been pointed out by the reader of the paper, even the water was worthy of consideration. He thought that until they proceeded on the lines he had suggested, they would not overcome the difficulty now existing in regard to water-tightness. In connection with aggregates he might state that it had been his privilege for a good many years to conduct tests on slabs for the Institute of Architects, and also on blocks at the Technical College, and he had been impressed with the relative efficiency of the clinker concrete. On one occasion a number of slabs were made by a company which was introducing a certain type of reinforcement and some of these were of blue metal aggregate, and some of ash aggregate. The strength of the ash concrete approximated very closely to that of the blue metal. He had found that clinker would provide an advantage on account of its elasticity. It was very much more elastic than the blue metal, so that, if it were not for the question of making the concrete water-tight, it seemed to him there was a good deal in favour of the ash or clinker concrete. He should like to emphasise the extra importance of having the cement very finely ground. Mr. Hart might have emphasised this point a little more. To-day it was quite easy to obtain the locally manufactured cement with a residue of only 10 per cent. on a 32,000 hole per square inch sieve. Some of the older practitioners were rather keen about having it exposed to the air for a time. The practice of exposing the finely-ground cement to the air caused a partial setting, and destroyed the advantages of fine grinding. In these times, however, anything expensive was usually neglected, and so, he supposed, they were not likely to pay very much attention to the aerated cements.

Another salient feature, worthy of mention, as occurring in connection with reinforced construction, was the necessity of getting the concrete to thoroughly surround

the reinforcement. They had, of course, to bear in mind that, unless there was a grip by the concrete of the steel they obtained really no more effect than would be obtainable from the concrete and steel separately; and, therefore, they might as well do without the two parts where there was a failure on the part of the concrete to grip the steel reinforcement. In this connection they arrived at one of the greatest arguments in regard to a wet mixture. He thought there must be many gentlemen present there that night who, along with other members of this association, paid a visit of inspection some years ago to the Lillybridge Sewer Duct, which was then in the course of erection. It was pointed out, on that occasion, that they could not have the mixture too dry. He remembered that it would quite freely blow from the hand, and if it were gripped tightly it was impossible to squeeze any moisture from it. At the same time, the whole of his experience with dry cement had been extremely unfortunate, and it was not until comparatively recent times that he realised the importance of the wet mixture.

In conclusion, he would like to mention that they had to thank Mr. Hart for a great deal in connection with his ability as a sound exponent of what could be done with reinforced concrete. His knowledge of the subject, and readiness to put up really economical structures with this material was an object lesson, and he felt sure they must all feel indebted to him for his part in the pioneering work he had performed in the face of much opposition.

Mr. H. Thompson remarked that he had been deeply interested that evening, and regretted very much that the hour was so late, thereby preventing him from hearing the author's views on several things. He would, however, like to ask him whether he had had any ex-

perience with old wire rope in connection with the work of reinforcement.

A little while ago he had read a short description of a reinforced bridge which had been erected in Victoria, and mention was made therein of the fact that old tramway cables had been employed as reinforcement. He had referred this matter to one or two experts on previous occasions, but they were unanimous in their rejection of the idea, and they wanted to know what effect the oil which remained in all old wire ropes would have upon the cement.

Mr. McEwin said that as the previous speakers had covered so much ground he had only one question to put to the author. In one of the lantern slides displayed upon the screen a circular tank at Randwick was shown. Why was the reinforcement nearer the inside from the centre of the wall than the outside? There was, he presumed, some particular reason why the reinforcement had been so placed, but at first sight it appeared that it should be placed nearer the external than the internal wall of the tank.

Mr. Budden wished to thank the members of the Association for the privilege he had enjoyed of hearing the reading of the very good paper by Mr. Hart.

It might be of interest to them, in view of the remarks which had been passed about the Sydney Building Act, to learn that there was in existence, at the present time, something even more atrocious in Adelaide. Now, in connection with this matter he would like to state that it was his firm conviction that if anybody resolved to erect a reinforced concrete building in Sydney they would have the sympathy and approval of the Town Hall authorities immediately, assuming, of course, that they were approached in a proper manner. He should be very glad to meet Mr. Hart and others interested at any time

with a view of going into the matter. They all appreciated Mr. Hart's thorough treatment of his subject, and he was sure they all felt very grateful for the privilege they had enjoyed that evening.

The speaker said that he thought Mr. Nangle had put his finger on the weak spot, so far as Sydney was concerned, in regard to the matter of centering for reinforced concrete. In connection with clinker concrete he would very much like Mr. Hart to give them his ideas upon the question of the corrosion that was liable to take place of the reinforcement.

Mr. S. H. Buchanan expressed his satisfaction with the helpful remarks made by the author in regard to the many uses to which reinforced concrete was now being applied, and he thought they would all agree with him that it certainly covered a very wide scope so far as building construction was concerned.

Personally, he was of the opinion that the time was not far distant when the architects would have to combine with the engineers and concrete experts in the construction and erection of many buildings.

He would like to ask a question in reference to the crushing strength of the blue metal concrete. Would not the concrete be stronger if the ¾-inch metal were mixed with the 1½-inch? The author made reference to the fact that the gauges should be graded.

In conclusion, he would take this opportunity of congratulating the Engineering Association upon the excellent attendance at their meetings. He thought they set a splendid example to the many other associations now in existence in connection with the various professions. He had noticed that there were some among them to-night who, like himself, were not engineers. The Institute of Architects had many fine lectures such as

they had heard that evening but he did not think invitations had been extended to many outside their own Institute. But, especially with such a subject as had been dealt with that night, it was obvious that many of the Engineering Association would be pleased to attend. Their interests to a great extent were closely allied.

Mr. Power desired to thank the Association for the privilege conferred upon him by inviting him there that evening, and also Mr. Hart for his excellent paper.

There was one point he would like to refer to, as had already been done by a previous speaker. Mr. Hart appeared to him to prefer blue metal concrete to ash or clinker, or any other kind. He (the speaker) had made some experiments lately, and had since come to the conclusion that good ash concrete would be preferable to the blue metal every time; although, of course, in regard to the question of water-proofing he quite agreed with the author.

He obtained his results with the ash concrete with aggregates passed through a ¾-inch sieve, and they were somewhat remarkable. If Mr. Hart would go into the matter he thought he would find his opinion would very soon be in accordance with that he, the speaker, had expressed.

In regard to tanks, he had put one up four or five years ago, and it had not given him the slightest reason to feel uneasy as to its water-proofness. As he had said, he did not think there was anything to be feared in regard to that question, but he would like the author to take this opportunity of further warning members against certain so-called water-proof mixtures. Recently, he made a test he had heard of on several occasions. He mixed soft soap with the water. When trowelling the cement on the wall it dried very swiftly and began to crack, and they could judge of his astonishment when,

on testing it about a fortnight after, he found the crust so hard as to resemble flint on the surfaces, but easily to be rubbed away underneath.

He would like to ask the author if he had had anything in the nature of a similar experience.

Mr. D. F. J. Harricks said he would like to add a few words of appreciation of the author's paper, for he felt they had to thank him for putting before them some very clear and concise notes on most important matters relating to ferro-concrete construction. Mr. Hart, in his opinion, wisely set out with the intention of avoiding a discussion of the theoretical side of his subject, and confined himself almost entirely to the practical side.

If the success of ferro-concrete had to be judged to-day it would, of course, be necessary to take into consideration the failures, few though they were, and he felt sure that in practically every instance it would be found that such failures had been due almost entirely to the lack of knowledge in laying down or in the carrying out of practical rules of construction, rather than from any lack of skill in calculation or design; for this reason, such papers as the author's were most helpful.

Mr. Hart had offered an apology for not having presented the paper he intended reading that night upon the reconstruction of the Bowen Creek Bridge in Brisbane, but if the temporary delay, although probably somewhat unfortunate for Mr. Hart, meant that they would ultimately get a paper on the subject from him, he felt sure that members would agree that the circumstances were rather favourable for the Association. They had probably given them two papers instead of one.

As several references had been made that night to ferro-concrete tanks, it occurred to him that it might be of interest to quote some experiences that the C.S.R. Company had had with fairly large molasses tanks. In a paper

read before this Association some years ago, the author, Mr. W. H. German, described the earlier molasses tanks made, which were of composite construction, the bases being of reinforced concrete and the bodies and tops of steel. The steel belts were dropped into circumferential grooves in the concrete bases and the spaces surrounding the lower edges of the belts were then filled in with Val-de-Travers asphalt, which same material was afterwards also used for covering the whole of the bottoms of the tanks. This form of construction had been adopted for several reasons, but probably mainly because, as most engineers knew, the bottom of a tank was generally the most difficult and expensive to make and to support, and was also, unless raised from the ground, hard to get at for painting or otherwise maintaining. For these reasons the concrete base was desirable, as it formed the support and the bottom at the same time. Since that time some larger tanks had been built for similar purposes; they were 40ft. in diameter and from 23 to 27ft. deep, holding from 1100 to 1300 tons of molasses. One of these was erected at a Fiji mill for storing molasses before being transferred to steamers' tanks. The most suitable site for this tank was at the top of the ocean beach, practically on a ridge, for the land fell away to a swamp on the land side. Very careful tests were made to ascertain the bearing capacity of the ground, these extending over some months, but, even after liberal allowance had been made, the tank when first loaded began to sink, and it would probably be surprising for them to know that before coming to rest the tank had sunk bodily nearly 2ft. below its original level and with a very slight tilt to one side. Notwithstanding this remarkable occurrence, no leakage had taken place and the reinforced concrete bottom, which was practically a raft, did not show any signs of cracking; they certainly expected that if the tank sank

at all, from the indications of the ground tests, that it would sink evenly over the whole area. This it had practically done. When recently considering the question of having two more tanks of the same size it was decided to follow the same construction, but to increase the reinforcement of the raft and to make it larger in diameter. The question of piling was considered, but there seemed to be a doubt whether this would be the safer method as it seemed probable that when the coral formation was met with certain piles might meet with more obstruction than others, with the possible result that they would not be forced down evenly with the remainder of the piles and the concrete bottom would be cracked. Under these circumstances, and for other reasons, he thought they had been wise in adopting the form of construction described, and had not adopted the complete concrete tank. As a matter of interest he had roughly compared the cost of these tanks with the one at Randwick described by the author, and he found that the costs were practically the same; there did not seem to be a greater difference than about 2/- per 1000 gallons of water stored, but, of course, the composite tanks were very much deeper than the Randwick one, and consequently the cost of making the deeper tanks in concrete would be proportionately more.

The description of the treatment meted out to a large steel water tank by a Southern Californian engineer and which recently came under his notice occurred to him as an instance that must have pleased the hearts of the American enthusiasts in reinforced concrete. The tank in question was a large elevated one and although originally built with a liberal factor of safety, recent unexplained failures of tanks of similar construction in various parts of the country led to the tank above referred to being reinforced. As there seemed to be no

evidence of decay from corrosion it was difficult to imagine just what the failures could be due to, but he thought that most engineers would have tackled the problem by reinforcing the belt with hoops or bands, but the engineer who had to deal with the proposition must have been very interested in reinforced concrete construction, for he decided to enclose the tank in a complete reinforced concrete jacket, the walls being made of sufficient strength to withstand the hydraulic pressure with an ample factor of safety. With a simple, yet aesthetic, treatment of the concrete jacket, it was stated in the report that "the unsightly black steel tank had now been replaced with one commanding in appearance." There was no doubt, of course, that with such tanks as these, where appearance was a consideration, if such tanks had to be built, concrete would now be the most desirable construction.

THE AUTHOR'S REPLY.

The author, in reply, said that he was very much obliged to Mr. Vicars for the very kind remarks he had made when proposing a vote of thanks to him.

In regard to the formulæ which Mr. Vicars so kindly furnished, and which he imagined he must have deduced from his own practice, he must confess that he was not aware of it before, and it had deeply interested him. He had not known before that there was any formulæ by which they could approximate crushing strengths for concrete made with varying proportions of cement; although it was now perfectly obvious that such a formula could be simply deduced.

In regard to the question as to whether the metal was graded, he might mention that the metal usually obtained in Sydney was screened, by a screen passing all sizes