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IMPORTANT PRINCIPLES OF BRIDGE DESIGN

SYNOPSIS OF PAPER BY CHARLES EVAN FOWLER, M.CAN.SOC.C.E., M.AM.SOC.C.E., BEFORE PACIFIC NORTHWEST SOCIETY OF ENGINEERS.

THE designing of a bridge structure is not merely a matter of figuring the stresses, fixing the sizes of materials, and making a set of drawings. This may all be completed and a design result, but not the design suitable to the location, not such as it should be architecturally, nor for the traffic the structure will carry.

The true design to adopt must come very largely as an inspiration to the designer, who must have the necessary talent or imagination to conceive a bridge that will be the most appropriate and harmonious for a given location and for the existing or future surroundings.

The tower bridge in London, considered by many writers to be a monstrosity, was conceived by the engineer, Sir John Wolf-Barry, to harmonize with the surroundings, and particularly with the old Tower of London in the immediate vicinity. When considered in this light, it is an appropriate and harmonious design; the medieval towers are monumental and the steel work graceful.

The great suspension bridges of New York City are of the same class and are mostly in harmony with the towering buildings in the adjacent territory. The details, however, are not always carried out in the proper spirit, the towers of the Roebling bridge having never been completed and are thus lacking as truly monumental or architectural features; the towers of the nearby Manhattan bridge are too light to harmonize with those of the Roebling bridge or the nearby buildings, although considered alone it is a complete and pleasing design; the Williamsburg bridge is entirely lacking in architectural features, is out of harmony with the present or probable future surroundings, and is only notable in design by reason of its magnitude and the graceful sweep of its cables.

The great arch at Hell Gate, over East River in New York City, is with its 1,000-ft. span and carefully designed abutment towers a truly monumental structure, and the abutment towers are well designed and appropriate; the great arch demanding this mass for backing to properly satisfy the impression of a great thrust properly cared for or resisted.

The Washington bridge across the Harlem, one of the great bridges of the world, is wonderful in its architectural detail, but lacking in the great essentials for a work of architecture. The main structure consists of two spans instead of three, thus giving a pier in the middle; and the approaches are not balanced, thus causing the structure to lack in symmetry. Some of the other designs for this structure, while more simple in detail, would have made a much better structure and a more pleasing one, as they possessed the fundamental features that are necessary to any real work of architecture, simplicity, symmetry, harmony, and proportion.

This is well illustrated by the Eads bridge at St. Louis, with its three great arch spans and appropriate approaches, and although the details of the structure are very simple, it is one of the most pleasing and dignified of the world's bridges.

The conception of a design depends upon no rules, but upon the inherent ability of the designer, limited as we shall hereafter see by certain theoretical and practical requirements. There may be conceived a number of designs for a given location of different types, any one of which would be appropriate and beautiful, but the final decision as to which one of these to adopt must be made on the basis of relative cost, the most economical being usually selected. On the other hand, the most economical should not always be selected, but the best design architecturally be adopted, especially where the difference in cost is not very large.

The cost, for example, of a four-span structure for a given crossing might be found to be somewhat less than for a three-span bridge, and yet it would be wise from an architectural standpoint to adopt the three-span design, as the risk of one more foundation in the river would be avoided, with a probable saving in cost, should difficulties be encountered, that would make the three-span structure the cheaper in the end. In other words, the four-span design would have to be very much cheaper than three spans to call for its adoption. The reason for adopting a three-span design in place of a two-span bridge, might, on the other hand, be based entirely on the architectural features, as the cost and risk of the three-span structure might be much the greatest.

There are, then, two considerations that govern in making a decision as to what design to adopt for any location, the architectural features and the economy of construction, which latter may well be discussed in full before considering the architecture of bridges, and entirely aside from the esthetics of the problem.

The reactions or loads on piers for various lengths of spans must first be determined in order that foundations, abutments, and piers may be designed and the costs determined as factors in the cost of complete structures with different numbers of spans. The load on the pier and the weight of the pier having been determined, the size of the base of the pier may be arrived at by using the formula for the allowable pressure on the foundation bed, as given in the writer's treatise on "Sub-Aqueous Foundations," the character of the foundation bed having been determined previously by careful core borings. Several trials may be necessary before the proper size of a pier is de-