that meeting, which they had proposed should be embodied in an Act of Parliament for the German Empire. This latter suggestion was afterwards supported by the officers of the Imperial Laboratory for the testing of the building materials, who, being perfectly disinterested parties, should be well able to form impartial and reliable opinions on the injurious practice of adulterating cements. The resolutions read as follows :—

I. Portland Cement is a product that is obtained by thoroughly mixing lime and clay together, as principal constituents, the mixture being afterwards burned to clinkers, and ground to the fineness of flour.

II. Any compositions produced in a different manner, and to which are added foreign constituents, either while or after being burned, are not to be regarded as Portland Cement ; an admixture of 2 per cent. or less of gypsum being excepted.

III. The sale of cement, containing an admixture of foreign substances, under the designation of Portland Cement, is therefore to be considered as a fraud on the consumer.

IV. Good Portland Cement cannot be improved by the admixture of foreign substances, such as blast furnace slag, clay, slate or lime-stone. But even if in an isolated case such an improvement might be demonstrated by the use of these admixtures, they should not be permitted, for the reason that the consumer is not able to control the quantity or quality of these admixtures, and is thereby unable to protect himself against being defrauded.

V. The addition of every such admixture is to be considered as a step in the preparation of mortar, the making of which should not be commenced by the manufacturer, but should be left to the discretion of the consumer.

VI. As the standard tests, when determined on, were not intended to apply to Portland cement mixed with foreign substances, and as furthermore the special character of Portland cement becomes changed by such admixtures, therefore these standard tests cannot be used in making comparison between adulterated and pure Portland cement.

Signed by the Council of the Soc. of Germ. Portl. Cem. Manufacturers.

He (Mr. Fischer) thought that the above would conclusively show that this question of adulterating Portland cements had been considered by the persons most interested in maintaining the good character which German cement had enjoyed until lately, and it was to be hoped that if these resolutions had not as yet been passed into law, they would soon become so. To protect the colony against these frauds a short Act of Parliament based on these resolutions might easily settle the question at issue.

Mr. J. B. Henson, after referring to the practical character of the paper read by Mr. Mountain, said that the use of powdered blast furnace slag for adulterating cement, was certainly objectionable, but the employment of the same material as an ingredient in the manufacture of Portland cement had been attended with very good results. The cracks in the test pat of cement exhibited by Mr. Mountain, to illustrate his remarks about the injurious effects of the presence of free (unslaked) lime in cement, were, he thought, ascribed to the wrong cause. The pat appeared to have been set upon paper, whereas the other pat which was not defective had been set upon a smooth hard surface. The cracks in the defective pat were radial, were few in number and appeared in the edges. Cracks due to the expansion of particles of unslaked lime were charaterised by being irregular in direction and numerous, and intersecting each other, destroyed the continuity of the mass. The cracks in the pat exhibited being radial were due to some other cause than the presence of unslaked lime, probably to the material upon which the pat was placed to set, or to shrinkage, possibly to both combined. Very great care and attention were required in the testing of cement. He had seen briquettes broken, showing air bubbles in the line of fracture, and it was necessary before recording a tensile test, to examine the fracture carefully for air bubbles and uniform hardness; for sometimes an unduly large proportion of sand might accidentally appear at the neck of the briquette, when cement and sand mixtures were being prepared for testing. The result of the tests of the strength of concretes made with various aggregates, were particularly interesting. Crushed sandstone, unwashed, produced a stronger concrete than the washed material, similarly with the crushed bluestone. This might be due to the "sap" of the sandstone in the unwashed sample (which sap contained silica in solution) combining with the cement, and increasing the hardness thereof. Washing the crushed sandstone or bluestone, no doubt removed soluble portions which, if left, would enter into

combination with the cement, and increase its hardness and cohesive power. He could not agree with the remarks of the author of the paper respecting the unsuitability of local materials for the manufacture of Portland cement. He (Mr. Henson) had made many experiments, and had obtained very good results. An intimate knowledge of the quality of the raw materials and the process of manufacture were required to insure success. Abundance of materials was available for the manufacture of Portland cement, but the price of good English cement in this market was so low, that the local manufacture could not at present be undertaken with the certainty of producing a profit.

Mr. Burman said that being in the department of which the author of the paper was the head, he had naturally taken a great interest in all work performed in the testing-room. It might be of some interest to many of the members to know that since the beginning of 1885 something like 2964 briquettes 1″ x 1″ section had been broken in the testing machine.

408	...	...	...	At	3	days	neat
408	...	...	...	,,	7	,,	,,
408	...	...	...	,,	7	,,	3 to 1
408	...	...	...	,,	28	,,	neat
408	...	...	...	,,	28	,,	3 to 1
264	...	...	...	,,	3	months	neat
264	...	...	...	,,	3	,,	3 to 1
216	...	...	...	,,	6	,,	neat
216	...	...	...	,,	6	,,	3 to 1
186	...	...	...	,,	12	,,	neat
186	...	...	...	,,	12	,,	3 to 1

The number of briquettes in setting tanks to be broken at 3, 6 and 12 months was as follows :—

At	3	months	= 132
At	6	,,	= 228
At	12	,,	= 228
			648 total

The number of briquettes required for one complete set of tests was

For	3	days	test	neat	= 6
,,	7	,,	,,	neat	= 6
,,	7	,,	,,	3 to 1	= 6
,,	28	,,	,,	neat	= 6
,,	28	,,	,,	3 to 1	= 6

For	3	mos.	test neat	= 6
,,	3	,,	,, 3 to 1	= 6
,,	6	,,	,, neat	= 6
,,	6	,,	,, 3 to 1	= 6
,,	12	,,	,, neat	= 6
,,	12	,,	,, 3 to 1	= 6
				—
				Total 66 briquettes

The sand required for the 3 to 1 briquettes necessitated the crushing of something like 50 lbs. of stone. The above tests did not include the special tests which would amount to about 18 dozen. When it was considered that each cargo of cement was subjected to tests for fineness, blowing, setting-quality, besides the strain tests, it would be conceded, he thought, that a great amount of time, patience and care had to be bestowed on this work to arrive at accurate results. There was however another step to be taken with reference to testing cement concrete, &c., that was the strain tests of the actual mixtures proposed to be used in different works so as to arrive at the actual gain or loss of strength by admixture with different works, so as to arrive at the actual gain or loss of strength by admixture with different materials of different gauges and quantities, according to the proportions in specifications for different works. He had heard it expressed by some who use cement concrete, that a loss of tensile strength occurred by mixing with salt water. In Grant it was stated that this was not the case, and in vol. LXXX. Proc. Inst. C.E., Kidd on Blyth Harbour, it was stated that a gain was shown in tensile strain, by mixing with salt instead of fresh water. Mr. Henson had mentioned finding blow holes in the centre of some briquettes of small sectional area, he had tested. He was of opinion that this must have been a quick setting cement, as it was often found that minute holes occurred in briquettes of quick setting cement, and was accounted for generally that the cement had begun to set before the ramming into moulds was finished. If, however, any large void space was found in a test briquette, it was at once thrown out. Some cements would set hard enough to bear the pressure of the needle in ten minutes, whilst others would take two hours to become equally as hard.

Mr. Greenwood, noticed that the author had used crushed sandstone as the standard material for mixing with the cement in testing the briquettes. During the time he had been in the colony he had only once seen this material used for mortar, although its use was

very common in England; and it was a common practice in Sydney, when sandstone concrete was being used, to sift the stone and reject the sand, substituting Sydney sand. He would very much like to know the result of tests of briquettes made with Sydney sand (white and yellow), as this material was generally used by Sydney architects, and also in one or two departments of the Government service.

Mr. Shellshear remarked that a small sample of the Tasmanian cement had been tested with the following results :—

Neat cement, set in 9 hours 39 minutes.
,, after 3 days, 453 lbs. per sq. in.
,, ,, 7 ,, 526 lbs. ,,
,, ,, 28 ,, 870 lbs. ,,
Increase of tensile strength between 3 and 7 days, 16.11 per cent.
,, ,, ,, 7 and 28 ,, 65.40 ,,
One of cement to three of sand, after 7 days, 192 lbs. per sq. in.
,, ,, 28 ,, 260 lbs. ,,
Increase of tensile strength between 7 and 28 days, 35.42 per cent.
Neat cement with 18.69 per cent. of water.
One of cement to three of sand, with 11.12 per cent. of water.

This test showed that the cement was of unusually good quality and if cement of equal quality could be made in bulk there would, no doubt, be a great future for the Tasmanian cement. Of late years, cement concrete had come very largely into use for engineering works, and although great progress had been made, there was every prospect of this material coming still more generally into use as its properties became better understood. Perhaps no better material could be used for the linings of tunnels, and it was interesting to note that in the tunnel on the Blayney to Cowra railway this material was now being used. Having had a recent opportunity of seeing this work, he might record that it appeared in every respect better than the old system of brick-lining, as the concrete effectually filled all the irregularities of the excavation, and made a really solid job. There were many cases where concrete in the liquid state could be used with advantage, and in a recent paper read before the association reference had been made to its use for sea-works. It would be very advantageous to the users of cement concrete if a more extensive series of tests were carried out as to the compressive resistance of different mixtures of concrete. The best thanks of the association and the engineering public were due to Mr. Mountain for his very valuable paper, and perhaps the most important part of the paper was that which dwelt on the necessity of

testing samples from each shipment of cement, as unfortunately there was a large amount of spurious material in the Sydney market.

Mr. Mountain, in reply, said he was pleased to find the subject of his Paper elicit such general interest amongst members, and lead to so valuable a discussion, which must be productive of good in directing attention to the importance of this question to engineers generally, and which in all probability was as thorough a debate as had taken place in these rooms until the present time. Professor Warren had given very valuable remarks on the subject of cement, and had, in addition, arranged to test a complete series of concrete blocks of different gaugings and aggregates, also cement mortars of varying strengths, which were now being prepared for that purpose by himself. The results of these tests, which would give accurate comparative results of compressive, tensile, and shearing strains—the tests being all prepared by the one individual—would be of great practical utility, and would doubtless be made known to this association. The remarks of Mr. Henson to the effect that adulteration of cement in some cases may increase its absolute strength, although in opposition to the experience of Drs. Böhme and Dykerhoff, who had investigated the matter, were practically corroborated by the experiments made by Professor Tetmayer, of Zurich, who stated that certain ingredients used for purposes of adulteration (viz., "those containing silicic acid in a state adapted for chemical combination" *(vide Minutes Inst. C.E., vol. 81, page 350)* did not impair the strength of Portland cement, and in some cases actually increased it. But the main point to consider, after all, was the necessity of enforcing the principle that if a manufacturer professed to sell Portland cement, it should be composed of the recognised constituents which formed that material, *and no other*. If he desired to manufacture a preparation containing foreign ingredients, let him do so by all means, but let him not sell it under the name of Portland cement, otherwise the user did not know what he was purchasing, unless by the application of elaborate chemical processes that were unknown to the practical engineer. This was the aim of that meeting of the Society of German Cement Manufacturers, whose resolutions had been quoted by Mr. Fischer, and it was to be hoped that their efforts would be attended with good results. The special reference to German cements as being adulterated occurred in the Paper in consequence of that practice having obtained in that country to a greater degree than elsewhere, but the author quite recognised the excellence of some of the cements of German manufac-

ture, which were equal in quality to any cement made elsewhere. With reference to the cracking of the pats, Mr. Henson was in error in supposing that they were not all subjected to precisely similar treatment. The blotting paper was placed between the iron plate and the cement pat in each case, only in this particular instance the paper seemed to have adhered to one of the pats, and had been brushed off the other. The radial nature of the crack was evidently due to the expansion first of all acting on the thin edge—the weakest part—of the pat, and thence extending more or less inwards. Mr. Smail had done well in drawing attention to the fact that salt water was practically as serviceable for making concrete or cement mortar as was fresh water, as this fact—although well known, and admitted amongst engineers generally—had been much disputed by admitted authorities in this city. Mr. John Grant, M. Inst. C.E., had ascertained the usefulness of salt water in this respect many years before the tests referred to by Mr. Smail were conducted, and the subject was not dealt with in the Paper as being one on which the author had not personal experience. Referring to the weight and specific gravity tests, he (Mr. Mountain) considered the latter as of the greater value as it was an invariable record, whereas the weight test varied in direct ratio to the fineness. There was one thing very evident, which was that the weights originally stipulated and obtained twenty years back, were not frequently to be met with at the present time, the result of his experience being that the average weight of cements as supplied to this colony did not exceed for English, 106 to 107 lbs., and for German and other continental, 102 to 103 lbs. per Imperial bushel, and notwithstanding this fact, the standard for tensile strength had been steadily increasing, shewing that the decrease of weight was in many cases due to the fineness of the grinding, which of course enabled the cement to do its work of coating all surfaces of the aggregate more thoroughly in proportion to the extent to which it was ground. The specific gravity test was therefore a substitute for the less reliable one of weight, which was valueless unless considered in relation to fineness. Regarding Mr. Smail's remarks as to the necessity of adopting an uniform speed whilst increasing the weight on the testing lever of machine, he would say that in practice this was recognised, the rate being about 200 lbs. per minute, that being the speed most generally adopted. He had not, however, been able to agree in all particulars with the standards laid down by Mr. Faija, more especially in the small maximum strength that he prescribes for the three days

tensile strain, viz., 275 lbs. A short examination of the tables attached to the paper would show that nearly all the cements (including the best that underwent tests) failed to conform to that limitation, and would consequently have been rejected had the author conformed to its conditions. Also, Mr. Faija's tests for ascertaining the fitness of cement for immediate use (consisting of a vessel containing water heated to a certain temperature, and over which the pats are placed on bars, so as to be subject to the influence of the moist air emanating from the warmed water) had been used by him for a long time in conjunction with the usual method, already referred to, of placing the pats in water for seven days. This had not been attended with successful results, as the latter process had frequently shown cracks in cement that showed no variation of volume when subjected to Faija's treatment. Mr. Greenwood had expressed regret that tests of cements mixed with the ordinary Sydney sand of the building trade had not been made for the purpose of comparing the value of that material with those experimented on by the author. This was certainly an omission which would be speedily rectified, and could be explained only by the statement that this kind of sand had not been largely used for cement work by the author. The reason for adopting crushed sandstone was because uniformity in quality of material used was thereby possible and thus afforded more accurate comparative results than would have been obtainable had sands varying in strength and texture been employed. Crushed sandstone was the material usually adopted for standard testing by engineers, and it was also a valuable sand for mortar. Mr. Greenwood's statement that it was disallowed in certain quarters in Sydney, and preference given to the ordinary sand obtained from the vicinity of the city, was therefore surprising. Respecting the weights given in the paper of various materials used as aggregates, the author would explain that he finds they are in excess of trade-weights of large quantities, having been calculated from the basis of the Imperial bushel, which allowed the particles to be shaken together, and thus packed more closely together than was possible with material loosely shovelled into a box, as is the case in actual work, and where perhaps the measurement was less rigidly conducted: *e.g.*, sand and gravel mixed in the proportion of 2.86 to 1 so as to fill interstitial spaces, gave in the box 121 lbs. per cubic foot, whilst river sand (wet) gave as low as 89¼ lbs. On the other hand, wet river gravel, varying from ¼″ to 4″ in gauge, weighed at the rate of 117½ lbs. per cubic foot, which was in

excess of that given in the paper, which, however, was for *dry* sand. Since the commencement of the discussion, the author had been able to commence some tests illustrative of the respective strength of Sydney sand and the other sands used in the three to one tests. The first instalment of these tests was given now, as likely to prove of interest generally. The tests, as before, were the mean of six briquettes in each instance, and were for the proportion of three to one, both by weight and by volume. The cement used (L in the appendix B) was rather lighter than that previously used for the tests recorded in the paper, which accounted for a slight difference in the ratios of weight to volume. It was intended to continue the observation of these tests for twelve months.

(1) *Crushed Sandstone*, as used in ordinary tests. Weight, 83.15 lbs. per cubic foot. Ratio of volume to 3 to 1 by weight, as 2.8 to 1; ratio of weight to 3 to 1 by volume, as 3.11 to 1.

(13) *Sydney Yellow Sand* (from Dowling-street sand-hill) .34 per cent. residue on 900-mesh sieve. Weight, 100.88 lbs. per cubic foot. Ratio of volume to 3 to 1 by weight, as 2.45 to 1; ratio of weight to 3 to 1 by volume, as 3.78 to 1.

(14) *Sydney White Sand* (from Dowling-street sand-hill), no residue on 900-mesh sieve. Weight 103.2 lbs. per cubic foot. Ratio of volume to 3 to 1 by weight, as 2.36 to 1; ratio of weight to 3 to 1 by volume, as 3.87 to 1.

(15) *Nepean River Sand*, freed from pebbles and fine gravel, 57½ per cent. residue on 900-mesh sieve. Weight, 98⅓ lbs. per cubic foot, without shaking. Ratio of volume to 3 to 1 by weight, as 2.43 to 1; ratio of weight to 3 to 1 by volume, as 3.68 to 1.

(16) *Nepean River Sand*, but sieved through 400-mesh and caught in 900-mesh sieve. Weight, 96 lbs. per cubic foot without shaking. Ratio of volume to 3 to 1 by weight, as 2.48 to 1; ratio of weight to 3 to 1 by volume, as 3.61 to 1.

COMPARATIVE STRENGTH OF ABOVE BY WEIGHT AND VOLUME—3 TO 1 TESTS.

No.	By Weight at		Percentage of increase from 3 to 7 days.	By Volume at		Percentage of increase from 3 to 7 days.	Extent to which strength is decreased when proportions are by volume instead of by weight, at	
	3 days.	7 days.		3 days.	7 days.		3 days.	7 days.
1	104	191	83.65	102	167	63.72	1.92	12.56
13	43	77	79.06	12	28	133. 3	72.09	63.63
14	132	183	38.64	82	123	50. 0	37.87	32.78
15	123	182	47.96	96	129	34.37	21.13	29.12
16	111	173	55.85	87	127	45.97	21.62	26.59

The above results give some startling evidences of inferiority in the Sydney yellow sand (which in some instances hardly bore the strain of the lever at all) to the ordinary white sand, and shows that none of the sands were equal in strength to the crushed stone, at all events up to the 7-day period. Since the reading of the paper, the result of the 28 days' test of the Tasmanian cement had been obtained, which was 919 lbs. for the neat, and 213 lbs. for the 3 to 1 briquettes. With such results as these it appeared to be now merely a question as to whether the cost of manufacture could compete with the prices at which the imported article was sold. The President, Mr. Burman, and other speakers had pointed out the advisability of prosecuting further experiments, with reference chiefly to concretes of different gaugings. These the author hoped to carry out as opportunity offered, and in conclusion he would express his gratification at the evident appreciation of the subject which had been manifested by so many members, and at the brisk discussion which his paper evoked.

ADDENDUM.

Subsequently to the closing of the discussion on the above paper, the author had his attention directed to the peculiar behaviour of one of the pats of the Tasmanian cement alluded to therein, which gave evidence of deterioration and showed the presence of innumerable and intersecting cracks. Further examination disclosed the fact not only hat this pat was the one which had been placed in Faija's moist air bath, but that both the pat kept in air and the one placed in water