Heritage Bridge Impact Assessment

Caledonia (Argyle Street) Bridge
Caledonia, Town of Haldimand

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ASI File#: 02MT-14
January, 2004
Revised June 2005 and July 2005

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1.0 INTRODUCTION

The firm of Archaeological Services Inc. was retained by Morrison Hershfield Group Ltd. to undertake a heritage assessment of the Caledonia Bridge, a nine span concrete bow string truss bridge on Argyle Street South (Old Highway 6) in Caledonia, Town of Haldimand-Norfolk (Plate 1 and Figure 1). The Caledonia Bridge is listed on the Ministry of Culture's Ontario Heritage Bridge List (Site 9-2).

In particular, the heritage assessment of the structure is considered with respect to proposed rehabilitation/replacement of the existing bridge. The study area comprises the existing footprint of the bridge and its approaches.

The following report is presented as part of an approved planning and design process for municipal roads projects subject to a Class Environmental Assessment. The principal aims of this report are to:

- provide an historical overview of the design and construction of the bridge within the broader context of Ontario and bridge construction generally (Section 2);
- identify any heritage attributes associated with the bridge and outline policy considerations within Ontario's Heritage Bridge Program (Section 3) and the Canadian Heritage Rivers System (Section 4);
- ascertain sensitivity to change in the context of identified heritage attributes and evaluate alternatives and make recommendations within the broader policy context (Sections 5 and 6).

Plate 1. Caledonia Bridge, Argyle Street South (Old Highway 6)

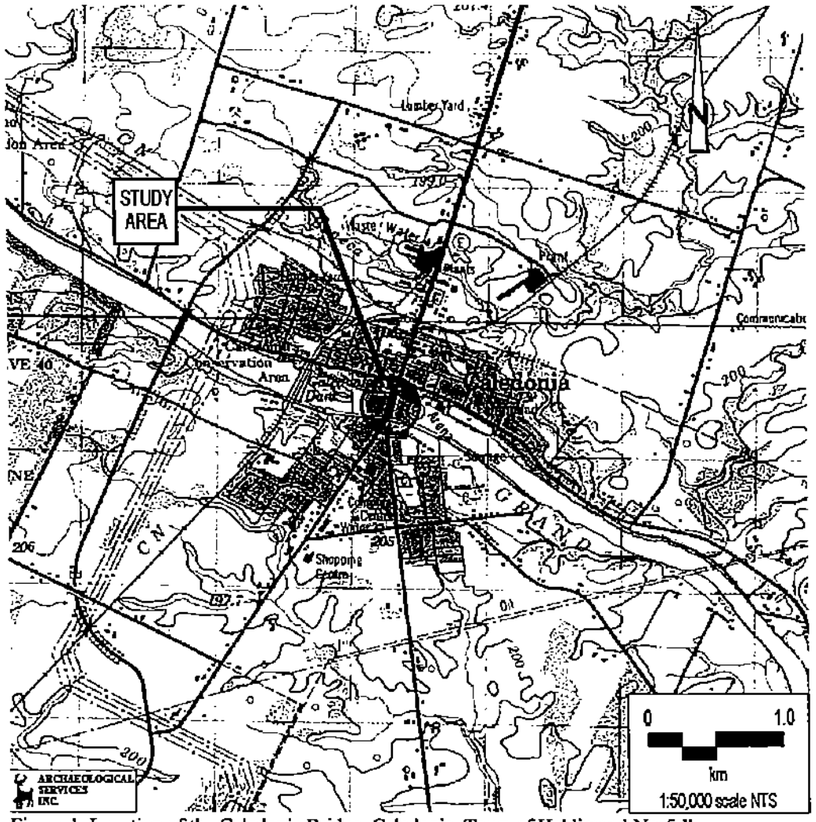


Figure 1. Location of the Caledonia Bridge, Caledonia, Town of Haldimand-Norfolk

2.0 HISTORICAL CONTEXT AND EXISTING CONDITIONS

2.1 Introduction

Heritage features are those buildings or structures that have one or more heritage attributes, i.e., historical associations, architectural or engineering qualities and landscape or scenic interest and importance. Inevitably many, if not all heritage structures are inherently tied to "place", geographical space, within which they are uniquely linked to local themes of historical activity and from which many of their heritage attributes are directly distinguished today.

The Caledonia Bridge is a locally recognized heritage asset that contributes to the special character of Caledonia and the surrounding landscape. Therefore, Section 2 of this report details a brief historical background to the settlement of Caledonia with particular attention given to the location of the bridge crossing. In certain cases, heritage features may also be viewed within a much broader context and Section 2 will also provide a discussion of the construction of the bridge within its historical engineering context.

This narrative will demonstrate that the Caledonia Bridge is of local, provincial, national and international heritage significance, being the only nine span concrete bowstring truss bridge known to be in existence.

2.2 Caledonia: Early roads, growth and settlement

Caledonia, situated on the Grand River, was laid out in the 1840s and the town plot at that time took in the village of Seneca to the east and for a number of years the post office was known by that name. Jacob Turner had built a sawmill in Seneca in 1834 and the two settlements grew side by side, with Caledonia becoming the larger and more important of the two when the Hamilton and Port Dover Plank Road (present day Argyle Street, Old Highway 6) came through. Its future growth was further assured by the building of a swing bridge across the Grand River in 1842. The community was incorporated as a village in 1853, though its name was not changed to Caledonia until 1880.

Caledonia's early growth was directly linked to its location, including its position on the Grand River and its place along an important transportation route. Prior to European settlement, the future Hamilton and Port Dover Plank Road and Highway 6 had already been carved into the landscape by Native travelers following a portage route from the Head of the Lake (Ontario) to the Grand River, as seen in the 1815 "Map of the Niagara District in Upper Canada, by Lieutenant W.A. Nesfield, drawn partly from Survey & from documents obtained from the Q^{r} M^{r} Gen^{l} Department" (Figure 2). This map indicates the general extent of trail development in and around the area and shows a clearly demarcated system of trails and roads. The 1815 map illustrates a number of trails converging on top of the escarpment. Two lead west, one to Ancaster and another to the Grand River and native settlements, and two strike southeast and east: the former to

Pelham and Thorold townships, and the latter "A road cut by Governor Simcoe", parallels the escarpment in an effort to avoid swampy lands below. The trail to the Grand River follows the present day route alignment of former Highway 6 through Glanford. The track, formerly called the Caledonia Stage Road and the Hamilton to Port Dover Road, was lined with at least 15 taverns from Hamilton to Caledonia on the Grand and it was planked to Mount Hope as early as 1837.

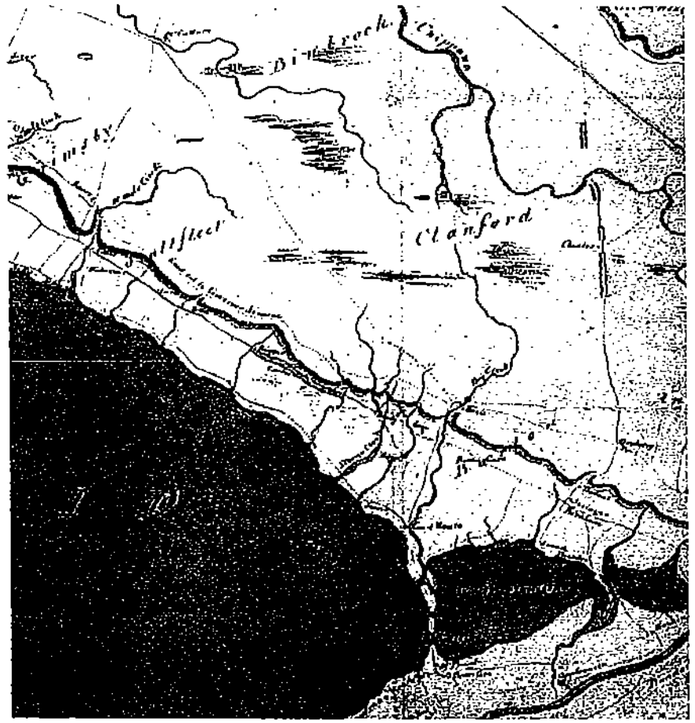


Figure 2. "Map of the Niagara District in Upper Canada", by Lieutenant W.A. Nesfield, 1815.

By 1850, the "Map of the Principal Communications in Canada West Compiled from the most authentick sources, actual Surveys, District maps etc., etc. by Major Baron de Rottenberg (Figure 3), shows a well developed system of roads, including the Hamilton to Port Dover Plank road (and bridge) passing through Caledonia.

Figure 3. "Map of the Principal Communications in Canada West Compiled from the most authentick sources, actual Surveys, District maps etc., etc. by Major Baron de Rottenberg, 1850.

Caledonia's early settlement history can be traced to the years just after the American Revolution. On October 25, 1784, the British Crown gave Mohawk Chief Joseph Brant and his Six Nations Confederacy six miles of land on either side of the Grand River from its mouth at Lake Erie to its source in present-day Dufferin County. This land grant was given in payment for the loyalty of the Six Nations to the Crown during the war and in restitution for lands lost to the United States.

The grant was completed by Sir Frederick Haldimand, Governor-in-Chief of Canada. That same year Chief Brant and a group of non-Native Loyalist refugees settled in the Grand River Valley and Brant gave his friends tracts of land along the river. Shortly after 1830 the government, with the consent of the Chiefs, decided to sell all the remaining portions of the reserve in Haldimand, except for a small section in Oneida, and open this area for development. The proceeds were to be invested for the benefit of the Six Nations, with the interest on the investment being paid in goods such as guns, blankets, and ammunition. Consequently, a treaty drawn up that resulted in the surrender of the lands to the government and the opening up of the townships for white settlement.

In 1832 a bill was passed by the provincial government authorizing canal and lock building on the Grand, or Ouse River, as it was first called by European travelers, and the Grand River Navigation Company laid out small villages on the north and south banks of the Grand. The village of Seneca was located on the north bank at Dam four, while the village of South Seneca was on the south bank. By 1834 Jacob Turner, the contractor for dam four, was operating a sawmill at Seneca Village. By 1833 dams one, two and three were completed at Indiana, York and Sims Locks. Dam four, just east of present day Caledonia at Seneca, was constructed by 1834.

Ronald MacKinnon, the first reeve of the village was a central figure in the Caledonia's early development. McKinnon was hired as a contractor for the construction of dam five for the Grand River Navigation Company at the Oneida. When McKinnon first came to the area, Caledonia (between Seneca and Oneida) was known as Bryant's Corners (a name which can still be seen on the 1850 Von Rottenberg map) and it was comprised of a hamlet with two log houses and a tavern owned by Mr. Bryant. In 1836 McKinnon built a sawmill and a store and in 1844 he erected a gristmill, followed by a woolen factory in 1848. A number of hotels and stores were also constructed during this early period, and they serviced the surrounding community and plank road travelers.

William H. Smith's 1846 *Canadian Gazetteer* provides the following description of the growing village.

> **CALEDONIA**. A flourishing Village on the banks of the Grand River, twenty miles from Brantford, fourteen from Hamilton, and twenty-three from Port Dover; principally situated in the township of Seneca, with a small portion on the opposite side of the river, in the township of Oneida. The two portions of the village are connected by means of a handsome swing bridge across the river. Caledonia was laid out as a village by the Crown , about two years since, and the village of Seneca was included in the town plot. The plank road from Hamilton to Port Dover passes through the village. Stages run daily to Hamilton and Port Dover, and a mail runs three times a week to Dunnville, and from thence to St. Catherines. A settlement called "Little Caledonia," where is a grist mill, and a saw mill with two saws), is situated about a quarter of a mile distant.
> Population, including Little Caledonia, about 300.
> Post Office (in Oneida), post daily.
> *Professions and Trades*.—One physician and surgeon, five stores, three taverns, two groceries, one saddler, two waggon makers, two cabinet makers, three blacksmiths, three shoemakers, three tailor, two bakers.

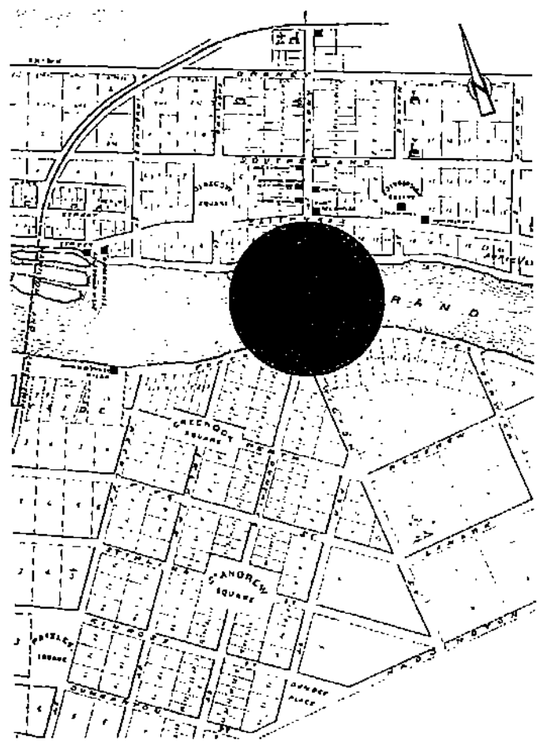


Figure 4: *Illustrated Atlas of the County of Haldimand*, 1877.

The 1846 list of professions, trades and services clearly indicates that the village of Caledonia largely existed to serve travelers on their way south. Of course, permanent settlers needed community services as well and a frame building housed both church and school until 1848, when the Anglicans and the Presbyterians both erected churches. Sometime prior to 1856 Thomas Messenger began publishing a newspaper which he called the *Advertiser*. That year he changed the name to the *Grand River Sachem*, and it is still published under that name today.

Due to its enviable hub position, Caledonia also became a supply centre for the agricultural area. Substantial community buildings were constructed in the 1860s and 1870s, including a Town Hall in 1860, attesting to the local prosperity, and the 1877 *Illustrated Atlas of the County Haldimand* depicts a well-developed pattern of village lots (Figure 4) at the crossing.

2.3 Caledonia: the Grand River bridge crossing

The bridge at Caledonia carries Argyle Street (Old Highway 6) over the Grand River, and it is the fourth permanent bridge to be constructed at this crossing. The first of crib and frame construction was washed away by ice and floods and the second was a sixty feet wide wooden structure reinforced with steel plates. It was erected in 1842 to provide permanent and unimpeded passage on the plank road between Hamilton and Port Dover, and it was comprised of six spans, one with a swing section. After nineteen years of being buffeted by the elements, it too was destroyed by jams and ice floes during the spring of 1861. Temporary bridges were constructed between 1861 and 1875.

In 1875 a six-span iron bridge replaced the temporary structures, which were regularly washed away by rising water and swift currents. Although the Haldimand Navigation Company held navigation rights on the river, infrequent traffic removed the need for a swing section and the county paid $400.00 to compensate for dispensing with the requirement. Each of the spans were 105 feet long with each supported by a cast iron bow-string truss manufactured at the Scott Foundry of Caledonia. It had a wooden decking, a wooden wall on either side and a six foot wide wooden sidewalk along the west side. The bow string truss was supported on masonry piers and abutments. These piers were constructed of large blocks of limestone placed on large pine timbers. The upstream face of these piers had to be protected by sheet iron. A swing iron gate at the north end stopped drivers from passing through without paying the toll and, adjacent to the bridge, a red and buff brick Gothic revival house was built for the new bridge's toll keeper. Tolls were collected until about 1890 to help defray the cost of the bridge, which was around $22,500.

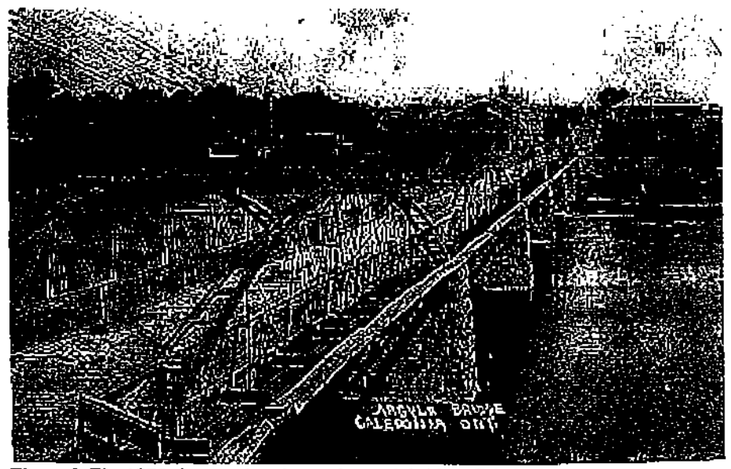


Figure 5. The 1875 six-span iron bowstring arch bridge, Caledonia

Owing to a 1925 accident, in which the middle span of the iron bridge collapsed under the weight of a truck carrying a load of stone, negotiations took place between the Provincial government and the County Council and in 1926 the Department of Public Highways assumed responsibility for this important piece of the highway from Hamilton to Port Dover (the former historic Hamilton and Port Dover Plank Road).

The present bridge was designed by A.B. Crealock, bridge engineer with the Department of Public Highways, and it was constructed in 1927 by Randolph MacDonald Co. Ltd. of Toronto. It is a continuous span comprising nine reinforced concrete tied arches over eight piers. Pedestrian sidewalks are on either side of the bridge. It was one of three bridges of similar construction built in Ontario during the mid to late 1920's. The other two are also along Grand River at Freeport and Bridgeport. The Annual Report of the Department of Public Works for 1927-28 indicates that construction of the bridge began in June and was completed two weeks ahead of schedule on November 19. Its dimensions were noted as being 653 feet long comprising 2,400 cubic yards of concrete, of which 1,200 were reinforced by 176 tons of steel. The stone was supplied by the Canada Crushed Stone Corporation Ltd., Hamilton, the sand by the Paris Sand and Gravel Co., Ltd, the reinforcing steel for the floors and sidewalk was furnished by Burlington Steel Co. Ltd. Hamilton, and for the arches and main girders by the Steel Company of Canada Ltd. Hamilton Cement supplied by the Canada Cement Co. Ltd. was used throughout the structure.

On December 20, 1927 *The Canadian Engineer* (Figures 7 and 8) reported that "the spans rest on two abutments and eight piers, the foundations of which were excavated from four to five feet below the bed of the river, where good foundations were obtained. This necessitated to construction of a coffer dam for each pier and, owing to the fact that the surface rock was shattered and contained numerous seams, the pumping was a costly item; in some cases, two large pumps being required to handle the water."

The article outlines the swift construction of each span and author B.H.M. Balfour, Superintendent for Randolph Macdonald Co. Ltd. enthused that "this is a record for this type of bridge and the contractors deserve credit for speedy construction and excellent workmanship." He further congratulated designer A.B. Crealock for his "rare genius in being able to weave in the beautiful and picturesque, at the same not losing sight and strength and permanence."

According to local historian Barbara Martindale a gala two day event was held to celebrate the completion of the bridge, including a dance sponsored by the fire brigade. On Saturday a crowd gathered to hear the speeches of provincial officials (which were continued later in the Opera House) and a procession led by the Caledonia Citizen Band was the first to cross the new bridge, while the first car carried the wife of the contractor.

The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Concrete Bridge at Caledonia, Ont.

Reinforced Concrete Arch Structure Built Across Grand River Consisting of Nine Spans Each 72 ft. 7 in. Long—Total Length 700 ft. and Overall Width 41 ft. 8 in. — Temporary Bridge Erected to Take Care of Traffic During Construction

By B. H. M. BALFOUR
Superintendent, Randolph Macdonald Co. Ltd., Toronto

CALEDONIA is a pretty little town situated on the Grand River about fourteen miles south of Hamilton, Ontario.

The surrounding country was first settled by United Empire Loyalists and at the same time the Indian chief, General Brant, and his family, followed the flag from the State of Iowa to this district.

From that time to the present, the crossing of the Grand River at Caledonia has been a problem for many engineers and contractors. At times, the water in this river is so shallow that a child could walk across, but a day of rain causes a rapid rise in the water level, and a two days rain changes it into a raging torrent. During the spring freshet, the water rises from 10 to 12 ft. above the normal flow and the ice from the whole length of the river rushes towards Lake Erie. This sometimes causes serious blockades and damages structures along the river. Many improvements have been made along the river, in recent years, and the ice and flood danger is gradually being overcome.

CALEDONIA BRIDGE FROM THE SOUTH

There have been four bridges built across the river at Caledonia before the present structure was placed there.

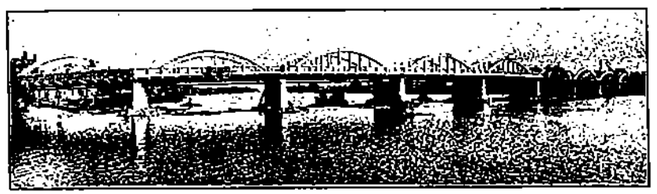
The first two bridges of crib and frame construction were demolished by ice and floods. The third structure was built in 1873-74. It consisted of six spans of the bow string truss type supported on masonry piers and abutments. These piers were constructed of large blocks of limestone placed on large pine timbers. The upstream face of these piers had to be protected by sheet iron, as the ice rushing down in the Spring had begun to cause serious damage. This bridge carried the traffic for fifty years, but in 1924 a truck loaded with stone broke down one of the spans and it was time to build another bridge suitable to carry the traffic of the present day.

In 1926 the Ontario Department of Public Highways took over this portion of the road, as it was part of the important highway from Hamilton to Port Dover.

The Hon. Geo. S. Henry, Minister of Public Highways, and F. M. Smith, the Acting Deputy Minister and Chief Engineer, issued instructions to A. B. Crealock, bridge engineer, to prepare plans for a new bridge and the present structure is the result.

The bridge consists of nine spans of reinforced concrete, as shown in the accompanying illustrations.

Each span is 72 ft. 7 in. long, width of roadway 23 ft., with a 5-ft. sidewalk on each side. The length from end to end of hand rails is 700 ft., the width is 41 ft. 8 in. overall. The hand rail is 4 ft. high and blends well with the arch

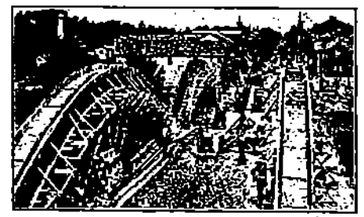


GENERAL VIEW OF CALEDONIA BRIDGE PRACTICALLY COMPLETED

Figure 6. *The Canadian Engineer*, December 20, 1927.

construction, giving the finishing touch to a very beautiful structure.

The spans rest on two abutments and eight piers, the foundations of which were excavated from 4 to 5 ft. below



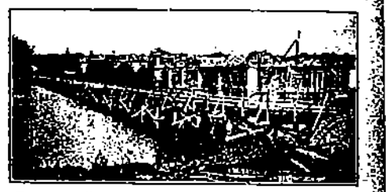
SHOWING FORM WORK FOR ARCHES

the bed of the river, where good foundations were obtained. This necessitated the construction of a coffer dam for each pier and, owing to the fact that the surface rock was shattered and contained numerous seams, the pumping was a costly item; in some cases, two large pumps being required to handle the water. Work was commenced on the temporary trestle on June 11th, this structure being completed and open to traffic in two weeks.

THE COMPLETED BRIDGE

The first concrete was poured for the substructure on July 8th, 1927, and the first span was poured August 16th, two other spans being poured by the end of this month. Five complete spans were poured in the month of September and the last span early in October. Even though a serious flood occurred on July 24th, which endangered the temporary trestle and the falsework for the new structure, causing serious delay and change in the construction program, the bridge was finished more than two weeks before November 30th, the date set for completion, and was opened for traffic November 19th.

This is a record for this type of bridge and the contractors deserve credit for speedy construction and excellent workmanship. The total time from start to completion, including the construction of the temporary trestle being only one hundred and forty working days.



TEMPORARY TRESTLE BRIDGE IN FRONT OF MAIN STRUCTURE

The designer, A. B. Crealock, showed rare genius in being able to weave in the beautiful and picturesque, at the same time not losing sight of strength and permanence.

The contract for construction of this bridge was awarded to The Randolph Macdonald Co. Ltd., engineers and contractors, 1130 Bay Street, Toronto.

The stone was supplied by the Canada Crushed Stone Corporation Ltd., Hamilton, the sand by the Paris Sand & Gravel Co. Ltd. The reinforcing steel for the floors and sidewalk was furnished by the Burlington Steel Co. Ltd., Hamilton, and for the arches and main girders by the Steel Company of Canada Ltd., Hamilton. Cement supplied by the Canada Cement Co. Ltd. was used throughout the work. The writer was the superintendent in charge of the work for the contractors.

Figure 7. *The Canadian Engineer*, December 20, 1927.

2.4 Transportation: historical engineering context

The Good Roads Movement

Throughout the latter half of the nineteenth century, many of roads outside of urban area consisted of dirt gravel or broken stone surfaces. Few were macadamized. Turnpikes and toll roads were becoming increasingly unpopular and during the 1890s there was a consolidated provincial effort to improve all roads throughout the province. The "Good Roads" movement, together with new county road systems saw many of the old turnpikes brought under public control. With this move came accompanying improvements in road construction and improvement were consolidated in a number of ways. Many major roads were routinely asphalted and improved and concrete also played a prominent role in highway construction. The first concrete highway in Ontario, from Toronto to Hamilton, was commenced in 1911 and finished in 1919, complete with concrete bow string arches over Mimico Creek, Etobicoke River, Credit River, and Twelve Mile Creek. None of these remain.

By 1925, 11 per cent of Ontario's population owned cars and, as their popularity grew, highway development had to keep pace. In 1918, there were fewer than 80 miles of hard-surfaced highways in Ontario, including the Toronto-to-Hamilton highway which, when completed in 1917, was Ontario's first concrete highway and one of the longest such inter-city stretches in the world. By the late twenties, there were 30 times as many miles of hard surfaced highways.

Bridge building in Ontario

Following David Cuming's chronology of Ontario bridge building in *Discovering Heritage Bridges on Ontario Roads*, the history of Ontario's bridge construction can be divided into three phases. The first phase, the century from 1780 to 1880, presents few innovations in road and bridge building in Ontario. Pioneers and settlers used materials readily at hand and the first bridges in the province were generally timber structures of either horizontally laid "corduroy" beams (logs packed with earth and gravel and fixed side by side) or a simple truss construction. The King post truss consisted of two vertical posts with two inclined members and horizontal top beam while the Queen post truss modified the original design with two vertical posts, two inclined members and a horizontal top beam. These two truss designs could span a length of between sixty feet and one hundred and twenty feet respectively.

These early bridges, though functional, did not result in a reliable transportation road system given the instability of both labour and materials. However, an influx of government investment in the Canada West's infrastructure after 1840 resulted in a period of innovation and prolific development. Investments were made in canals and roads and bridges received new attention. In Canada West many projects were undertaken, particularly on long distance routes between navigable waterways such as the Dundas-Owen Sound Road and the Hamilton-Port Dover and Lake Erie Road.

Responsibility for these projects fell to the superintending engineer of roads and harbours, Casimir Stanislous Gzowski (1813-1898). Under Gzowski, between 1841 and 1849, the Department of Public Works spent over a million dollars on roads in Canada West, including forty-three major bridges for the sum of $206,928. The first permanent bridge at Caledonia (1842) would have been a part of this massive influx of work and funding. A variety of bridges were built during this period although the Queen's post truss accounted for nearly a third of the total.

Despite its early and expansive involvement in infrastructural improvements in the mid nineteenth-century, the Department of Public Works had only short term involvement in bridge and road building. Spiraling costs led to the abandonment of works spending and the completion of many roads and structures fell to private consortiums and toll road companies. Then, in 1849, the new *Municipal Act* put the responsibility for roads and bridges onto local governments. The Act empowered counties, townships, cities and towns to carry a variety of building duties and to impose property taxes to fund them. As a result, for the next sixty years the road system evolved unevenly. Nevertheless, the post 1850s railroad era furthered bridge designing both north and south of the border, and new truss designs were created to provide stronger and longer solutions for numerous crossings. The Pratt truss, patented in 1844, featured vertical timber beams in compression and diagonal wrought iron tie roads in tension and this represented another step forward in the transition from timber and iron bridges to completely metal structures.

The typical mid-nineteenth century American bridge generally employed wrought iron throughout and in Ontario, wrought iron bridges appeared most often in market towns and cities, especially in the 1870s. The second (permanent) bridge at Caledonia (1875) is an excellent example of state-of-the-art wrought iron construction at this time (Figure 8). Wrought iron was still favoured in the 1880s, although bridge builders had begun to use steel. Increased load capacities necessitated even greater strength and steel functioned well in both compression and tension. Hybrid wrought iron and steel bridges appeared for a while and wholly steel bridges proliferated after 1900. However in the late 1890s, engineers and designers also began to experiment with concrete and concrete reinforced with iron and steel.

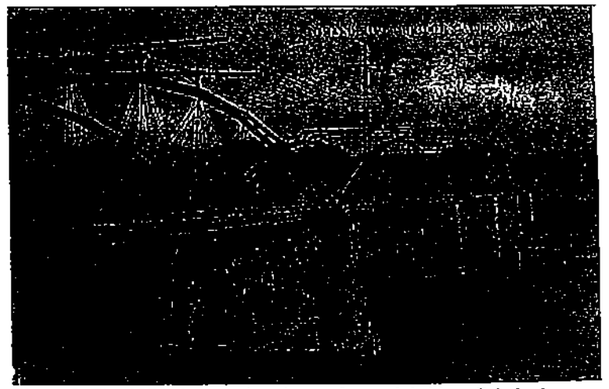


Figure 8. The 1875 six-span iron bowstring arch bridge, Caledonia

The reinforced concrete bow string or tied arch

Early concrete arches in Ontario comprised mass concrete. As engineers became familiar with the properties of the new material and utilized reinforcing materials such as iron or steel, confidence in concrete soared. Exponents of concrete bridges cited numerous advantages of its use over steel: in short spans the use of local materials and labour enabled inexpensive structures; advocates claimed that concrete, unlike steel, actually strengthened with age; and the material required no painting or rust removal, reducing maintenance to a minimum. In addition, a concrete span could take heavy loads safely for a long period of time provided that the foundations were sound. Foundation sinking could cause cracks and possible structural failure. W.A. McLean, assistant engineer in the Ontario Department of Public Works under "Good Roads" Campbell, built the first reinforced concrete arch bridge in Ontario in 1906. This arch, still in existence, is 92 feet long and spans the Aux Sables River at Massey.

Several concrete arch spans appeared during the first decade of the twentieth century in Ontario but a new type of concrete bridge soon developed: the concrete bow string truss bridge or the tied arch. Engineers had recognized the advantages of the semi circular reinforced concrete arch, but in many cases it proved unsuitable for streams with low banks. The reinforced concrete tied arch, however, could be adapted for use at almost any location, either in single or multiple spans. The ends of a segmental arch, i.e., a low "flat" arch span, usually exert tremendous thrusts on abutments, Instead of attempting to contain the thrust, the problem is overcome in a bow-string truss by "tying" the arch ends together with beams and the roadway. Thus the suspended roadway is transformed into a tied arch, by putting the tie beams and roadway into tension, like the string of a bow. Tied arches were particularly useful where large abutments were unsuitable or long distances required spanning. The design originated in Europe with the first record of such a span being built by M. A. Considere in 1904, in France.

The first use of the concrete bow string in North America is recorded as being built in Nashville, Tennessee in 1908. Designed by Howard M. Jones, engineer for the Cumberland River Bridge Commission, the bridge still stands today. The first span to be built of this type in Canada, and the second in North America, was designed and constructed in 1909 by Frank Barber and C.W. Young, of Barber and Young, Bridge and Structural Engineers, Toronto. It crossed the Etobicoke Creek near Long Branch, between the former counties of York and Peel, and carried the Middle Road (Figure 9). The bridge was designed for a load of 10 tons on two axles. The length of the bridge was 80 feet, with a 16 feet wide roadway, 14 feet above water, containing 13 tons of steel and weighing nearly 200 tons. It featured 6 vertical hangers in tension, creating 7 panels together with a system of counter-bracing. Expansion brass plates were sandwiched between steel plates and allowed for expansion at one end. It was tested at the time of construction with a concentrated load of 10 tons moving across the bridge, and by a herd of seventy cattle, weighing 35 tons. Vibration under such loads was considered slight.

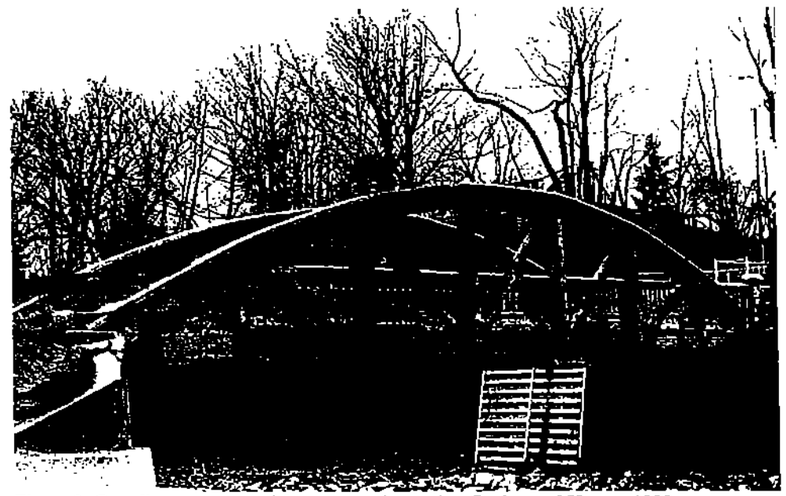


Figure 9. Canadian prototype of the concrete bowstring, Barber and Young, 1909

Commentators of the day noted that "During construction and since completion it has excited a great deal of interest among engineers and municipal officers from its novel character and the possibilities suggested by its successful completion and operation" (The Canadian Engineer, February 25, 1910). As Barber noted the use of concrete in urban areas seemed unpopular. In rural areas, however, the use of the concrete bowstring truss appeared to hold advantages, for those reasons described earlier

Even in 1919, however, some authorities still exhibited unease with concrete; so much so that Frank Barber scoffed at "dear old conservative Toronto" for its fear of "this newfangled material." Nevertheless, the 1920s saw a boom in concrete bridge building with concrete girders being used for short spans. Concrete tied arches were used for larger bridges with multiple spans crossing the Grand River at Caledonia, Bridgeport, and Freeport.

Figure 10. Caledonia Bridge, 1927.

2.5 Existing conditions and integrity

The bridge at Caledonia carries Argyle Street over the Grand River (Plate 2). Here the river is wide and relatively swift. Although the bridge has a low profile it is noticeable in the landscape from a variety of locations, particularly along the river banks, although it is only prominent in the river area and cannot be seen from a distance. There is a park to the north-east and the banks are built up on either side with low density housing to the south and the central business district to the north.

The bridge deck rests on eight concrete piers (Plate 3) and two concrete abutments (Plate 4). Each of the nine spans is 21.12 metres long. The width is about 12.5 metres with sidewalk and hand-railing on each side. The foundations for the piers were excavated to solid ground rock and the concrete poured on this foundation.

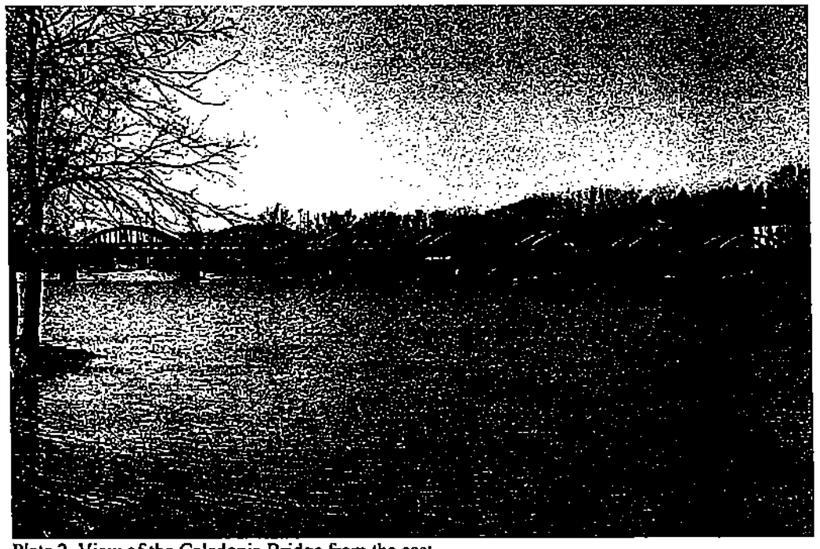


Plate 2. View of the Caledonia Bridge from the east

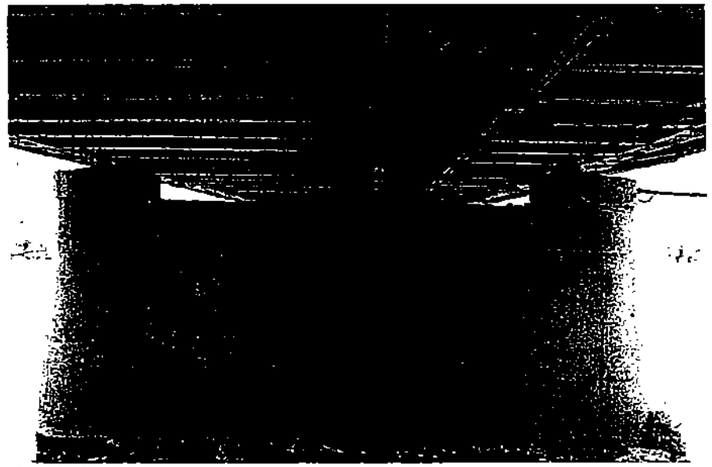


Plate 3. A typical pier and the underside of the deck

Plate 4. East side abutment

Minor changes have been made to the structure over time and a series of extensive repairs were completed in 1984, when reconstruction strengthened the bridge for future use. At that time new expansion bearings were installed under every span, a new deck and drains were installed, expansion joints were added between the concrete handrails, and portions of deteriorated concrete were replaced throughout the structure. In addition, abutment and pier concrete were repaired, including the replacement of the north ballast wall. New heritage light standards were added to the deck and adjacent parkland. None of the rehabilitative measures have altered its heritage integrity.

The former toll keeper's house is adjacent to the bridge (Plate 5). It is a red and buff brick Ontario Gothic revival structure with decorative elements including buff brick quoins and voussoirs and substantial twin chimneys.

The bridge is a landmark gateway to the town centre. It provides both a vehicular and pedestrian link between the residential areas to the south and the commercial core. For people passing through Caledonia on their way to somewhere else it demarcates the entrance to the community and the exit from it (Plates 6 and 7). The arches are graceful with slight indentations. Pedestrian sidewalks on either side allow for excellent scenic viewing both up and down the river (Plates 8 and 9).

Plate 5. The Toll keeper's House

Plate 6. Bridge approach from the north

Plate 7. Bridge approach from the south

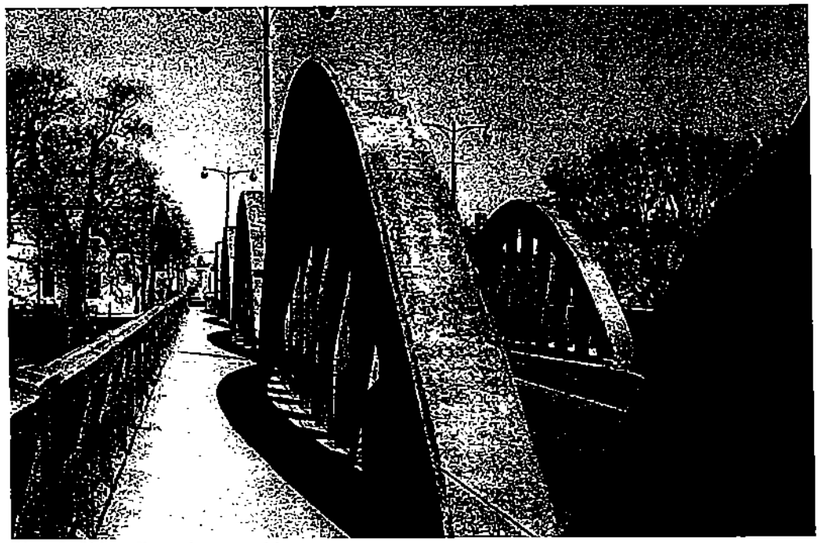


Plate 8. Sidewalk on the west side

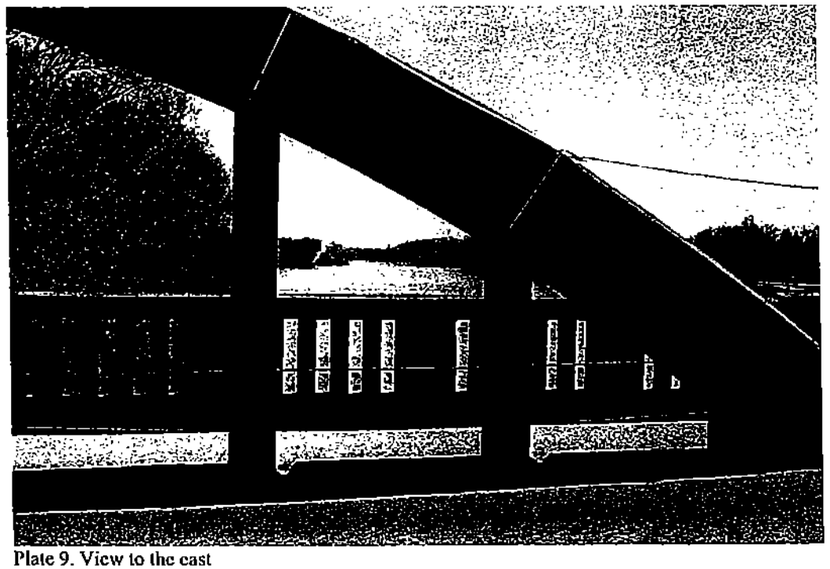


Plate 9. View to the east

Plate 10. Southeast corner

Although Argyle Street including the Grand River crossing is only a 2 lane local road, heavy trucks frequently use it to access the 4 lane Highway 6 north of Caledonia from the south as a short cut, instead of using the Highway 6 Bypass. Heavy traffic has taken a toll on the structure and it is substantially deteriorated.

A Bridge Deck Condition Survey reviewed that there were defects on deck concrete including delamination of the overlay installed in 1983, localized delamination and spalls, with general surface scaling of arches and impact damages at the two bridge ends. Defects at the supporting beam systems include delaminated areas and localized spalls, localized severe honeycombing pocket exposing severely rusted bars and anchor plates and ends of hangers. Diagonal cracks were found invariably at each end of each tie girder and were apparently deep or full depth cracks. Hangers were generally severely delaminated and spalled at the lower portions, and have continuously been maintained through emergency repairs. The abutments, piers, and wingwalls were generally in fair condition with significant deterioration of the concrete found in the areas of the construction joints and cracks extending between the construction joints or from the joints to the top bearing seat or the ground surface. The underside surface of the deck was generally in fair to poor condition with concrete patches, delamination and spalls areas, and a few narrow cracks, as well as signs of previous shotcrete repairs.

Based on the foundation investigation findings, the upper 4 to 7m of rock at the existing bridge location were highly weathered and fractured. The existing bridge is founded on poor quality rock mainly attributed to gypsum layers which gradually dissolve in the

water. The consulting engineers concluded that the poor founding stratum on which the bridge currently sits must be strengthened, or some form of underpinning must be carried out to transfer the loading to a deeper and more competent founding layer.

The following are major concerns raised in the structural evaluation:

- The end of arches and girders were severely overstressed by 67% in shear.
- The hangers were found to be 27% overstressed in axial tensile load.
- The main girder 5% and 38% is overstressed in moment and shear respectively at centre span locations; and at the stress limit for axial load.
- The end diaphragms were 39% overstressed in moment at the centre of span.

It is believed that these values will be significantly worsened if taking into consideration of the poor condition of the members and loss of section in concrete and steel due to spalling and rusting.

2.6 Conclusions

The Caledonia Bridge, a nine span concrete bow string truss or tied arch span, carries Argyle Street South (Old Highway 6) over the Grand River in the Town of Haldimand. The structure was completed in 1927 and is the longest span of this type in both Ontario and Canada. The Caledonia Bridge is also one of a few remaining examples of concrete bowstring truss construction generally, as the demolition of similar structures of shorter length have been accelerating in recent years.

While these bridges share a basic form, there is variety among these structures. The first span of this type to be constructed in Ontario was built in 1909 and featured a system of cross bracing between the vertical hangers. This span departs from the Barber design by not including a system of cross bracing and is representative of the form of bridge design that had become typical and standard practice throughout Ontario. The Caledonia Bridge is distinguished by its length, as well as by its low profile. The introduction of these concrete structures reflects the transition from horse-drawn vehicles to motorized vehicles, as well as the need for safe and durable structures that could handle heavy loads on expanding public highways.

The Caledonia Bridge is thus a unique example of the concrete bow string arch in the province of Ontario. Additionally, a review of available statistics suggests that it is also now a rare surviving example.

In a broader national context it is suggested that the observations for Ontario hold true for Canada as well. In considering the North American context of bridge engineering, i.e., the experience of the United States, where structure design, construction and technology have been more widely documented, there is ample evidence to suggest that such bridges are of recognized heritage value. They were popular between 1915 and 1930, and

advanced in particular by engineer James Marsh. Many have been nominated to the National Register with the earliest appearing to be the Spring Street Bridge in Chippewa Falls, Wisconsin constructed in 1916.

Heavy traffic has taken a toll on the structure over its past 80 years of use and a recent inspection report concluded that it is substantially deteriorated. Notwithstanding the wear and tear, however, the Caledonia Bridge has excellent heritage integrity with no substantial material modifications.

Accordingly, it is concluded that the Caledonia Bridge is of provincial, national and international heritage significance.

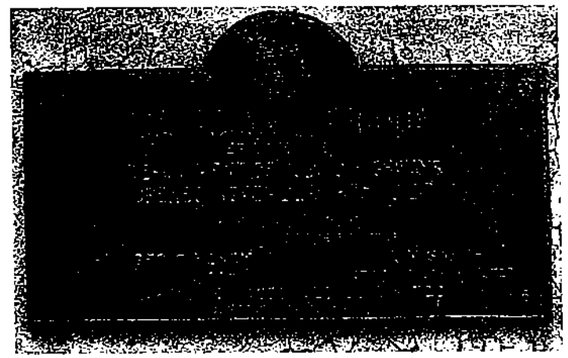


Plate 11. Bridge plaque, 1927.

Plate 12. Heritage plaque, Toll Keeper's House.