RECENT DEVELOPMENTS IN BRIDGE CONSTRUCTION.*

Frank P. McKibben.

Never before in the history of bridge engineering has the influence of public opinion been so noticeable as at the present time, and the interest shown by the public in this important branch of construction is very gratifying, especially to those engineers who have labored unceasingly to have bridges regarded from the artistic as well as from the utilitarian standpoint.

Public opinion is now demanding not only that bridges shall be made better but that they shall be more suited to and expressive of their purposes and environments. Although great advances have been made in the status of bridge engineering there is still room for improvement, for it is often impossible to make communities realize that a bridge is something more than merely a means of crossing an opening. They are not willing to make the additional appropriations necessary to secure artistic bridges, even though the structures may occupy such conspicuous positions as to require more impressive and finer treatment than some public buildings upon which vast sums of money are expended to secure pleasing architectural effect.

How common it is to see post office buildings, for example, beautifully designed and well constructed but placed in such surroundings as to lose the intended effect, while nearby may be a bridge in a location of magnificent possibilities but upon which no attempt has been made to display grace or beauty. Let the public fully realize that when a bridge is built without making it architecturally beautiful a splendid opportunity for civic improvement is lost. In the past the one great difficulty in securing pleasing structures has been that appropriations for bridges have generally been so small as to exclude all but the more utilitarian requirements, but, fortunately, more recent awakenings of civic pride are resulting in great improvements.

A beautiful arch bridge is a wonderful structure. There is something inspiring about it. And engineers must do all in their power to have the public realize this and to appreciate the beauties that can be created by proper and simple combinations of common materials of construction. Symmetry, grace, simplicity and truthfulness are essential elements in a bridge possessing architectural merit. Truth is a basic element, and when one material is disguised to represent another, or when a part is made to appear as if performing a certain function when in reality it is performing quite a different one, the result is a dismal failure.

The most remarkable development in bridge construction during the past quarter of a century has been the progress made in the use of concrete, either alone or reinforced with steel. When it is considered that only twenty-two years ago the first reinforced concrete arch bridge was built in Golden Gate Park at San Francisco, and that from this small span of only thirty-five feet to the recently constructed arch span of three hundred and twenty-five feet in New Zealand is a tremendous step, it is evident that progress has been truly wonderful. Concrete, like stone, is best suited to resist compressive stresses, and it can be readily molded into any desired form or size. It is, therefore, not surprising that when concrete came into use as a bridge material it should have been used in the arch form. It was a comparatively easy change from the stone arch that had been the standard arch form for many centuries to the concrete monolithic or voussoir arch of similar outline. But it was soon realized that concrete in combination with steel has a distinct individuality of its own, and hence important changes were made in the form of construction, resulting in the use of lighter structures of more pleasing design and appearance. The constant tendency has been towards the elimination of redundant material. The use of arch ribs, with the variation in size and shape thereof to conform to different classes of loads, or the use of solid arch rings upon which rest columns or cross walls to support the roadway above, approaches the design so commonly adopted for arches with steel ribs, and, in this respect, represents a decided departure from, and improvement upon, the solid arch ring with its superimposed earth fill, which was until recently the standard form of masonry arch construction.

The most recent type in reinforced concrete highway bridge construction consists of a flat deck on which the roadway is placed, the deck in turn being supported by columns or cross walls resting on a solid arch ring or upon ribs. These ribs are usually rectangular in cross section, although those of circular form would give a more pleasing appearance but would be more costly and more difficult to build. Unless the ribs are very wide they should be braced to prevent lateral displacement under stress. Much can be said in favor of this open spandrel construction except for very short spans or for spans of small rise, where the old method of placing the roadway on earth filling retained between longitudinal side walls is better. In the absence of such limitations, however, the open spandrel construction results in a great saving of weight of superstructure, with consequent diminution in size of foundations, and often also in a more pleasing design. For railroad bridges the column and rib type has not been adopted, but open spandrels with cross walls of solid arch rings are of frequent occurrence.

Arch analysis, that is, the determination of forces and stresses acting upon and within the arch is an interesting and beautiful application of mathematics and mechanics, and it is doubtful if in the whole category of engineering design a more enticing field for study can be found. The insertion of three hinges in the arch makes the solution more nearly determinate, and in case of slight settlement of foundations the stresses within the arch ring remain unchanged. In addition to this advantage, hinges relieve the ring from temperature stresses, since as the temperature of the arch changes the crown rises or falls with almost perfect freedom. For arches of small rise the advantages of hinges are so notable that their use will undoubttdly become more common, especially if some form be devised which can be economically constructed. For analysis of hingeless arches the elastic form theory should be employed because of temperature stresses which are usually large and which can be computed only by this method.

Little progress can be reported in short span steel bridges; in fact, concrete beams or arches are so admirably adapted to shorten span construction that steel hardly holds its own in this field. But for long spans, steel easily leads. Great progress is now being made in the manufacture of alloy steels and the time is not far distant when record breaking spans of steel will be built.

As a result of the increased strength of nickel steel, the new Municipal bridge spanning the Mississippi river at St. Louis has a span of six hundred and sixty-eight feet, which far surpasses any single truss length previously attempted. The manufacture of vanadium steel, nickel steel and other alloy steels for structural purposes is only in its infancy and seems to be a most promising field of investigation and progress for the immediate future.

No notable advances have been made recently in the type employed for long steel spans but many wonderful structures similar to those tried and not found wanting are

* Paper presented before the Congress of Technology.