# MUNICIPAL DEPARTMENT

## THE USE OF CONCRETE FOR BRIDGE FOUNDATIONS.*

By Joseph De Gurse Windsor.

The great value of concrete as a substratum for stone masonry in foundations upon damp and yielding soils, and where foundations are built in water, has been universally recognized; but many engineers are now using concrete for the entire foundation of bridges, such as piers, bridge seats, copings, etc. When properly made it possesses the qualities of strength and hardness in an almost equal degree with the best stone masonry, and is superior to second-class masonry in these respects, while it has been known to stand the disintegrating effects of the atmosphere and the abrasion of running water much better than some of the harder specimens of stone.

The prejudice against the extensive use of concrete for foundations that so generally prevails has doubtless been due to failures caused by improper mixing and handling, or to lack of care in the selection and proportioning of the ingredients. In bridge foundations the concrete is composed of cement, either Native or Portland, and the aggregate, which is usually sand and broken stone or gravel.

Trautwine states that in a heap of stone piled loosely or in dry sharp sand the voids occupy from thirty to fifty per cent. of its mass. To get the best results from concrete the voids in the aggregate should be slightly more than filled. A proportion very generally recommended by text books is one volume of cement, three of sand and five of broken stone or gravel. But in most cases, and especially where the concrete is exposed, and is above the surface of the ground, I would recommend an increased quantity of cement.

Owing to the limited number of quarries in western Ontario, where suitable stone for bridge masonry can be procured, the owners practically control prices for such work, and in accordance with their likes and dislikes of the engineer employed, are tempted to fix the prices arbitrarily for stone masonry. I therefore believe that the engineers of Ontario owe it as a duty to their clients to study carefully the merits of properly made concrete, and to apply it in place of stone masonry wherever it is possible. If this practice was followed it would only be a short time before the owners of quarries would recognize the fact that strong competition lay within reach of every engineer. At present the price is at least thirty per cent. lower than the masonry. And if once convinced that it is as good for all practical purposes it should require no further argument to induce engineers to use it.

During the summer of 1895 I was requested to prepare plans and specifications for three steel viaduct bridges on the London and Port Stanley Railway.

No. 1, over Kettle Creek, consisted of fifteen plate-girder spans, each thirty-six feet in length, excepting the two end spans, which were twenty-eight feet in length, and one truss span of eighty-five feet over the creek. The girders rested on columns braced together transversally to form bents, each pair of which was braced together to form towers, the bents varying in height from sixteen to sixty-two feet.

No. 2 was over Mill Creek, south of St. Thomas, similar to No. 1, but had no truss span.

No. 3 was over Zavitt's Pond, near Port Stanley, and has a total length of 228 feet.

The sub-structure for each of these bridges consisted of a masonry abutment at either end, and a pier of pedestal under each column. The abutments were composed of stone masonry to the depth of ten feet beneath the bridge seat, resting on a bed of concrete of sufficient depth to reach a hard clay foundation. Each of the pedestals was composed of concrete surmounted by a stone cap four feet by four feet by eighteen inches in depth, and pierced with two anchor bolts one and one-eighth inches in diameter, and four to five feet long.

I should have preferred to have dispensed with the stone cap, but had to give way somewhat to prevailing prejudice. The concrete pedestals varied in depth from five to nine and one-half feet, and were in the shape of a frustrum of a pyramid with a batter of one in six, the surface under the stone cap being three feet nine inches by three feet nine inches in all cases, except those on either side of Kettle Creek, which were larger, likewise the stone cap surmounting them.

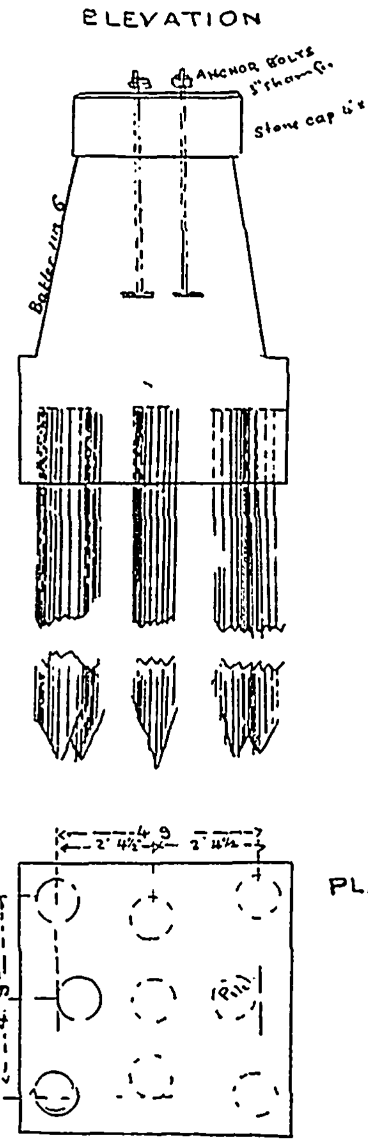
The pedestals were made as follows: The ground was excavated to the required depth to reach a hard clay or gravel foundation, when a strong box having the required batter and proper dimensions was lowered into the excavation, securely braced and properly centered. The concrete, after being mixed, was shovelled into the box and rammed. As soon as sufficiently set, the box was removed, after which the concrete was kept wet for about a week, and until no further damage was anticipated from the outer layer drying too quickly, and robbing the mortar of moisture which is so essential to crystallization, after which a mortar bed composed of one part of cement to two parts of sharp sand was placed, of sufficient depth to receive the stone cap and bring it to the proper elevation.

The concrete used in the pedestals and beneath the stone abutments was composed of one part Portland cement, two parts of sand and three parts of broken stone. The cement specified for the work was Star Brand Napanee Portland, but on account of the great demand for this brand, the contractors, except in the case of the latter bridge, were unable to secure this cement, and imported brands were used.

The specificatons required: That there should not be more than 5% residue on a sieve of 10,000, and that the tensile strength at the end of 7 days, 1 day being in air, should be 350 lbs. per sq. inch; that the sand used should be clean, sharp, and on the coarse side free from loam, and of a silicious nature; that the stone should be good hard limestone, broken so as to pass through a two-inch ring, and just before being used shall be sprinkled with sufficient water to remove all dust and thoroughly wet the entire surface.

The mode of preparing the concrete was as follows: Two barrow-fulls of sand were spread evenly over a platform twelve feet by 12 feet. On this one barrel of cement was evenly spread, when the two were turned over at least three or four times while dry; enough water was then added to form a stiff paste. After being levelled the three barrels of broken stone were evenly spread over it, and repeatedly turned over until the ingredients were thoroughly incorporated. It was then put in place as quickly as possible and evenly and sufficiently rammed.

In bridge No. 3, six of the pedestals were found over quick-sand foundation, and with these I proceeded as follows: I procured nine piles of sufficient length and spaced as per annexed sketch for each pedestal, and then driven to a refusal with a 2,000 pound hammer, and sawed off two feet between the surface of the ground. Instead of following the more general practice of capping and flooring, I had the soil excavated from two to three feet below the top of piles, and had the con-




crete rammed between, around and on top of the piles until sufficient height had been obtained to receive the cap stone. By this method the bearing power of the soil between the piles was utilized, as well as the bearing power of the piles themselves, and the whole formed a monlothic mass which cannot fail in part.

With reference to the durability and resistance of concrete to abrasion, I may refer you to a paper by C. D. Purdon, M. Am. Soc. C. E., in Engineering News, Vol. 19, page 443, where the writer, after referring to the mode in which the concrete piers were built, adds:

"On May 7th I had an opportunity of inspecting them after a most extraordinary flood in the river, caused by a water spout, in which flood the river rose one and four-tenth feet above the highest water known, the current being estimated at from eight to nine miles per hour, with large quantities of drift running. Among the drift were cotton wood trees, two feet to three feet in diameter, many of which, I am informed, broke on the piers from the force of the current. No damage whatever was done to the piers and no greater marks left by the drift than could be made by a stick held in the hand and dragged across the surface.

It was the opinion of the bridge inspectors of the St. Louis and San Francisco Railroad who watched the bridge during the flood, and who were men of considerable experience, that had the piers been built of masonry of such stone as could have been obtained, they would not have been able to withstand the drift and the bridge would have been destroyed."

*Paper read at the last annual meeting of the Association of Ontario Land Surveyors.