# DISCUSSION.

Mr. Shirra, in opening the discussion, said he had been very much interested in the paper, and there were one or two points he would like information upon. One was in reference to the weight of the concrete piers. If the cylindrical pier was set water-tight on the bed rock, there would be no water pressure on the bottom, only dead-weight pressure of the concrete on the rock. If the water got in under the concrete, there would be an upward pressure equal to the displacement of the pier, and that would materially relieve the pressure on the foundation. In the conical piers, there would be not only the pressure of the concrete on the rock, but the water pressure over its spreading base also, like atmospheric pressure on a "sucker." It seemed to him that there was not much to be saved by making the pier that shape, as the weight of concrete outweighed but slightly its equivalent volume of water.

It seemed to him also that instead of a temporary shell of ice, as the author proposed, a permanent one might be formed by injecting cement grout under hydraulic pressure.

As to the author's opinion that the design of certain bridges destroyed the beauty of the landscape, he (the speaker) referred to the Connel Ferry Bridge the largest span railway bridge, next to the Forth Bridge in Great Britain, on the West Highland Railway in Scotland; it stood out in all the beauty of engineering simplicity, and did not seem to be a blot on the landscape. Sir William Arrol, who built it and

the Forth Bridge, was also building two large bridges on the Nile, and they were not only strong and cheap, but aesthetic enough to please the architects. He thought we should have no need to go to Germany to get good work and architectural effect, when they could get it in Glasgow.

There was another recently built bridge he would call attention to, a swing bridge over the river Weaver, in the salt district of Cheshire, as it contained the germ of a great idea. The ground there is sinking all the time, though the water level keeps constant, and good foundations are impossible. There was a ring of screw piles carrying girders to take the guide rollers of the swing, but the weight of the bridge was almost wholly taken by submerged buoyant caissons, which form a perfect hydraulic pivot. It was a simple idea, and could be carried out in the Sydney Bridge. Large caissons could be made, in sections, and placed in the water at the base of the piers, their buoyancy would relieve the foundations of much of their load.

Such a course, though, would involve another re-adjustment of the specifications, and he thought the Sydney Bridge guessing competition was already becoming a by-word in the engineering world. But the resources of civilisation were not exhausted, and he had no doubt the bridge would yet be built, one way or another.

Mr. F. E. Stowe said he would like to ask the author whether in the construction it would not be better to use brick or stone in preference to concrete. In an open-air structure he thought brick or stone would be better than concrete.

Mr. Kidd said it seemed to him that the conditions laid down in the specifications of the Advisory Board regarding the weight per square foot on foundation

of concrete piers should be altered, and allowance made for the reduction of weight due to immersion in the water, and also for the friction of the clay strata through which they pass.

With reference to the use of refrigeration for consolidating the clay and giving it sufficient compressive resistance to withstand the water pressure to permit of sinking down to the rock without the use of air-locks, the method seemed practicable, but it would be advisable to make careful tests to determine the extent to which the freezing should be carried, as there was very little data extant on this method of sinking such deep foundations.

With reference to the remarks of a previous speaker on forcing liquid cement into the clay, it would take a very great pressure to do so, and it was very doubtful if the liquid cement would permeate the clay and make a homogeneous mixture; if it did not do so, there would be considerable risk of failure. Had the formation through which the foundation had to be sunk been sand, there would be little difficulty in forcing liquid cement into it to cause induration so that the sinking could be done with perfect safety. The work recently carried out by Sir Benjamin Baker in Egypt with such satisfactory results, was ample proof of the practicability of carrying out such works when sand was the material to be dealt with.

He would like to ask the author if there was any information about the character of the clay through which the foundations had to be sunk. It seemed to him that if the clay was very tough and sound, the excavation might be made with a shield similar in principal to those used in the piercing of tunnels. As an example of the supporting power of clay, he might mention that he had an opportunity of walking through

a quarter of a mile of the in-take tunnel of the City of Chicago Water Supply, which was cut through very stiff clay, no supports of any kind being used. The tunnel was lined with brickwork, in cement, when finished.

He hoped that the author would be spared to see the great Sydney bridge built, and he was sanguine that the method proposed would be successfully carried out.

In conclusion, he had great pleasure in proposing a hearty vote of thanks to the author for his very able and interesting paper. The engineering profession was much indebted to the author for the great interest he had taken in this bridge question, and for the time and labour he had given to the matter. A perusal of the paper showed that the author stood out conspicuously as an engineer, who was always on the alert to advance the engineering and architectural interests of Sydney, and to investigate any matter of interest to our profession, for which he deserved the very best thanks of the members.

Mr. Russell Sinclair, seconding the motion, said that they were all indebted to the author, and he was sure that the paper would be a very valuable contribution to the proceedings of the Association. At the same time, the author had given them an opportunity of expressing their feelings on the matter of tendering. He thought the Government had treated the tenderers not quite in the way they ought to, as it was simply obtaining information for nothing. He, for one, had been treated in the same way while tendering out here. After going to much expense in getting up a tender, he found out it was only a matter of getting information. Making up a tender was not a simple matter; it was a subject requiring a great amount of thought and work; and in the case of bridge work, it

required an enormous amount. He thought the Government should consider the enormous amount of work and skill required in preparing these plans, and they certainly had no right to withhold them without remuneration. As to freezing the foundations, he thought that was quite a feasible scheme. To carry the circulating brine pipes from top to bottom in one line of 180 feet was, he thought, too long for the brine to travel, because of change of temperature. Then there was the great pressure of 110lbs to the square inch. To freeze the water round the foundations would necessitate a great amount of refrigeration, and he was afraid it would cost a large sum of money. It was, however, an admirable scheme, and one that would require much thinking out.

Mr. Selfe, in reply, said with regard to Mr. Shirra's objections to the foundations, he would say that the conditions of the specifications were clear and emphatic. There were so many lbs. to the square foot allowed on the rock bottom, and if a column of water was of such a height above as to give that pressure, then that would be the maximum loading. Whether the water got in below some of the concrete or not did not make the slightest difference. There were so many lbs. of concrete to the cubic foot, and there was a maximum number of lbs. loading to the square foot, and that divided by 135 gave the maximum height. He did not go to Germany because he liked Germans better than his own countrymen. With regard to Mr. Shirra's remarks about water pressure, he (the speaker) said that the pressure with the shallow foundation at 90 feet depth was 6.3 tons to the square foot, while the natural pressure at that depth was only 3.6 tons; so that 6.3 was considered too great. As he found the piers of other competitors were only resting on the clay, he put in a design for a similar foundation, simply for compari-

son, although he did not approve of it, and to show that, although it depended entirely on the clay it cost as much as the conoidal pier carried down to the solid rock.

The weight on the sole plate was 7,000 tons, and the conoidal pier was 32 feet in diameter at the top, the area being increased as the loading due to its own weight increased. It was enlarged at the bottom from 40 feet to 44 feet diameter, because the conditions demanded less load on the rock than on the concrete. They might hold their opinion as to whether the rock would carry more loading, that had nothing to do with the question of competition; his design was sent in to fulfil the conditions asked, and the conditions provided a maximum loading for concrete, brick, stone, and granite, as well as on the rock, and under these conditions, concrete, made to the specifications worked out the cheapest.

In answer to Mr. Stowe he would say that it was simply a question of relative cost.

Regarding Mr. Sinclair's remarks, he thought that gentleman had not got hold of the right idea. There was no frozen water; an island was to be made, or an enclosure constructed, and then filled up. With regard to the question of a long circulating pipe, he did not go into that, but he pointed out that with salt and frozen mud, it might be six months before the bottom was reached. It was just a question of cold production or heat abstraction. As to the cost of the refrigeration machinery, it must be remembered that to put down a cylinder under the pneumatic system, the plant would cost from £50,000 to £80,000, and it would probably have to go as scrap after the building of the bridge; but when the refrigerating apparatus was done with,

he could hand it over to Mr. Sinclair to freeze bullocks with.

Mr. Selfe, concluding, said he fully appreciated the kindness of the members. He was not so often here as in the old days, as he lived a long way out of town, but when he came he liked to do a little. He confessed, however, that he did not know that the bridge would ever be built to the approved plans, although they were the result of three years' work of the engineers of three continents.