He had now endeavoured to put before them some points of interest in reinforced concrete construction. In the discussion which he hoped would follow, he trusted that many other points of interest would be raised, and which he could deal with in reply.

Discussion.

Mr. James Vicars, in proposing a vote of thanks to the author, said that the subject, as Mr. Hart had presented it to them that night, had appeared extremely simple, but on a very careful perusal of the paper he was forced to the conclusion that its apparently remarkable simplicity was largely attributable to the manner in which the author chose to convey his thoughts.

The matter dealt with was, he thought, at least so far as the majority of the members present were concerned, an exceedingly complex one, yet, as he had already remarked, it had been put before them that night as if there was little in it, and he desired, on his own account, to pay a tribute which he thought was due to the author for the able way in which he had treated it.

He would also like to take the opportunity of asking a few questions which had occurred to him whilst the paper was being read. Mr. Hart, in premising his remarks, stated that the majority of papers which one had the privilege of hearing read at such gatherings as these, were too theoretical, and that he therefore proposed to confine himself to the more practical aspect of the subject. Personally he was entirely in accord with him,

but, at the same time, he was sure they would all agree that Mr. Hart would not have stood there to-night and undertaken the task of expounding and illustrating the subject they were about to discuss, were he not well versed in the theory of it.

Dealing with the matter as it arose in the paper, he would like, with their permission, to add a few figures which had occurred to him in the course of his own studies:—

$$(500 - 200 \times \tfrac{1}{1}) = A = 300$$
$$(A - 200 \times \tfrac{1}{2}) = B = 200$$
$$(B - 200 \times \tfrac{1}{3}) = C = 133$$
$$(C - 200 \times \tfrac{1}{4}) = D = 83$$
$$(D - 200 \times \tfrac{1}{5}) = E = 43$$

The above figures were the result of some recent experiments upon concrete. He found that they very nearly expressed the relation between the different mixes of concrete. If they took the 500 or whatever it might be —in this case it was assumed to be 500—for the strength of neat cement, the next ratio taken was one to one, which gave 300. If 300 was taken from 500 it would give 200, which was a constant, and if 200 was then deducted and multiplied by the proportion of the sand in the mix, there would be obtained approximately, the strength of the mortar, and so on for the various ratios.

He had just suggested the formula for whatever interest it might contain, and perhaps someone else in the room might have proceeded on similar lines, and would be able to qualify or support it.

He was also desirous of ascertaining from the author of the paper what gauge of metal he customarily used in the mixes, and whether it was crushed-run, or passed through a ¾in. sieve, and caught on a ¼in. sieve?

And, further, what gauge of sand had he adopted in his own practice in the examples he had furnished, and was it just ordinary sand as delivered from Nepean or selected sand properly graded?

They all knew that there was more in the grading and in the size of the grains of sand than possibly in anything else in the art of concrete making. It had been amply proved that, by a proper selection of the sand, and the careful grading of the same, that as much as 20 per cent. was saved in the value of the cement in the mixture.

The author had clearly indicated his preference for a fine ground cement, and he would ask if there was any particular standard which it had been ascertained was more suitable than another for concrete making.

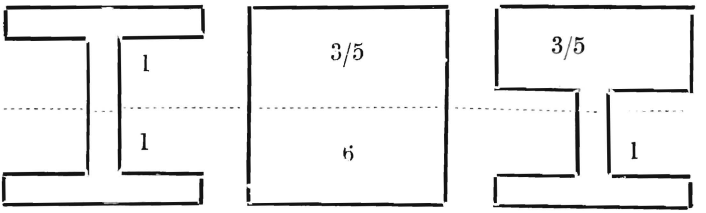
He knew that cement would leave a varying percentage of residue in sieves of different fineness, but very frequently in testing a cement at a distance from the works, it had been considered sufficient to have just one small standard sieve of a very fine mesh, and to ascertain what percentage was left on that; could a cement be approximately tested by passing it through a sieve of, say, 20,000 meshes or 10,000 meshes to the square inch, and what residue he would expect to find on these sieves?

Then again, some makers adopted gypsum for maturing their cement, and preventing it from developing heat cracks or expansion cracks, and it had always been his impression that such a practice was somewhat dangerous. He understood that it was adopted by more than one firm of manufacturers in Australia; still, he held the opinion that, even with a small percentage, say 0.6 to 1 per cent. of gypsum, the mixture of cement was likely to give variable results; that was to say, if a cement was new it might furnish a very workable concrete or mortar, but at the age of six or twelve months its results might vary considerably. In the case of the dry steam-blown

cement, all the fire was supposed to be taken out of it without injuring its setting qualities or its tensile strength. He could not profess to have had much experience with dry-steam blown cement, although he knew a great deal of it had been used throughout Australia. If the author of the paper could furnish them with his experience on this point it would be of great value.

In regard to clinker cement, he would like to know what objections Mr. Hart would have to its employment on stair-cases and for flooring purposes, apart altogether from the question of water-proof work.

He thought that the illustrations of actual costs would prove of some value to those present, and he suggested that the following diagram might perhaps be worth notice as to the relative costs of concrete work.



He regretted that he was unable to state who was the author of the above, as he had merely a rough note with him, abstracted from a magazine.

If they took the value of steel per cwt. as being practically the same as that of a cask of cement the costs of all steel beams, all concrete beams, and reinforced concrete beams would be as indicated in the diagram. The middle line running through was simply to distinguish the compression portion from the tension portion. If they considered the top as the compression, and the bottom as the tension it would convey his meaning. For all steel the cost of the top portion could be taken as one and the bottom portion also as one. Then for all concrete the top

portion would cost three-fifths as much as steel, whereas on the bottom tensile side the cost would be quite six times as much as the steel.

Again, where the tension portion of the concrete was reinforced with steel, the cost of the reinforced portion might be taken as one and the compression portion as three-fifths. The diagram showed that the cost of reinforced work was approximately the same as that of all steel. The diagram he had shown was given by an English authority, but in the lapse of time he had lost trace of the name. He considered it was a most forcible way of illustrating the relative costs of reinforced concrete compared with steel construction.

In his own practice he had had some hesitation in using reinforced concrete for certain purposes. He had built two tar tanks of bricks and cement. They were very hard bricks, and, in his opinion,, of a very much better quality than he had seen in and around Sydney. After lying for 48 hours in water a single brick only absorbed three ounces of water, which was about one-third of what ordinary Sydney bricks would take up at the present time.

One tank was 8 feet high, 20 feet in diameter, and the wall was of brick 9 inches thick, well built with two to one cement or mortar. It let the tar through, chiefly at the joints.

The other tank was also 8 feet high, but 30 feet in diameter, and the wall, in this case, was 14 inches thick. It also let the tar through, although the bricks were flushed up at every joint.

Subsequently he had to build a tank capable of holding one hundred thousand gallons of tar. The specifications required it to be 50 feet in diameter and 10 feet deep. He decided to take the risk of building it of reinforced concrete. The walls were made 5 inches thick. That

tank had held tar for the last seven years without letting a drop through. As they would readily understand, the latter example had proved a very interesting one to him, first, because it confirmed his judgment in pursuing the course he had indicated and, secondly, because as they were all aware, if there was anything which would thoroughly search a material, such as concrete, or stone work, it was crude tar.

Later on he was consulted in the building of five all reinforced concrete buildings in Adelaide, one of which was the first to be constructed in Australia. It was 96 feet high, and had 37 feet frontage, and the walls, which, if constructed in brick, would have been 3 feet 6 inches, were only 6 inches. Six inches had been found quite sufficient for the walls to keep out the moisture, and floors, of course, had been made of varying thicknesses, acording to requirements, from 4 to 7 inches.

Unfortunately, he was unable to furnish any particulars in regard to the approximate cost of the concrete per cubic yard for these buildings. He had telegraphed for the information, but it was impossible for him to receive it in time for the meeting.

In conclusion, he would like once more to give expression to his grateful appreciation of the very helpful remarks which had been made by Mr. Hart, and he had very much pleasure in proposing a very hearty vote of thanks to the lecturer for the very useful paper he had just presented.

Mr. W. H. Grieve in seconding the vote of thanks, remarked that he was afraid he was unable to discuss the subject of the paper with the ease and familiarity which had characterised the remarks of the proposer, but he was glad to know that there were several gentlemen present who were well qualified to exercise that privi-

lege, and so he would confine himself to one or two observations which might furnish some further discussion.

He would like, first of all, to ask Mr. Hart for his opinion in the matter of mixing concrete. There were, of course, two main methods now in existence in regard to this process, the one was known as " continuous mixing " and the other as " batch mixing."

A little while ago he had visited the United States of America, and while there he received an eye opener as to the methods of mixing concrete, and found that practically all concrete was "batch" mixed.

In reference to Mr. Hart's remarks in regard to a certain building, the construction of which was allowable only because it was outside the jurisdiction of the City Building Act, he would like to say that it seemed to him an extraordinary confession to have to make in an age like this, and he had no hesitation in saying that the present Sydney Building Act was one which would appear to have been framed in mediæval times, were it not that the city of Sydney was only a century and a quarter old. He hoped the Government would very soon provide them with a more satisfactory Act than at present existed.

As he had already said, a trip to America furnished one with endless examples of the wonderful possibilities of reinforced concrete, and which would be difficult to appreciate unless they had been actually viewed.

He had very much pleasure in seconding the proposal put before the meeting by the previous speaker.

Mr. James Nangle said that he desired first of all to thank the Association very much for having extended an invitation to him to attend their exceptionally interesting meeting. At the same time he felt bound to remark

that he came as a listener and had really no intention of adding anything to the paper read by Mr. Hart. Like some other authors, Mr. Hart had displayed a knowledge of the tactics adopted by many good teachers, for, he presumed, from the fact that several points had been omitted, it was a skilful attempt to awaken a lively discussion, and he had therefore a few questions to put to him.

Before doing so, however, he would like to say—speaking as an architect—that in Sydney they were very much behind the times as far as concrete construction was concerned, but he was sure they all agreed that this unhappy condition of affairs was attributable, as someone previously remarked, to the absurdness of their Building Act, which required them to put up external brick walls. Not only was this antiquated practice responsible for much unnecessary expenditure, but also there was the fact that a great deal of very valuable building space in the city was lost, owing to the thickness they were compelled to construct the walls.

He felt sure that the architects in Sydney would very readily build whole concrete structures if the Government of New South Wales could be induced to abolish the archaic restrictions now existing in the Building Act, and make its provisions more reasonable and liberal.

It had occurred to him, when he had been looking at whatever reinforced, or to be correct, partially reinforced, work was carried out in this city, that the centering appeared to be very expensive, and, he thought it would be of great interest to them all if Mr. Hart would tell them of anything which might be in existence in the way of special provisions in regard to centering.

He understood Mr. Hart to mention something about patent centres. It seemed to him that it would be very advantageous to those concerned if they had less expen-

sive centering than was observed in Sydney at the present time.

He was also quite satisfied that they in Sydney had yet to learn how to make the best concrete. Mr. Hart voiced the position very accurately, he thought, when he referred to the impression which had prevailed amongst the users of concrete for some considerable time past, namely, that any materials would do for concrete. They had become so accustomed to the careless employment of concrete in the footings of buildings that, to his mind, it was very doubtful if the care which was admittedly necessary to produce satisfactory results with reinforced concrete was exercised as a matter of practice, so far as Sydney was concerned.

Mr. Hart also mentioned a discussion which took place last year at the Institute of Architects in regard to the water-tightness of reinforced concrete. As they all knew, one of the most important considerations affecting the successful work of an architect was the ability of the material employed to keep the water out. He might be able to build a structure both beautiful and strong, but if the water penetrated inside it was practically ruined from the point of view of utility. He must say—having built a few flat roofs with concrete—that he had experienced a great deal of trouble in the matter, still he was satisfied, as an architect, that there should be no trouble at all. The examples now in existence justified the last assertion. They were able to see many fine specimens of engineering work in which it was possible to ascertain precisely the extent of the pressure on sides and bottoms of tanks, and this should suffice to convince them of the fact that reinforced concrete would be made perfectly water-tight. They had, however, still to learn how to make it more carefully. The aggregate should be clean and very thoroughly mixed and, as had already