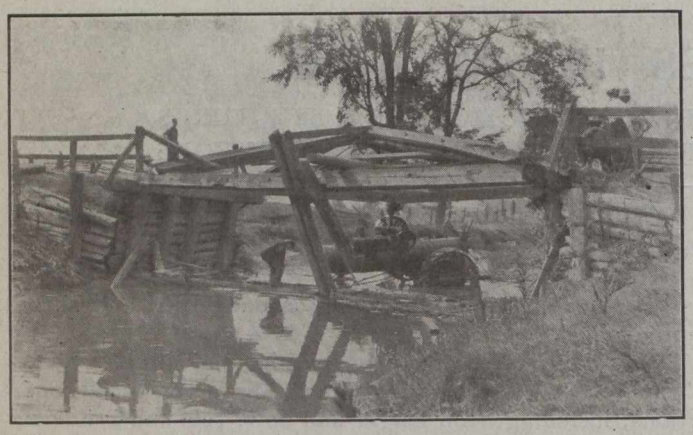
panying illustration shows. In this case the driver of the threshing engine knew before reaching the bridge that it was unsafe, but hoped to cross safely by running rapidly. The bridge fell when the full weight of the rear

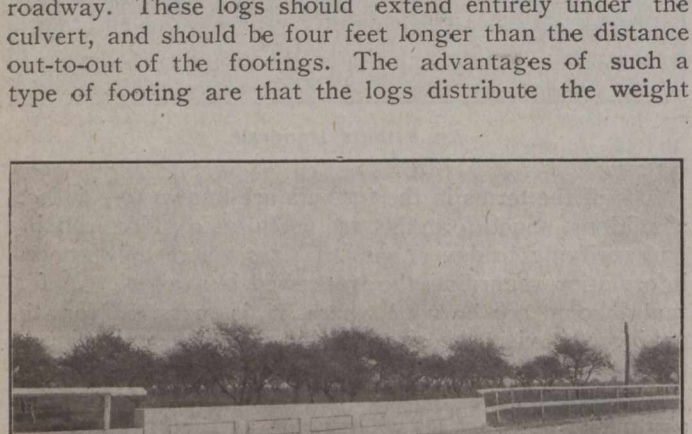


A Timber Bridge after Collapse.

wheels of the engine came on the centre floor beam and the machine went down in four or five feet of mud and water.

Foundations.—The word "foundation" in this article means the natural bed of material upon which rest the footings of the piers or abutments. This material may be muck, silt, sand, gravel, clay, boulders, rock, an artificial timber foundation of logs or other material, or it may consist of piles driven to support the structure.

For the smaller structures, such as pipe and box culverts, carrying the customary highway loads, the ordinary earth foundation is usually sufficient, but care must be exercised to provide protection against the undermining of the foundation by running water. Where the ground is very wet and soft or in swamps it may be necessary to increase the supporting power of the soil by placing logs 10 inches to 12 inches in diameter and about two feet apart under the footing and parallel with the roadway. These logs should extend entirely under the culvert, and should be four feet longer than the distance out-to-out of the footings. The advantages of such a type of footing are that the logs distribute the weight



Handrail of Concrete Arch.

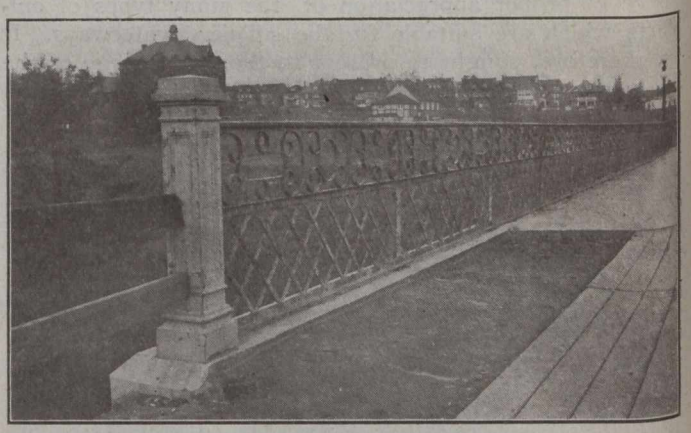
of the culvert and so prevent uneven settlement and tipping of the end and sidewalls.

Footings.—Footings of piers, abutments and headwalls should be carried down below the surface of the ground or the bed of the river to such a depth as to be safe from the heaving effect of frost and scour of the water. In the southern portion of Ontario the effects of frost may extend to depths of 2½ feet, while in the north it may vary from 3½ to 4 feet.

Piers.—Where a bridge is required of over 100 feet span it may be economical to consider using two or more short spans of about 50 feet, and support their ends by placing a pier in the river.

Whether this type of construction is economical or not depends upon the cost of the various spans, and also upon the size and cost of the pier or piers required. Where a river can be crossed by using a single span it is very often undesirable to use piers, as they furnish an obstruction to the waterway, and are liable to be damaged or destroyed by ice jams, logs, driftwood or floods. The kind of foundation available for the pier may also be a controlling factor in the design of the bridge, and should the river be very deep or have a soft, shifting bottom the use of piers may not be economical.

The size of piers is usually governed by the width of the top of the pier required to support the bearings of the bridge. This width may be from 3 to 5 or 6 or more feet. A coping having a width of about 3 inches and a height of 1 foot or more, depending on the height



Steel Lattice Handrail.

of the pier, is placed around the top of the pier, and the shaft of the pier then given a batter of from 1 in 12 to 1 in 24 from the under side of the coping to the top of the footing. The width of footing depends to some extent upon the nature of the foundation, but if it is extended for from 9 inches to 1 foot all around the pier, a satisfactory size will usually be secured.

On the upstream side of the pier a wedge-shaped cutwater or starling is usually provided to deflect the water and debris. As additional protection a steel plate or steel angle 8 inches x 8 inches x ½-inch in section may be built into the nose of the starling, and should extend from a point several feet above high water down into the footing. This steel angle should be secured to the pier by ¾-inch rag bolts, 12 inches long, having countersunk heads and spaced about two feet apart on centres.

The footings of piers should be carefully constructed, and if there is any possibility of the river scouring the foundation, a quantity of stone should be placed around the outside of the footing as a protection. Where possible the footing of a pier should not be placed upon a foundation which is liable to be softened, scoured or undermined by water action or on a hard strata, when overlying softer material.

Footings of piers should be embedded in firm ground to a depth of not less than four feet, in order to make