Heavy Movable Structures, Inc.

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Doubletree Resort Surfside
Clearwater Beach, Florida

Libby Street Bridge, Wallaceburg, Ontario, Canada

by

R. David Swift, P. Eng., M.R. Byrne & Associates Limited

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Introduction

This paper describes the design considerations and construction of a new swing bridge over the Sydenham River in Wallaceburg, Ontario, Canada.

Location

The town of Wallaceburg is located in south-west Ontario, approximately 60 km north-east of Detroit, Michigan. The Sydenham River drains the largely agricultural area to the north and east of the town.

The location of the bridge was fixed by existing approach roads, Baseline Road on the east side and Libby Street on the west side of the river. In the immediate future, the bridge will serve as an access to an industrial area. In the future, it may form part of a complete bypass to the town centre.

Bridge Layout

The site is located on a bend in the river at a point where the river is approximately 100 metres wide. The river bed contours and subsequent hydraulic testing indicated that the flow was at an angle to the bridge. To minimize scour, it was necessary to design the bridge with a 25° skew angle.

Flooding and Ice Conditions

The area drained by the Sydenham River is extremely flat. There was therefore a serious concern about any obstruction in the river which could result in upstream flooding. Any obstruction to smooth flow in the river was to be minimized.

While there was concern about the flow in the summer, during and after heavy rain storms or occasional hurricanes, there was more concern about the conditions during the spring run-off. Typically the maximum flow occurs during a warm spell in the spring which melts the snow cover. This results in a high volume of water coinciding with melting ice on the surface. This raises the possibility of an ice bridge forming and resultant flooding.

To mitigate this possibility, tests were performed at the University of Windsor to determine flow patterns in the area of the bridge. The results confirmed the need to minimize the size of the piers.

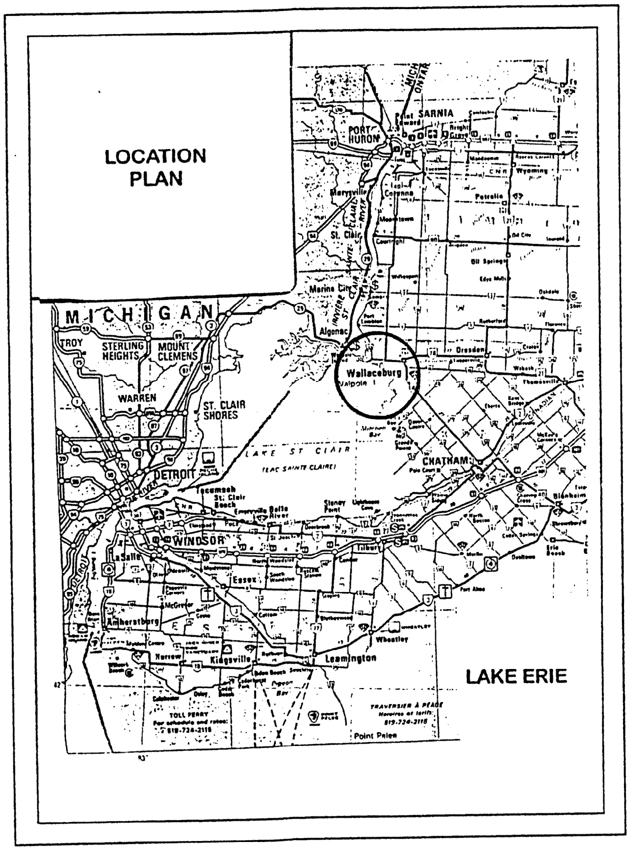


Fig. 1 Location Plan

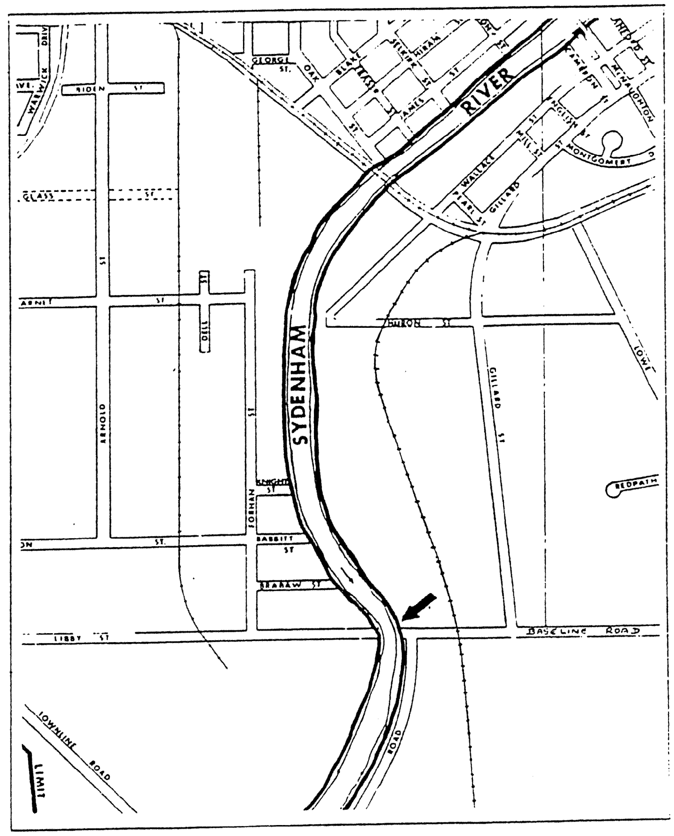


Fig. 2 Street Plan

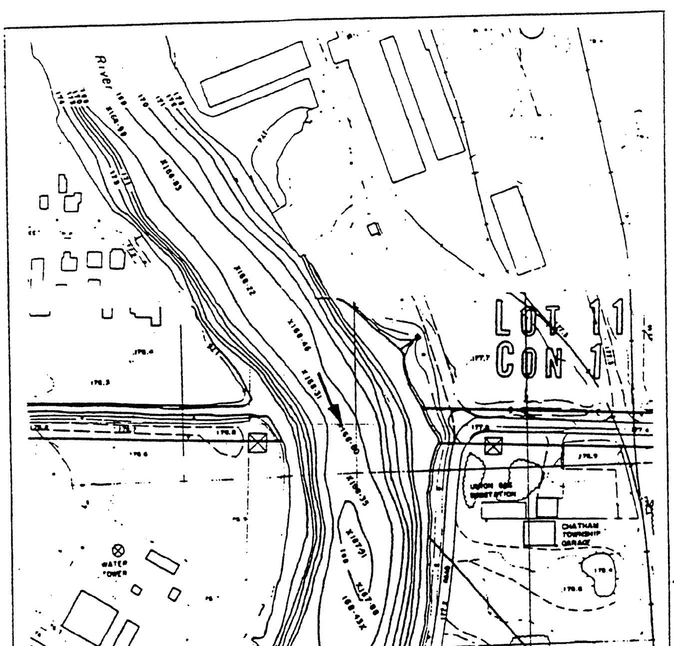


Fig. 3 River Contours

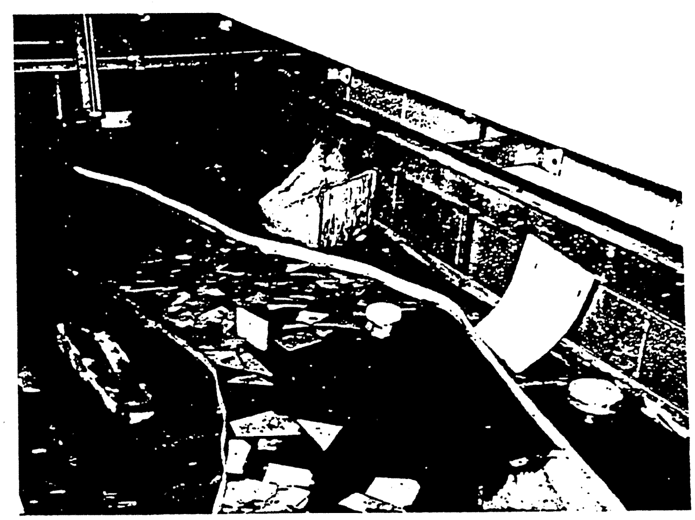


Fig. 4 Model Testing

Marine Traffic

Prime users of the river are pleasure craft from Wallaceburg moving down river or from other locations such as Detroit moving up river. These craft include both power boats and sail boats with masts. While the mast and superstructure of some vessels require reasonable clearance, the required waterway opening was determined by the occasional commercial vessel which also uses the river.

Two possible critical vessels were identified; one was a freighter and the other a barge. Because of their required draft the vessels were limited to the main channel down the centre of the river. Examination of their travel pattern determined the need for a clear channel opening of 32 metres (105 ft) centred on the main channel.

The only other marine traffic of note was an ice breaker which travelled upstream during the spring to break up the ice and minimize the possibility of ice bridges forming at the bridge or elsewhere.

Apart from the icebreaker, there was no requirement for opening the bridge during the winter months. The bridge may therefore remain closed from October to April each year.

Soil Conditions

The bridge was situated in a typical low lying area with alluvial silt. Geotechnical testing indicated that the main foundations had to be on piles over 30m (100 ft) long. For the top 6m (20 ft), between 10 and 20 blows were required to advance the sampler hammer. Below that level, the resistance decreased so that the sampler was advanced manually for the next 20m (65 ft). This lack of resistance later caused some problems in controlling the piles during the pile driving.

Because of the very weak soils, there were grave concerns about the stability of the approach embankments. It was therefore necessary to minimize the height of any embankments both to prevent excessive settlement and to prevent a slip failure into the river.

In the final design, some of the existing soil was removed and replaced with lightweight fill. Lightweight fill was also used for the embankment material adjacent to the river. The height of the embankment was restricted to 3.0m (10 ft) while still providing 4.0m (13 ft) clearance for boat traffic at normal water levels.

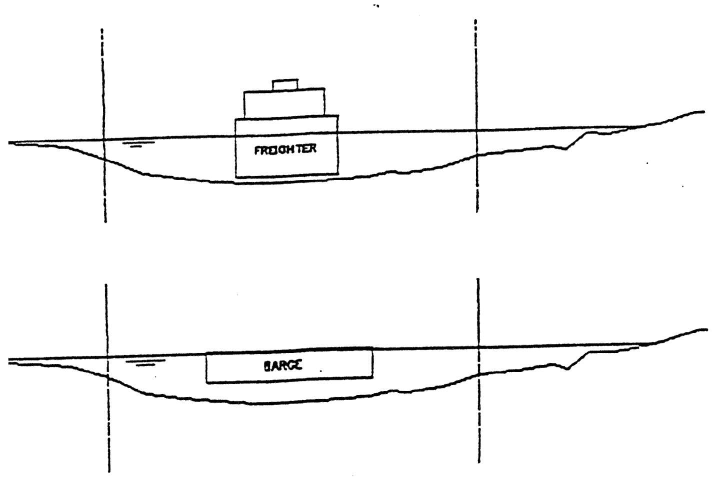


Fig. 5 Draft of Major Vessels

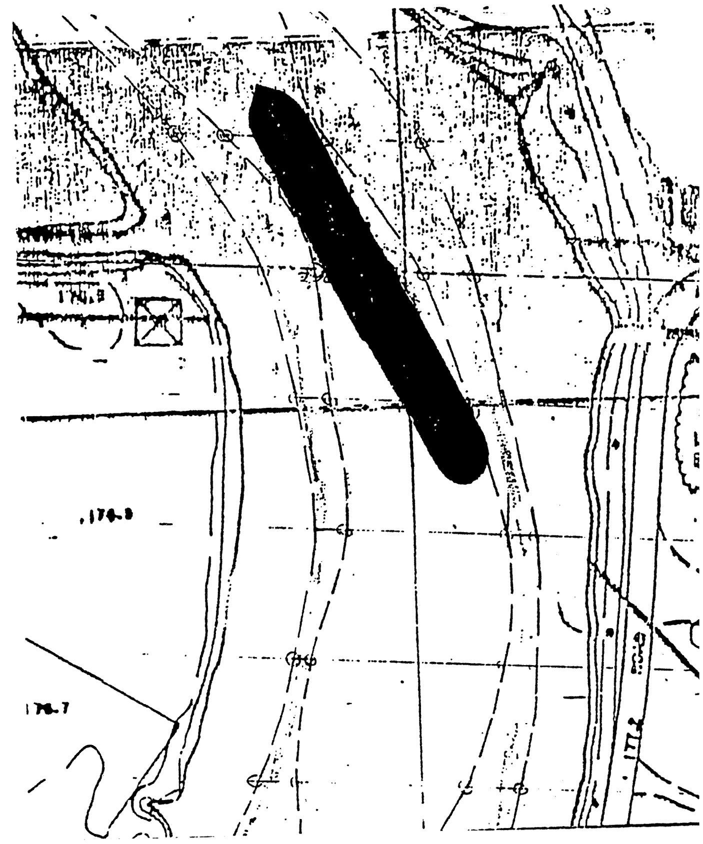


Fig. 6 Channel Definition

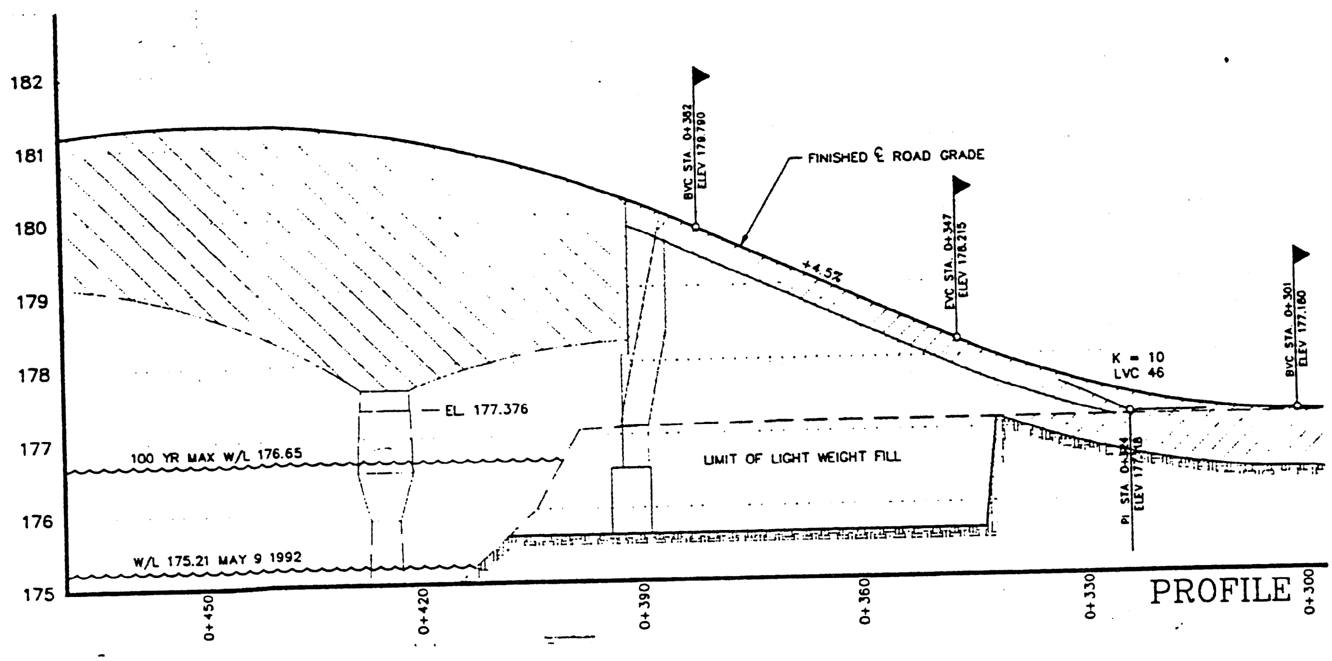


Fig. 7 Embankment Construction

Aesthetics

From the start of the project, the owners, the Town of Wallaceburg, indicated that they wanted a good looking bridge with a minimum of superstructure. In particular, they did not want the high towers associated with a vertical lift bridge or the overhead counterweights of a bascule bridge.

Vertical Lift Bridge Option

The vertical lift option was rejected because of the appearance of the towers. There was also concern about potential movement of the footing which would be reflected in the towers and cause jamming problems.

Bascule Bridge Option

The bascule bridge option was rejected for several reasons. Designs with overhead counterweights were not acceptable to the owners. The need for large piers in the river raised significant concern about any blockage to flow. Another reason for rejection was the complication introduced by the 25° skew angle.

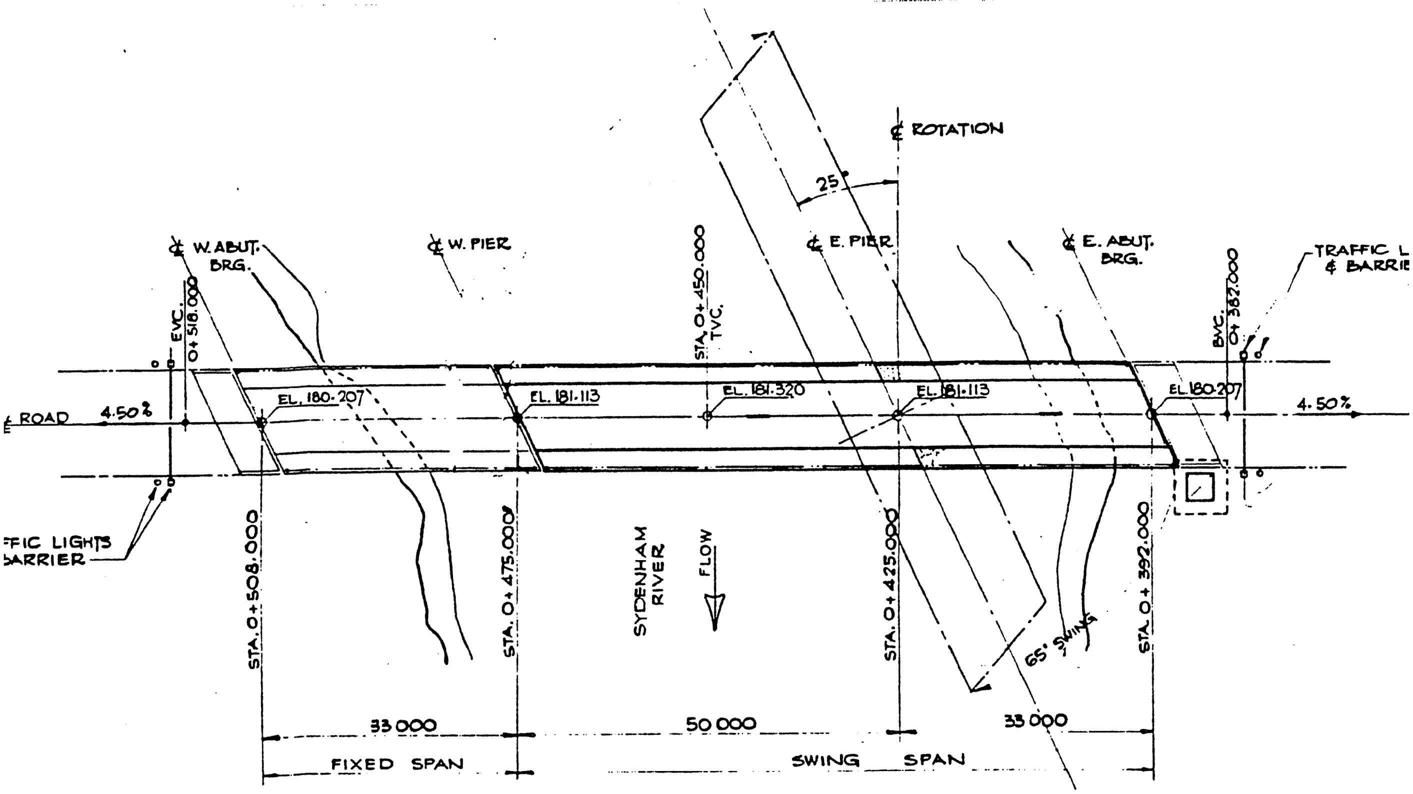
Swing Bridge Option

The option finally was a swing bridge. Space was available to accommodate the swing motion of 65° from fully closed to fully open. The channel location was determined by the contours of the river bed. Initially this resulted in a tail span which was much less than the main span. Subsequently the tail span was extended over the bank of the river. This gave easy access to the jacks and other equipment located at the tail end. Also, by moving the abutment further inland, problems associated with poor soil conditions, potential abutment movement and embankment settlement were diminished.

The final arrangement was a bobtail configuration with a 50m (164 ft) span over the main channel and a 33m (108 ft) tail span. This was matched by a 33m (108 ft) fixed span on the other side of the river.

The bridge was balanced by a concrete counterweight between the girders near the tail end. This is supplemented by the use of concrete sidewalks on the tail span whereas steel sidewalks were used on the main span.

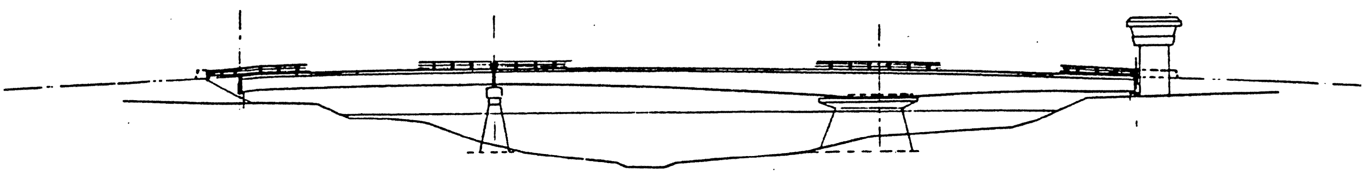
The operating weight of the bridge is approximately 600 tonnes.



PLAN A

1 : 500

0 5 10 20m



ELEVATION B

Fig. 8 Plan and Elevation

Pivot Pier

Because of flooding concerns, the pivot pier was minimized in size. The size of the cap was determined by the roller path circle which is only 3m (9.8 ft) radius. This is only 6% of the span which is a very low percentage. The result is high roller loads under certain unbalanced conditions. These include wind uplift loading in accordance with the Ontario Highway Bridge Code - a condition which is not specified in the AASHTO movable bridge specification. Below the roller path level, the pier is necked down to give a minimum size and circular shape at the water level.

Structure

The bridge is a two lane structure with a sidewalk on each side. It was designed to comply with the Ontario Highway Bridge Code in the closed position and the AASHTO Movable Bridge specification when open.

A 12 mm (1/2") thick orthotropic steel deck is used with 6 mm (1/4") trapezoidal stiffeners. The deck spans 3.85m (12.6 ft) between floor beams. These transfer the load to the two welded girders at 8.1m (26.6 ft) centres. The depth of the girders varies from 2.0m (6.5 ft) at the nose to 3.3m (10.8 ft) over the pivot pier. The skew and vertical curve result in the two girders not being completely identical and other similar detailing problems. To provide warping stiffness, knee braces were added to alternate floor beams and a diagonal bracing system installed. All steel on the bridge is atmospheric corrosion resistant to eliminate the need for painting.

Operating Equipment

All the operating equipment is located either on the bridge above the central pier or at the tail end of the bridge. There is no equipment at the relatively inaccessible nose end of the bridge. The tail end equipment is accessible from the river bank adjacent to the control house. The hydraulic power pack and other equipment are located in an enclosure alongside the main pivot girder under the bridge. This minimizes the number of rotary connections required. The only hose or cable required to accommodate rotation is the power cable which comes underwater and up through the concrete pier. With the bridge in the closed position access to the centre pier is possible via a catwalk underneath the bridge. This avoids manholes in the bridge deck.

The normal hydraulic operating pressure is 7.0 MPa (1000 psi). All cylinders, valves and pumps are rated for 20 MPa (3000 psi) operating pressure. The hydraulic reservoir is equipped with heaters to maintain a minimum oil temperature of 6°C (42°F) so that the hydraulic system can be operated at short notice, even in freezing conditions.

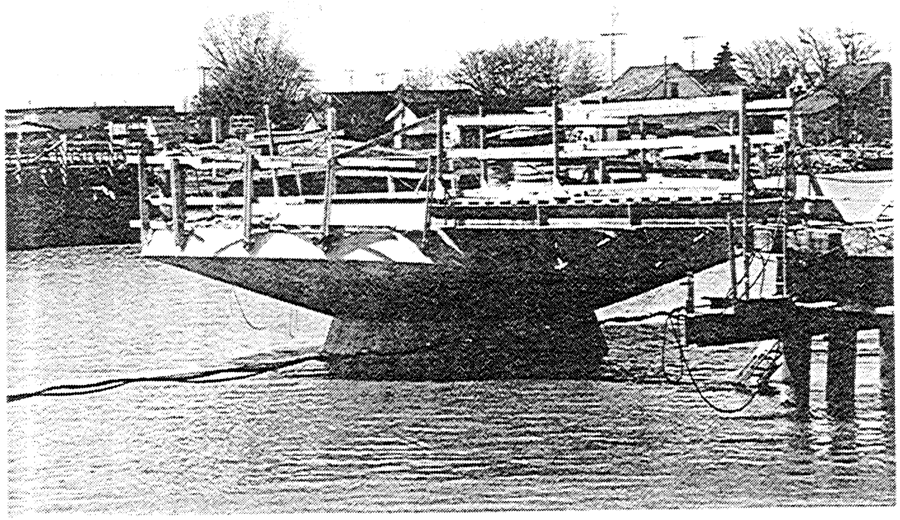


Fig. 9 Pivot Pier (under construction)

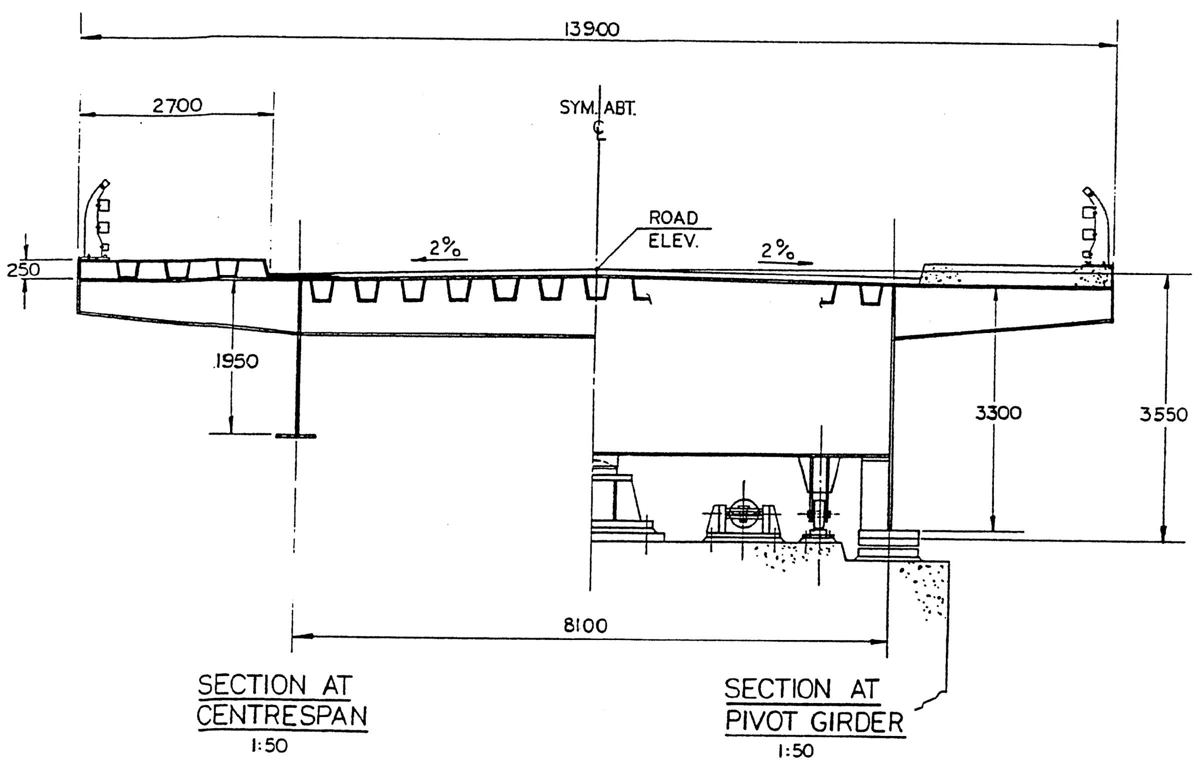


Fig. 10 Section through Structure

Swing Mechanism

The basic mechanism for slewing the bridge consists of two hydraulic cylinders which move the bridge through 65° about the centre self-lubricating bearing. The cylinders are 305mm (12") diameter with 2045mm (80.5") stroke. They are located within the roller path with an effective lever arm of approximately 1.6m (5.2 ft).

One complication from the skew angle was the need to stop the bridge in a precise location. Overswing would result in the bridge hitting the abutment.

Nose Bearing

The bearing at the nose is a simple elastomeric bearing with a steel cap. The bridge was constructed tail heavy so that the nose lifts vertically off the bearing at the commencement of opening. The only special equipment at the nose were deflectors to insure that nose was deflected upwards in the unlikely event that the nose is tipped down as the bridge closes.

Centre Bearing

The centre bearing is a spherical Lubrite bearing, 650mm (25.5") diameter on plan, with a spherical radius of 950mm (37.4"). This is supported on a steel pedestal with provision for removal of the bearing in the future if necessary. Jacking points are provided along the pivot girder.

In the event of unbalanced loads on the bridge, the bulk of the load is still carried on the main bearing. Minor loads are carried on balance wheels running on a 3.0 m (9.8 ft) radius track. The wheels have hardened rims and are supported on roller bearings.

Tail Bearing

In the closed position the tail is supported on rocker bearings with the load transferred directly through the bearing to the underside of the main girder flange. This type of bearing allows considerable longitudinal expansion. The bridge may be in the closed position for up to 6 continuous months during which time the temperature could range from -20°C to 30°C (-5°F to 85°F).

During opening the bridge is temporarily supported on jacks, 355mm (14") diameter located alongside the rocker bearings. The jacks have a stroke of 495mm (19.5") which is sufficient to provide the necessary clearances and to prestress the bridge with a maximum vertical reaction of 450 kN (100 kips) on each girder.

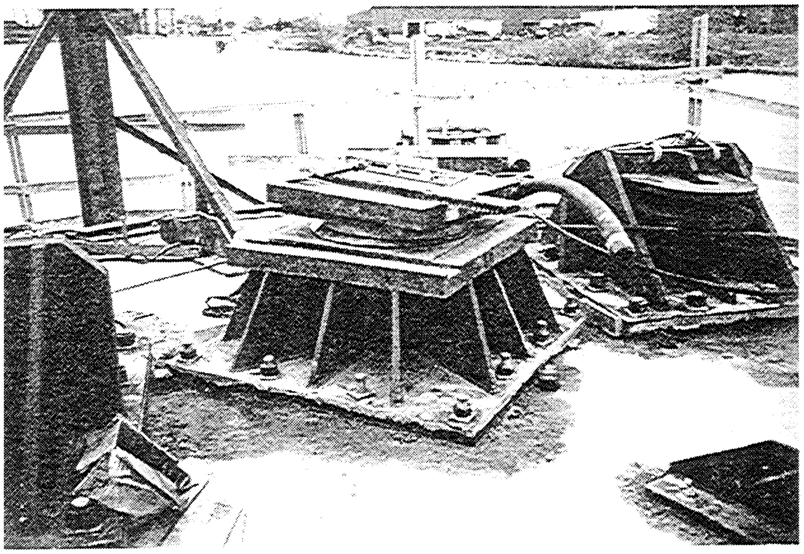


Fig. 11 Centre Bearing and Slew Cylinder Brackets

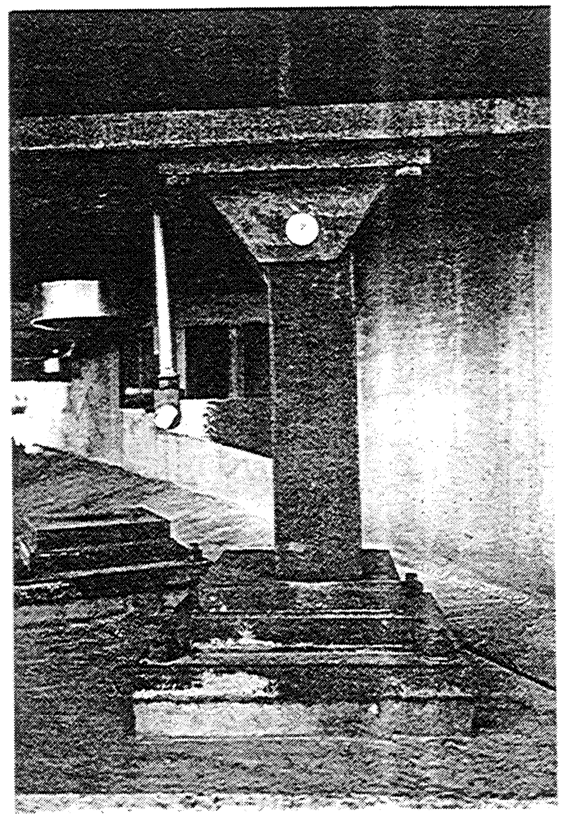


Fig 12. Tail Bearing

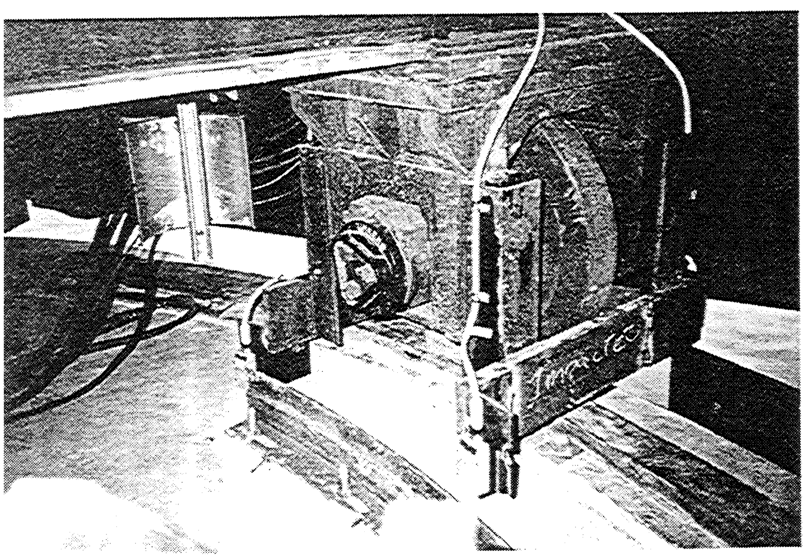


Fig. 13 Roller

Operating Procedure

After traffic has been stopped using a conventional traffic light and barrier system, the jacks located at the tail end lift the tail off the rocker bearings. The rocker bearings are then retracted and the jacks lower the tail end of the bridge. Because the bridge is intentionally counterweight heavy, the nose lifts off the bearing and the load is taken on the rollers nearer the tail end. Once the tail lock is open, the bridge accelerates to a constant slewing speed until it approaches the fully open position. Unless there is manual intervention, it then undergoes controlled deceleration to a stopped position. Opening time is approximately 4 minutes. The reverse procedure applies to the closing.

Controls

The bridge is normally controlled from a control console in the control tower. Provision was also made for a pendant type control plugged in underneath the bridge. This is intended primarily for maintenance and testing purposes.

The control console located in the Control Building is positioned to give clear visibility of vehicular, pedestrian and river traffic with continuous perimeter windows, sloped at an angle of 15 degrees. A projection of the roof affords shading and the windows are tinted to reduce solar gain.

Sequencing is controlled by an Allen Bradley SCL-500 PLC unit. One button operates the traffic barriers. Once traffic has stopped a single button is pressed to open the bridge. Lights on the control panel sequence to indicate the progress of opening and closing. The bridge can be stopped manually at any position, however if it travels the full distance it is automatically stopped at the 65° angle. Similarly, the closing is activated by pressing a single button.

In the event of problems there is an alarm signal to immediately inform the operator. If the problem is considered significantly serious, the bridge stops automatically. The lights are arranged to give an appropriate error code to help in diagnosing any problems.

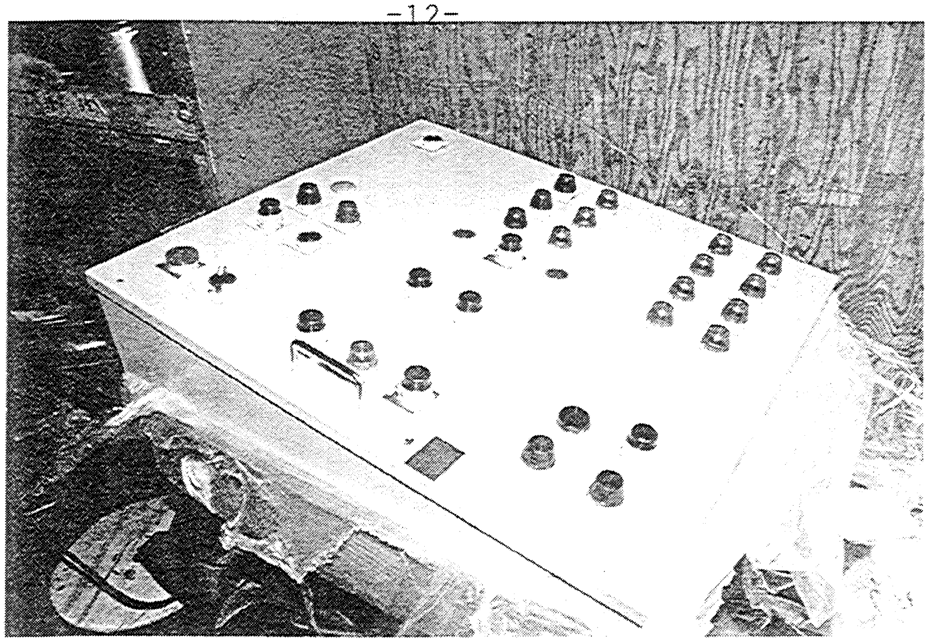


Fig. 14 Control Panel

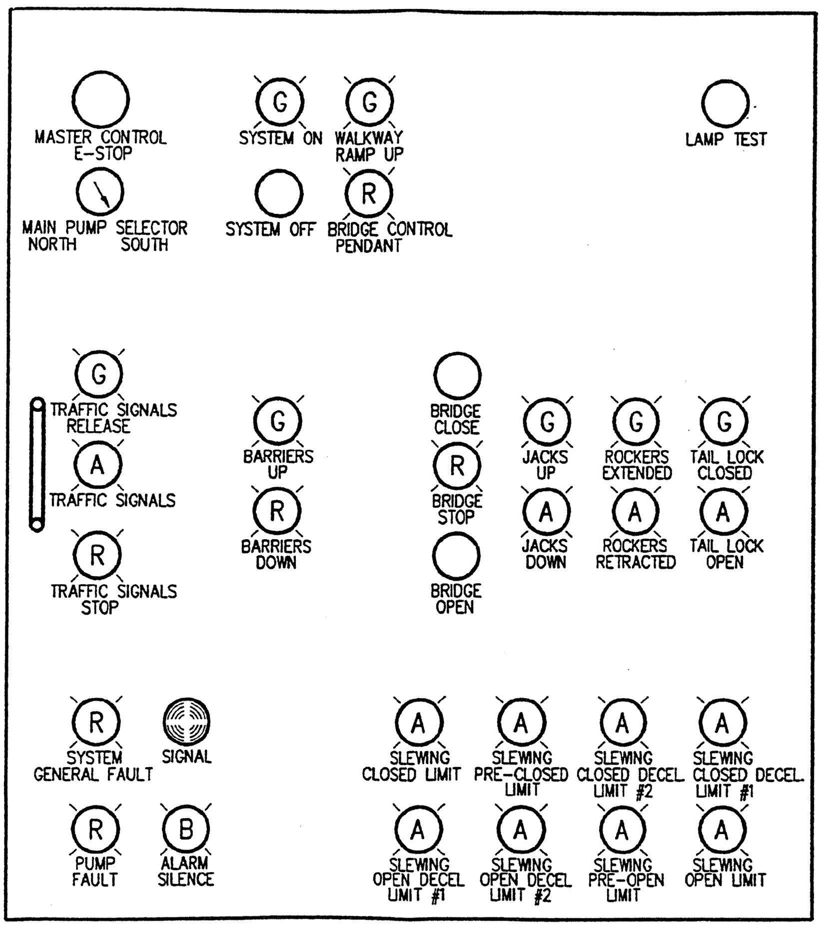


Fig. 15 Panel Layout

Construction

The superstructure was fabricated to the maximum extent possible in the fabricator's shop in Toronto. It was then shipped the 250 km (150 miles) to site, by truck. It was assembled on site on the east bank. This allowed assembly of the bridge superstructure to proceed while work was continuing on the abutments and piers.

When the steel portion of the superstructure was substantially complete the bridge was launched over the east abutment. Initially the structure was supported on rollers at the deepest section and lifted by crane at the tail end. The crane then pushed the structure forward over the east abutment. Once the nose was over the pivot pier, the load was transferred to temporary supports on the pier and lifted off the rollers. Subsequently it was transferred to a pontoon support structure and finally to the fixed pier and centre bearing.

To enable marine traffic to continue to use the river, the bridge was opened and tied down in the open position. Access from the river bank to the tail end enabled equipment to be installed. For operations such as pouring the concrete sidewalk and paving, the bridge had to be closed for limited periods of time.

The bridge was opened to the public in October 1994.

Construction Team

Owner:	Town of Wallaceburg
Prime Consultant:	M.M. Dillon Limited
Movable Bridge Subconsultant:	M.R. Byrne & Associates Limited
General Contractor:	Looby Construction Limited
Movable Bridge Fabricators:	Canron Inc.
Mechanical/Electrical Subcontractors:	Sheaffer Townsend Limited

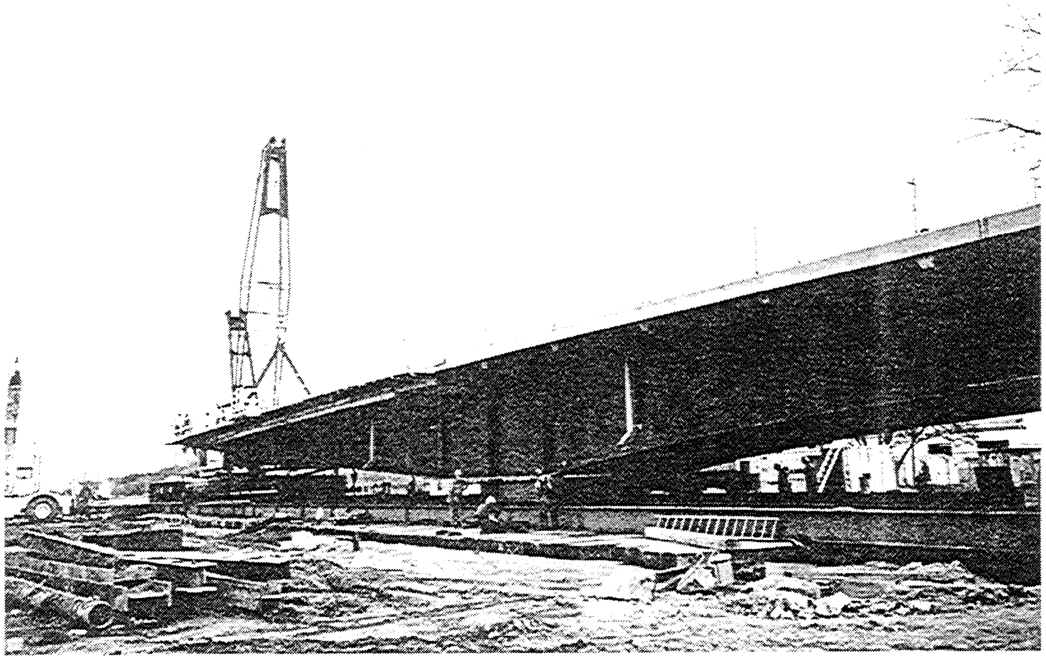


Fig. 16 Beginning of Launch

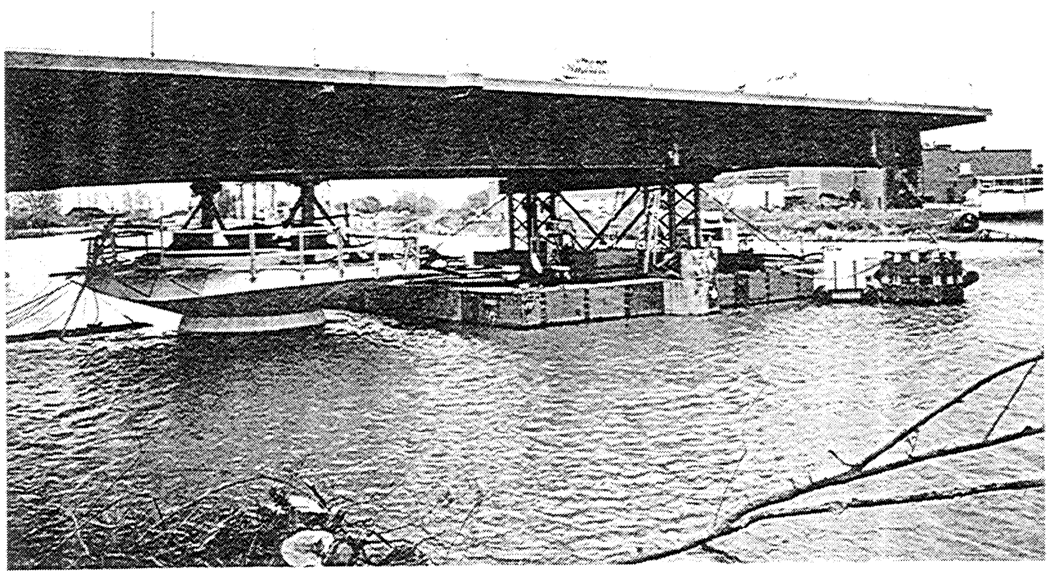


Fig. 17 Launch nearing completion

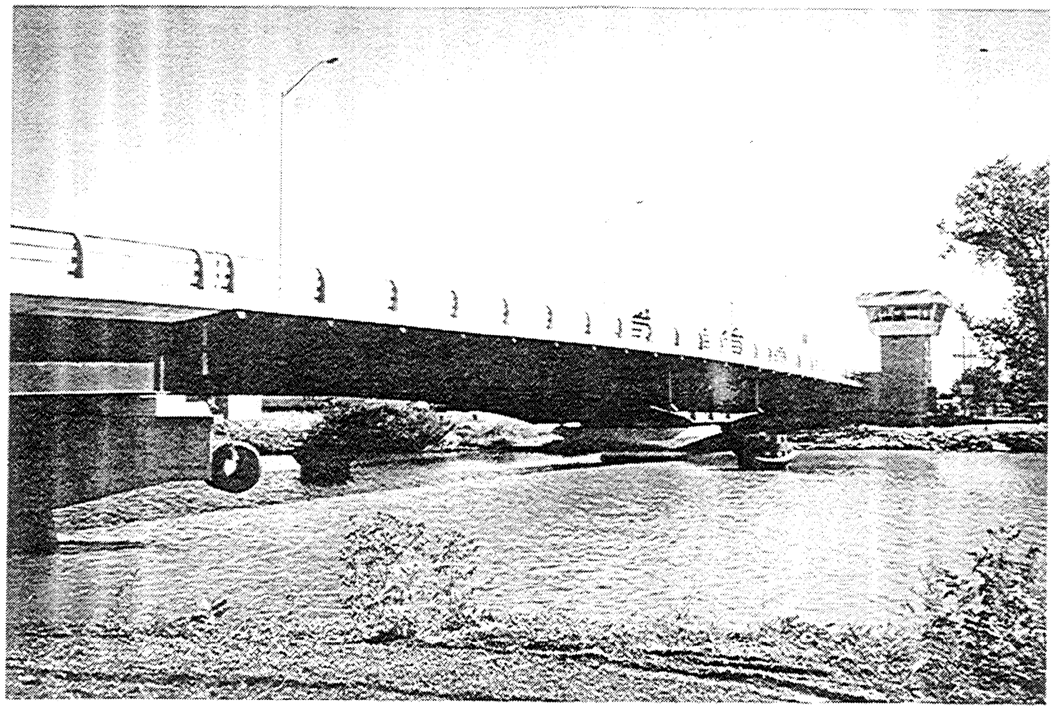


Fig. 18 View of Bridge and Control Tower

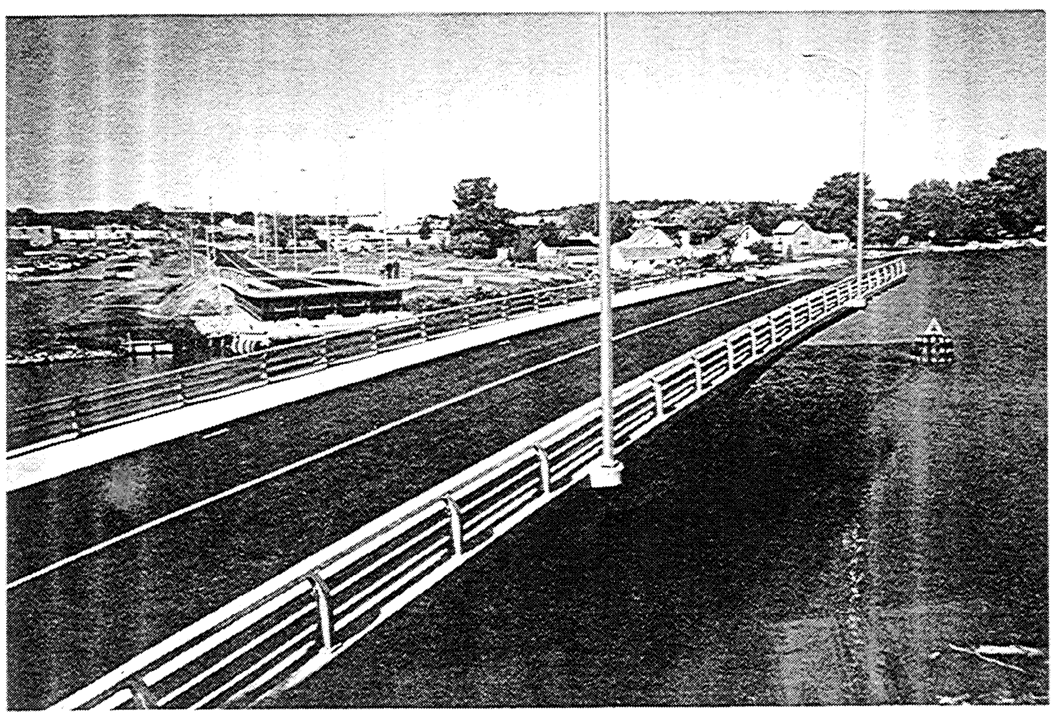


Fig. 19 View of Bridge from Control Tower

THE AUTHOR

David Swift is a structural engineer with degrees from the University of Cambridge in England and McMaster University in Canada. Following graduation, he worked for general contractor George Wimpey Limited and then for steel fabricators, Bridge and Tank Company and Dominion Bridge Company. He joined M.R.Byrne & Associates Limited in 1967 and became President in 1990. During his time with Byrne he has been in charge of many projects including replacement of 39 highway bridges over rivers in Indonesia, numerous heavy industrial projects as well as work on heavy movable structures such as bridges, cranes and hydro gates. He is a member of the Association of Professional Engineers of Ontario and the Institution of Civil Engineers in the U.K.