THE CONCRETE ARCH vs. THE CONCRETE GIRDER BRIDGE.

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The efficiency of the concrete bridge, its beauty and its permanency are becoming generally known, and concrete is now often preferred to steel. It will be interesting to compare two reinforced concrete bridges lately constructed for the Township of Markham as to efficiency and cost. They are of the same span, 50 feet in the clear, and are typical of the two main classes of concrete bridges: one at Unionville, opened last December, being a concrete girder bridge, and the other completed last week at Buttonville, being an arch. The bridges were designed by the late James McDougall, York County Engineer.

At Unionville the roadway is only eight feet above low water, and a girder bridge was decided upon as giving maximum waterway, but at Buttonville the roadway is twelve feet above low water, so that the arch constructed there with its ample rise allows sufficient waterway.

The reinforcement used in both bridges was mild steel round rods of ¾-inch diameter. The concrete for abutments was 1 of cement to 3 of sand and 5 of screened gravel, and for the superstructure 1 of cement to 2 of sand and 4 of crushed stone, except that the spandrel walls of the arch were of the former proportions.

The quantities of materials are as follows:—

Girder Bridge at Unionville.

	Cu. Yds.
Concrete: Abutments and wing walls	156
Superstructure	60
	Lbs.
Steel	7,000
Cost	$3,000

Contractor, O. L. Hicks, Humber Bay.

Concrete Arch at Buttonville.

	Cu. Yds.
Concrete: Abutments	190
Spandrel Walls	24
Arch ring	56
	Lbs.
Steel	14,000
Cost	$2,400

Contractors: McLennan and Alexander.

Had the girder bridge been built at Buttonville where the roadway is twelve feet from low water instead of eight feet, as at Unionville, it would have required about forty yards more of concrete; thus, comparing girder and arch if built in similar situations the quantity of concrete is only slightly less in the girder bridge. The steel in the arch is greater in quantity but is more easily placed than in the girder; probably the cost of steel and of placing it is $100 greater in the arch. On the other hand the cost of forms is probably greater in the girder than in the arch. The contract for the arch was let at a very low price. Mr. Hicks, who built the girder bridge complete for $3,000 also bid for the arch at $3,000, and the cost of filling the latter was $120 extra, so that under the same contractor the arch would have been more expensive. However, as noted before, the distance from water to roadway is greater at the arch. Probably under precisely similar conditions there is little difference in cost, if any, between girder bridge and arch of fifty feet span. If the foundations require piling the cost would be greater for the arch.

The temperature stresses which are an important factor in the arch are absent altogether in the girder bridge; therefore, as the arch must be designed to take the specified loading at the lowest temperature likely to occur, it is at any other time than during extreme and long continued cold weather stronger than the girder bridge. This is perhaps only a doubtful advantage, as the girder is at all times strong enough to take the specified loading (100 lbs. per square foot or a ten ton roller) with a factor of safety of four for the concrete and three and one half for the steel. But it may be noticed that in the case of the arch the ten ton roller is small compared to the moving load of 100 lbs. per square foot, so that the arch will always take a much heavier roller than the floor system of the girder will stand. The girder bridge was the first to be erected in this county.

Fifty Foot Arch, Lot 13, IVth Concession, Markham, Buttonville.

The number and distribution of the rods at the middle of each girder was arrived at by Marsh's empirical formula. The number of rods in other parts of the girder was found by an application of statics. Counter-braces are used, as in a Pratt truss. The stresses in the different parts of the girders may be checked by considering it as a Pratt truss divided into panels by the floor beaming, only noticing that the position of the neutral axis is different from what it would be in a steel beam. The floor beams were designed by Thatcher's empirical formula for T-beams.

This bridge was opened in December, 1907, centres being struck three weeks after completion of the concreting. The first load to cross it was a steam thresher. It is well known that the first load gives a permanent set to a con-

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