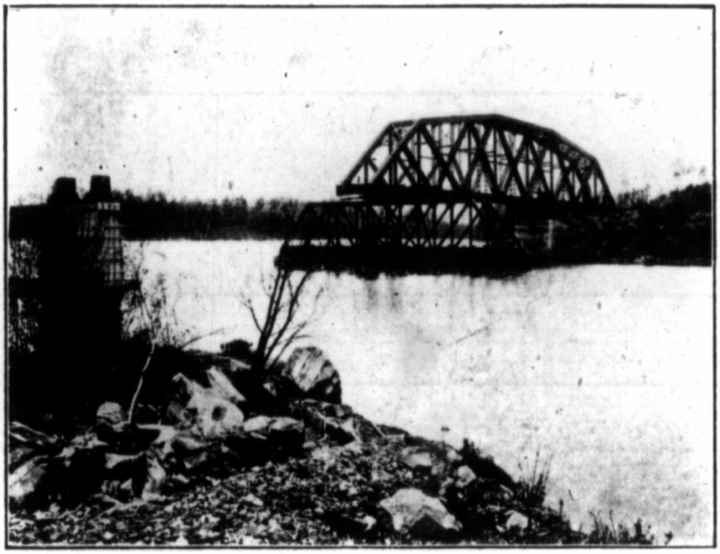
This outfit was operated by hydraulic pressure furnished by a large Worthington high pressure pump, having the necessary attachments and connections; two 30 H. P. boilers, two 32 H. P. hoisting engines with derricks and swinging gear complete, one 1¼-yard orange peel bucket; two 20 H. P. hoisting engines with derricks; four large scows, 24′ x 60′, and two tugs; two sets of diving apparatus, in addition to many other odds and ends of machinery. The drilling machinery was placed on the scows, which were anchored at the pier sites. After holes were drilled, they were shot with dynamite, and the loose rock removed by means of the orange peel bucket, or a derrick with chains and grappling hooks at the bottom, until the foundation had been properly benched and levelled off. Holes were then drilled in the rock about 4 feet apart, and 2-inch diameter steel dowels, 6 feet long, set in them, and projecting about 3 feet up into the concrete footing. The timber caisson for pier No. 1 was built about 48 feet high and well reinforced with timber braces. Heavy canvas was attached around the bottom on the inside, and after the caisson was sunk into position, the divers went down and rolled this out. Concrete in sacks was then deposited around the edges to make it conform to the contour of the rock and so prevent any wash or current through the pier. Mortar, of a consistency of one part of cement to two parts of sand, was then deposited to the amount of 50 cubic yards, followed without any intermission, by the work of concreting, which was carried on by means of bottom-dumping buckets. The concrete, up to water level, was mixed in proportions of one part of cement, two of sand, and four of broken stone, and above water one part of cement, three of sand, and five of broken stone. Similar methods were followed in constructing the second and smaller pier.

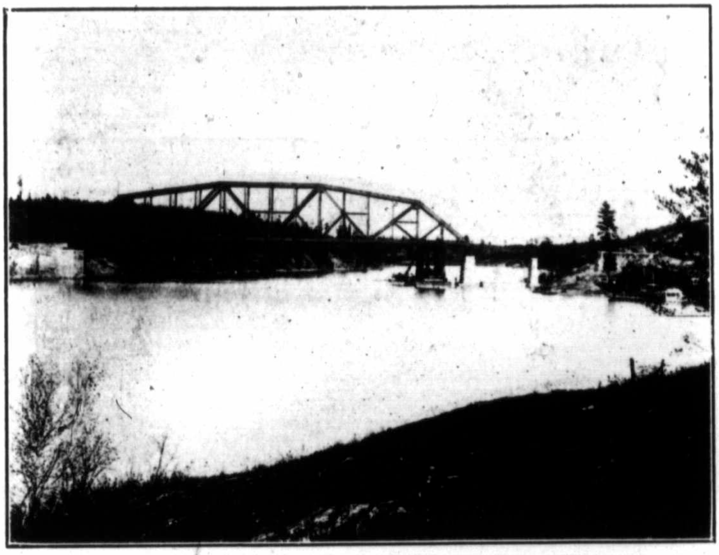
The quantities of concrete in the substructure aggregate 3020 cubic yards, as follows: North abutment, 913 cubic yards; No. 1, or main pier, 1421 cubic yards; pier No. 2, 226 cubic yards; and south abutment, 460 cubic yards; rock excavation, 337 cubic yards; earth, 141 cubic yards.

The above layout required one 415-ft. span, over the deepest part of the crossing, which was designed as a rivetted, subpanelled, through Warren truss with inclined top chords (weighing 2,563,362 pounds) and two 60-ft. deck plate girder spans (weighing together 126,540 pounds) over shallower water to the south abutment. The superstructure was designed in accordance with the requirements of Canadian Pacific Railway 1905 Specification, providing for a live load of two typical consolidation engines coupled together, weighing 337,000 pounds each, followed by a uniform train load of 4000 pounds per lineal foot.

Probably the most interesting feature in connection with this work was the erection of the main truss span. On account of the great depth of water, it was not possible to build falsework and erect the span in its proper place, so after due consideration of several possible schemes of erection it was decided to erect the span on the north approach embankment, on the centre line of the bridge, (produced) and launch it forward by supporting the forward end on a large scow, and sliding the rear, or north end, on a skidway of greased rails. This embankment, immediately north of the north abutment, was a new fill consisting mainly of boulders, coarse gravel, and sand, with a maximum height of about 25 feet against the abutment, running out to the natural surface of the ground about 100 feet north. The width of the embankment at subgrade was 16 feet, and in order to provide a proper bearing for the skidway, it had to be widened to 26 feet. On this specially prepared roadbed two parallel skidways, about 316 feet long, were built, 10 feet centre to centre, each consisting of railway ties about 15" on centres, with a 12" x 12" timber 16' 0" long, every 10 feet, to tie the two skidways together. On these ties were laid five lines of 12" x 12" longitudinal timbers, over which was laid a flooring of 3" x 12" planks, supporting 7 lines of 80-lb. rails, laid with joints staggered and securely spiked and bolted together.

The steel work was accordingly erected on the embankment, using a specially-designed traveller, consisting of two 60-foot boom derricks of ten tons capacity each, mounted upon a timber framework designed to travel upon rails gauged 14 feet centres, the platform of the traveller being placed 12' 7" above top of rail so that lorry cars, loaded with bridge material, could readily pass underneath on standard gauge railway track, and the material be picked up by the traveller booms. Each of the 60-foot boom derricks was handled by separate double-drum Beatty engines, placed at the rear end of the traveller and forming part of the 20 tons of counterweight on each side required to provide for the uplift due to loading the boom derricks. The assembling of the span on the embankment was, in itself, quite a difficult operation, on account of the large size of the members to be handled, some of them weighing as much as 40 tons. Before any work was started, the order in which each member was to be erected was fixed and clearly shown on the erection diagram. In order to permit of supporting the forward end of the span, by the scow, it was necessary to erect it with its south end projecting over the water about 103 feet. The bottom chords and floor system, excepting that portion overhanging the water, were first placed in position by means of a self-propelling derrick car, ties were then laid for temporary track on





the steel stringers, and the traveller erected with which the balance of the span was assembled.

In placing the two end bottom chord sections on top of the stiffening span, it was necessary to place the scow in the temporary position shown in dotted lines on plate No. 1, so that they could be placed by the traveller, the forward trucks of which could not be run out beyond the panel point resting over the bridge seat on the abutment. To do this it was necessary to blast out some of the rock projecting out under the water, to clear the northeast corner of the scow. When these chords were placed the scow was returned to its correct position and the erection of the overhanging portion, as a cantilever, from the portion of the span previously erected upon the embankment, was proceeded with.

In order to place the scow at the proper elevation under the projecting end of the large span, it was necessary to depress it about 4 feet by pumping in water. As this water ballast would render the scow unstable transversely until it took a bearing under the 415-foot span, it was necessary to use a small balancing scow, which was placed at the north side of the large scow and secured to the latter and the stiffening span, by means of diagonal and horizontal struts, and was equipped with counterweight and adjusting screws to provide for any raising or lowering of the large scow. The general dimensions of the large scow, referred to, which was built at the site, were: Length, 155 feet; 33 feet beam, and 12 feet deep; made in two sections for convenience in launching. It was built of 12" x 12" timbers for the ends; bulkheads and intermediate frames, 6" x 12"; sheating on the sides, 4" x 12" for the bottom, with joints staggered and secured to the framing with ⅝" x 12" lag screws. The bulkheads were spaced 22′ 1" centre to centre to conform with the panel points of the 150-foot through rivetted truss span, which was erected on the scow as a stiffening span, each panel point being blocked on a cross bulkhead. All seams in the sheeting, up to about 2 feet above load water line, were caulked with oakum.

On completion of the assembling of the large span, the traveller was taken down, the ties used as temporary floor removed, and all field connections, excepting end portals and sway bracing, were rivetted before launching was started. The field rivets, of which there were approximately 60,000, ⅞" diameter, were driven by means of pneumatic rivetting hammers, a compresed air plant having been installed for the purpose.

The scow was equipped with boiler and double-drum hoisting engine, as well as a centrifugal pump with 8" suction and 6" discharge pipes, and a sluice arrangement located over the double bulkhead forming the ends of the two component parts of the scow by which the water pumped in could be controlled, and directed into either half of the scow. Each intermediate bulkhead had an 8" x 8" hole near the bottom so as to equalize the water in each compartment.

The load from the south end of the 415-foot span, and the 150-foot stiffening truss supported by the scow, was about 1000 tons. The load from the north end of the span, amounting to about 640 tons, was transmitted to the skidway through the two large fixed end cast iron shoes (used temporarily for the purpose), placed 10 feet centre to centre, under the end floor beam, which had been designed with a special view to such use. This arrangement of the castings left a clear space under the truss bearings for landing of the span on oak blocking over the bridge seats preparatory to its being jacked down to its bearings. The oak blocking was required for the temporary support of the span at an elevation about 8' 5¼" higher than its final position, this height being necessary to permit the skidway to pass over the parapet wall of the abutment. Before the aforementioned cast iron shoes and the skidway rails was placed a ⅞" steel plate, large enough to include both castings, with strips rivetted to its under side to form guides to engage the rails on the skidway.

When the scow was in position under the overhanging end of the main span, in front of the north abutment and transverse to the centre line of the bridge, two guide anchors were located on the opposite shore at an angle of 45 degrees. Holes were drilled in the rock and 3½" steel bars were grouted in a vertical position. To each of these anchors was secured a two-sheave steel block carrying four lines of ⅝" wire cable, forming the forward guy lines which were wound up simultaneously on the drums of the hoisting engine, on the scow, as the span moved forward, steadying the floating end from any effect of wind or current.

The tackle used to haul the 415-foot span into position, consisted of two specially-constructed steel pulley blocks, having 14 sheaves each, through which was reaved a ⅝" diameter steel wire cable 1000 feet long, with a fall line leading back to the drum of a hoisting engine located on the land at the north end of the skidway. This engine was a 32 H. P. Beatty double drum hoisting engine, with two cylinders 8" x 12", boiler 41" in diameter by 108" high, and capable of pulling 8000 pounds on a single line.

One of the large blocks was secured to the skidding plate under the castings, and the other to the rear end of a string of bottom laterals belonging to a 250-foot through span designed for the crossing of the Pickerel River, a short distance south of the French, consisting of two angles 6" x 4" x ½" each, used as pulling links. These were in turn secured by a pin to a box girder supported by struts in front of the north abutment. Each section of these laterals was about 30 feet long, and when the two large blocks were brought together one or two sets of lateral links were removed and the blocks overhauled. When the last section was reached it was removed, and the forward block secured by the pin direct to the box girder.

When everything was in readiness, on the evening of October 27th, 1907, the scow was pumped out by means of the centrifugal pump, until the span was raised off the blocking. When this occurred it was found that there still remained a foot of water in the scow, showing that an ample margin of buoyancy had been allowed. At 8 a.m. on the 28th, the engine was started, and with the assistance of a slight shove from two 40-ton hydraulic jacks, the large span started on its way, moving on the well-greased skidding rails at the rate of 4 to 6 feet per minute. Considerable time was lost owing to the inability of the small boiler of the hoisting engine to keep up a sufficient steam pressure and also in the overhauling of the very heavy tackle.

The actual time occupied in moving the span was 3 hours, and in overhauling tackle, etc., 4 hours. The span was landed on its blocking at 4.05 p.m., without a hitch of any kind.

Trouble had been anticipated with settlement of the skidway on the new dump in view of the 640-ton concentrated moving load passing over it, but in no case was the settlement over 6 inches, and it was uniform at both sides, the greatest variation of the span from the level being about ⅛ of an inch in its width. So smoothly did the span move that it was possible to set it in its final location with the engine alone, without the assistance of jacks, and by means of the steering control afforded by the forward guy lines the span was within ¾ of an inch of its proper alignment when landed on the main pier on the south side of the river.

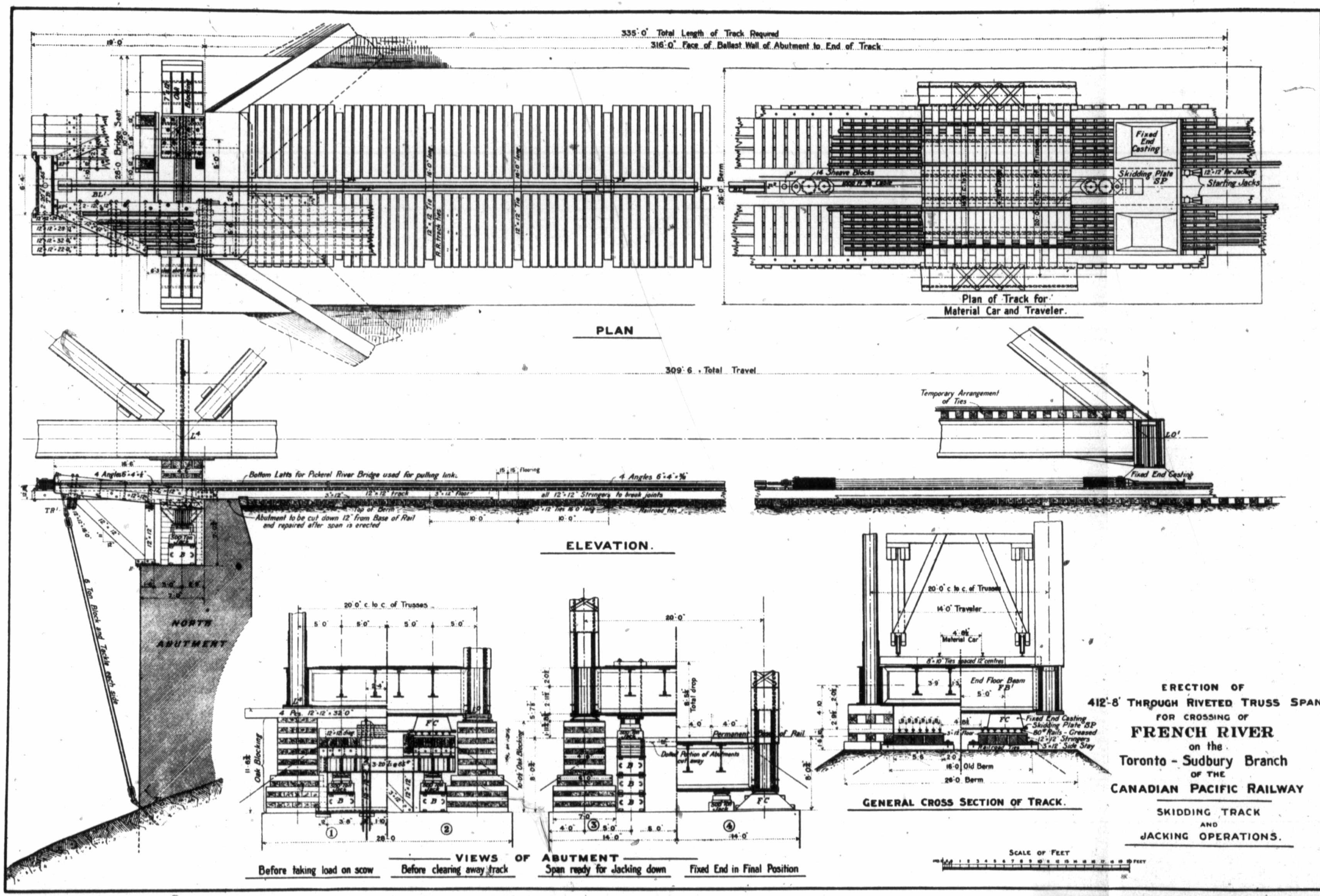
The lowering of the span to its final bearings on the bridge seats was accomplished by means of two specially-constructed 500-ton hydraulic jacks. After the span was landed on the wooden blocking, the skidway castings and skidding plate were removed and cast steel cap plates were bolted to the under side of the floor beam, these plates being turned out to fit over a cast steel disc plate 23" diameter by 3½" thick, placed on top of the plunger of each jack; between the bottom edges of these discs and the shoulders of the jack cylinders were placed a number of ¼" steel plate half ring shims, as a safety precaution against accident should anything go wrong with the jacks; in which event the weight would be transferred to the massive jack cylinders.

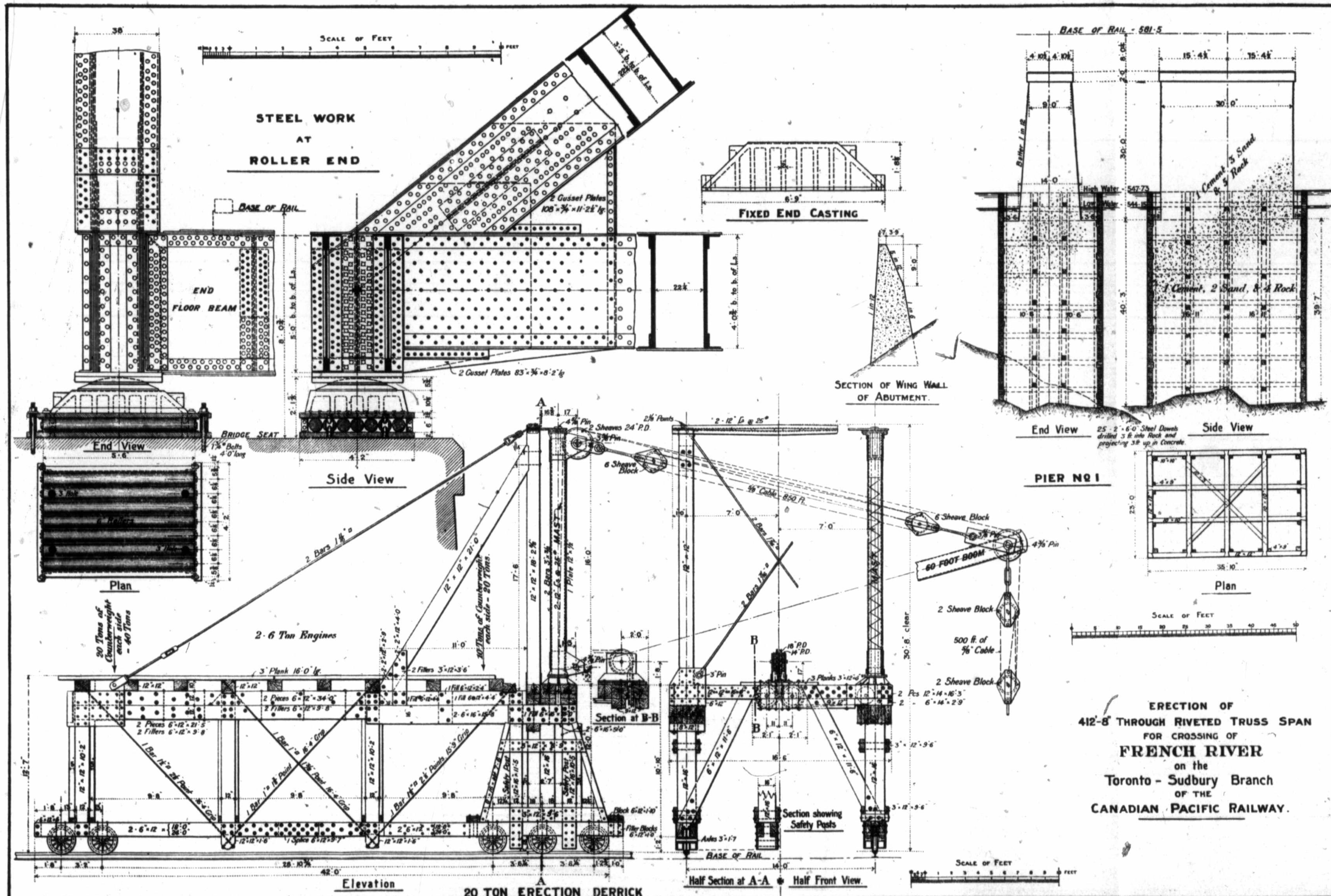
The jacks were each placed on blocking consisting of three super-imposed steel cylinders filled with concrete, over which were placed a number of cast iron cellular blocks 2′ 10″ in diameter by 3½″ thick. The ¼″ shim plates were removed one at a time as the span was lowered so that in no case was there left a space greater than ¼″ between the under side of the disc and the jack shoulders. Before the last of these shims was removed the span was landed on the oak blocking, the jacks released and one or more sections of cast iron blocking removed, the jacks pumped up, shims replaced, and the operation repeated until all the cast iron blocking had been removed, when one of the concrete-filled cylinders was taken out, the casting and shims replaced, and so on until the span was landed on its permanent shoes. The oak blocking was also removed as the span was lowered, the top of it being kept high enough to free the jacks while shims were being adjusted.

When the span had been lowered about 4 feet at one end, the jacks were transferred to the other and similar operations carried out there. That end, however, was lowered right down to the shoes before the jacks were returned to the end first lowered.

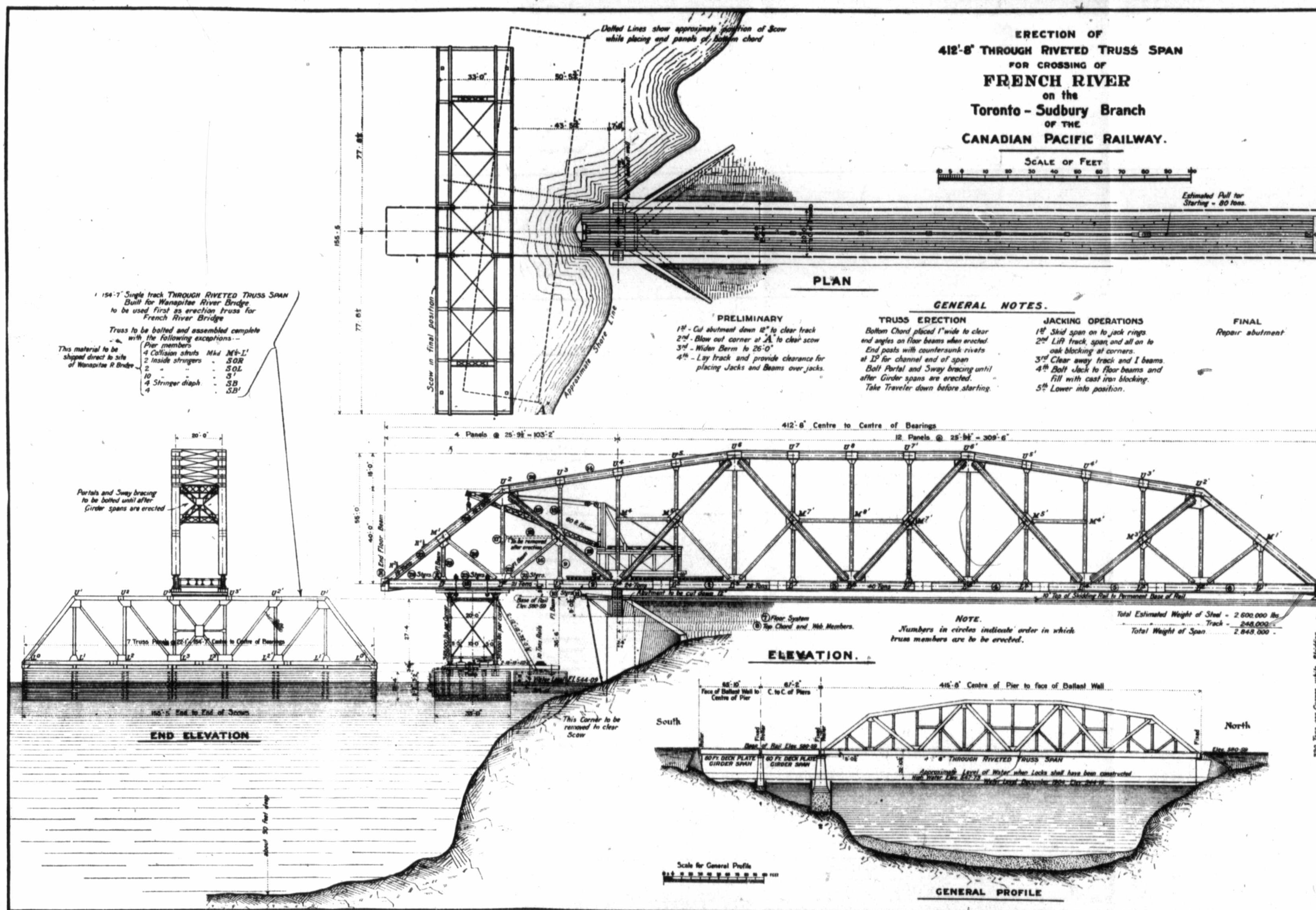
The bridge was designed by the Bridge Department of the Canadian Pacific Railway at Montreal. The substructure was built by the Toronto Construction Company of Toronto, under supervision of Mr. F. S. Darling, Division Engineer of Construction, while the steel work was manufactured and erected by the Canadian Bridge Company, of Walkerville, Ont. Mr. A. L. Colby was manager of construction, and Mr. C. Prettic was general foreman in charge of the steel erection.

The writer believes that this is the longest and heaviest single track fixed span yet built and erected in Canada, or ever erected by the end launching method.


335' 0" Total Length of Track Required
316' 0" Face of Ballast Wall of Abutment to End of Track
26'-0" Bridge Seat
28' 0" Berm
14 Sheave Blocks
Fixed End Casting
Skidding Plate SP
12 x 12 for Jacking
Starting Jacks
Plan of Track for Material Car and Traveler.
PLAN
309' 6" Total Travel
Temporary Arrangement of Ties
Fixed End Casting
4 Angles 6 x 4 x 1/2
Bottom Latts for Pickerel River Bridge used for pulling link.
4 Angles 6 x 4 x 3/8
12 x 12 Track
all 12 x 12 Stringers to break joints
Top of Berm
Railroad Ties
Abutment to be cut down 12" from Base of Rail and repaired after span is erected
ELEVATION.
NORTH ABUTMENT
6 Ton Block and Tackle each side
20' 0" c. to c. of Trusses
4 Pcs. 12 x 12 x 32' 0"
Oak Blocking
Total drop
Permanent Base of Rail
Dotted Portion of Abutments cut away
14' 0" Traveler
Material Car
8 x 10 Ties spaced 12" centres
End Floor Beam FB'
Fixed End Casting
Skidding Plate SP
80# Rails - Greased
12 x 12 Stringers
3 x 12 Side Sway
Railroad Ties
Old Berm
28' 0" Berm
GENERAL CROSS SECTION OF TRACK.
VIEWS OF ABUTMENT
Before taking load on scow
Before clearing away track
Span ready for Jacking down
Fixed End in Final Position
ERECTION OF
412'-8" THROUGH RIVETED TRUSS SPAN
FOR CROSSING OF
FRENCH RIVER
on the
Toronto - Sudbury Branch
OF THE
CANADIAN PACIFIC RAILWAY
SKIDDING TRACK
AND
JACKING OPERATIONS.
SCALE OF FEET



STEEL WORK AT ROLLER END
SCALE OF FEET
BASE OF RAIL
END FLOOR BEAM
2 Gusset Plates 108" x 3/4" x 11'-2 3/4" lg
2 Gusset Plates 83" x 3/4" x 8'-2" lg
BRIDGE SEAT
End View
Side View
Plan
FIXED END CASTING
SECTION OF WING WALL OF ABUTMENT
BASE OF RAIL - 581·5
1 Cement, 3 Sand & 5 Rock
1 Cement, 2 Sand, & 4 Rock
High Water - 547·73
Batter 1 in 8
End View
Side View
PIER No 1
Plan
2 Bars 1 3/4" ⌀
2-6 Ton Engines
3" Plank 16'-0" lg
20 Tons of Counterweight each side - 40 Tons
10 Tons of Counterweight each side - 20 Tons
MAST
60 FOOT BOOM
6 Sheave Block
2 Sheave Block
500 ft. of 5/8" Cable
5/8" Cable - 850 ft.
Section at B-B
Section showing Safety Posts
Elevation
20 TON ERECTION DERRICK
Half Section at A-A
Half Front View
ERECTION OF
412'-8" THROUGH RIVETED TRUSS SPAN
FOR CROSSING OF
FRENCH RIVER
on the
Toronto - Sudbury Branch
OF THE
CANADIAN PACIFIC RAILWAY.


ERECTION OF
412'-8" THROUGH RIVETED TRUSS SPAN
FOR CROSSING OF
FRENCH RIVER
on the
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OF THE
CANADIAN PACIFIC RAILWAY.
SCALE OF FEET
Dotted Lines show approximate position of Scow while placing end panels of bottom chord
Estimated Pull for Starting = 80 tons.
Scow in final position
Approximate Shore Line
PLAN
GENERAL NOTES.
PRELIMINARY
1st - Cut abutment down 12" to clear track
2nd - Blow out corner at "A" to clear scow
3rd - Widen Berm to 26'-0"
4th - Lay track and provide clearance for placing Jacks and Beams over jacks.
TRUSS ERECTION
Bottom Chord placed 1" wide to clear end angles on floor beams when erected.
End posts with countersunk rivets at L0 for channel end of span
Bolt Portal and Sway bracing until after Girder spans are erected.
Take Traveler down before starting.
JACKING OPERATIONS
1st Skid span on to jack rings
2nd Lift track, span and all on to oak blocking at corners.
3rd Clear away track and I beams.
4th Bolt Jack to floor beams and fill with cast iron blocking.
5th Lower into position.
FINAL
Repair abutment
1 154'-7" Single track THROUGH RIVETED TRUSS SPAN Built for Wanapitae River Bridge to be used first as erection truss for French River Bridge
Truss to be bolted and assembled complete with the following exceptions:—
This material to be shipped direct to site of Wanapitae R. Bridge
Pier members
4 Collision struts Mkd M4-L'
2 Inside stringers " SOR
2 " " " SOL
10 " " " S'
4 Stringer diaph. " SB
4 " SB'
Portals and Sway bracing to be bolted until after Girder spans are erected
412'-8" Centre to Centre of Bearings
4 Panels @ 25'-9½" = 103'-2"
12 Panels @ 25'-9½" = 309'-6"
NOTE.
Numbers in circles indicate order in which truss members are to be erected.
Floor System
Top Chord and Web Members.
Total Estimated Weight of Steel = 2,600,000 lbs.
Track = 248,000
Total Weight of Span 2,848,000
ELEVATION.
END ELEVATION
155'-5" End to End of Scows
This Corner to be removed to clear Scow
415'-8" Centre of Pier to face of Ballast Wall
South
North
60 Ft. DECK PLATE GIRDER SPAN
412'-8" THROUGH RIVETED TRUSS SPAN
Scale for General Profile
GENERAL PROFILE