

Mr. HARRISON, President, said he was sure it would be the wish of the Meeting to accord to Mr. Douglass their thanks for his exceedingly interesting and valuable paper. Mr. Douglass's brother was present, and would no doubt reply to any questions that might be put, or observations made.

Mr. MICHAEL BEAZELEY congratulated the Author on the ability displayed in carrying out a work attended by no slight difficulties, and on the success which had been attained. He had been for some years intimately connected with Mr. William Douglass in works of a similar character, and he was certain that whatever difficulties might have to be encountered, and they would be extremely formidable, in the erection of the Little Basses lighthouse, Mr. Douglass's courage and ability would enable him to grapple as successfully with them as with those met with on the Great Basses. He had been particularly struck by the small number of European hands employed on such a work. The total rock party of Europeans was only twelve, and the number on board the three vessels employed eighteen, making a total European party, excluding the engineer, of thirty. That was a very small force to accomplish such a work, including as it did only five skilled mechanics, because the difficulties in carrying it on were much greater in a tropical country than in a similar work at home. Here if anything was wanted it could be easily obtained; but no such facilities existed in a case like that of the Great Basses. The expense incurred, however, appeared to have been rather heavy, amounting to £62,039. The tower contained 37,365 cubic feet. The solid base, which contained 25,077 cubic feet, was there previously, and had no doubt been paid for. If that base had not existed its cost would have had to be added, and taking the contract price of 7s. 3d. per cubic foot delivered at Galle, the 25,077 cubic feet would have called for an outlay of £9,090, bringing the total up to £71,129, and that would come out at £1 18s. 1d. per cubic foot. He considered that rather high, because the Wolf Rock lighthouse, which was an exceptionally expensive one, cost only £1 8s. 2½d. per cubic foot. He could not gather from the Paper if the cost of the vessels was charged to the work. If it were included, of course the high price would be at once accounted for. Towards the end of the Paper, however, where the Little Basses was spoken of, it was stated that the vessels and plant had been transferred and charged for that purpose. He wished to know if the ten stones per hour which were discharged was the maximum or the average. He had no note of the rate at the Wolf Rock, but at the Longships, where

barges were used, five and a half stones per hour was the average. The barge was moored very close in, within 8 or 10 feet of the landing place in fine weather, yet the rate was only five and a half stones per hour. He therefore thought ten stones must mean the maximum at the Great Basses. The average number of hours worked on the rock was eight per day, which for one hundred and ninety-four landings would give fifteen hundred and fifty-two hours. Each steamer carried 120 tons of stone; each stone weighed $2\frac{1}{2}$ tons; giving fifty stones per steamer, or 1,620 cubic feet. The 37,365 cubic feet in the tower were landed and set in eleven hundred hours, which would give 34 cubic feet of stone set per hour during the working season, from the laying of the first to the last stone. Now the 1,620 cubic feet, or fifty stones, in the steamer, at ten per hour, could be discharged in five hours. The fifty stones would require forty-eight hours in setting, or six days of eight hours each, so that the steamer could discharge her cargo, return to Galle, load and return again before the stones were set, and as there were two steamers employed, of course the work was conveniently done. He thought, however, that ten per hour would be found to be too high an average. Long trials had so perfected the knowledge of the proper construction of these towers, that it was difficult to suggest any improvement; but he thought it would be an advantage to diminish the number of windows in the service room. The vibration caused by the lantern during high winds was considerable, and as the rooms were increased in diameter the floor stones had a greater tendency to tip, and it was advisable to get as great a weight on them as possible to hold them down. If the number of windows in the service room were reduced from four to three it would, he thought, be an improvement. In a small way he had himself suffered from the Great Basses not being illuminated. When he was returning from Calcutta, although the east coast of Ceylon was kept in sight all the evening, the captain was so afraid of the Great Basses Rock, that directly it got dusk he kept the course of the vessel to the south-west, till at dawn of day they found themselves 60 miles to the south-west of Galle, quite out of sight of land. Comparisons were certainly invidious, and he might be supposed to be prejudiced in favour of the corporation with which he had been for so many years connected; but he could not help referring to the miserable failure which caused £40,000 to be spent in doing nothing whatever as compared with what was accomplished as soon as the work was handed over for execution to the Trinity House. When he was at Galle in 1859, he saw the stones lying on

the glacis of the fort, and made inquiries why they had not been placed in position. The only explanation he could get was that there was great difficulty in laying the foundation. That was self-evident, as not a single stone had been put in position, but every difficulty vanished before the courage and ability of Mr. Douglass when he undertook the work.

Mr. REDMAN referred to the cost of some lighthouse towers nearer home. The Bell Rock lighthouse, of nearly the same height (117 feet) as that on the Great Basses, cost £61,331; the Skerryvore lighthouse, with an altitude of 158 feet, cost £83,126. No portion of the literature of Civil Engineering had met with greater attention than that relating to the construction of lighthouses; but it would be admitted that this Paper, following as it did that by Mr. J. N. Douglass describing the construction of the Wolf Rock lighthouse,¹ was no mean addition to that literature, which ranged from the well-known folio of the great master of the art, Smeaton, to the works of Stevenson on the Skerryvore and the Bell Rock lighthouses, and to the numerous Papers in the records of the Institution. It was in many cases fallacious to compare the cost of such works, for the conditions were extremely various. He thought the Author had scarcely sufficiently described the geological structure of the rock, and the material used in the construction of the tower. He also wished to have some further and more detailed explanation of the bending of the courses.

Admiral COLLINSON expressed his admiration at the arrangements which had been made for landing under great difficulties. As a sailor he considered the way in which the vessels were moored was a perfect specimen of what ought to be done where a difficult surf had to be dealt with. He also highly approved of the construction of the vessels. He went on board one before she left England, and was greatly delighted with its wonderful adaptability to the exigencies of the case. On behalf of the Trinity Corporation, he wished to express their sense of the great obligations they were under to Mr. Douglass for the successful issue of the undertaking.

Mr. SHEARER said the granite used in the construction of the Great Basses lighthouse was supplied from his works at Dalbeattie, in Scotland. The mode of construction adopted by Mr. Douglass made the structure almost a solid mass of granite, which would in all probability be everlasting. It certainly would not be subject to any annual outlay for painting or repairs, as would have been the case if built of iron. The stones for such a structure could be

¹ *Vide Minutes of Proceedings Inst. C.E., vol. xxx., pp. 1-28.*

despatched to any distance with the utmost regularity and safety. The first two or three cargoes were forwarded in sailing vessels, the rest in steamers *viâ* the Suez canal. The order for the working was put in hand on the 4th of January, 1870, and in October 1871 the last cargo was delivered at Galle. There were many advantages to be gained by using materials prepared in this country. Among others, the engineer, if resident in England, would have an opportunity of testing and examining them before they were sent away for distant foreign works. In this instance the tower was built in sections in the quarries under Mr. Douglass's inspection, and each block was marked for its particular place, so that little skill was necessary at the Great Basses in putting them together. Between nine hundred and one thousand blocks were used, and only one was damaged by accident at Galle; but as spare stones had been provided, capable of being worked into whatever shape was required, no inconvenience resulted from the accident.

Mr. J. N. DOUGLASS, replying to Mr. Beazeley's questions, said ten was the average number of stones landed per hour, twelve the maximum. If the stones had not been landed with such rapidity, many opportunities would have been lost, as it sometimes happened that the steamers could not ride near the rock for more than two or three hours during one day. He did not agree in the opinion that the cost of this work was heavy. It was true the cost of the granite base of the 'Gordon' light house was not included in the estimate of £64,661, or in the actual cost of £62,039. The cost of this base delivered at Galle was about £9,526, which would give a total for the structure of £71,565. Now, in this was included two steamers and a light-vessel, less their actual value on the completion of the work, at which value they were transferred to the works at the Little Basses lighthouse. The actual charge to the work for the light-vessel, and her maintenance during the time the work was in hand (about £8,004), should fairly be deducted, thus reducing the cost of the work to £63,561. It was well known that wages and the cost of materials had greatly risen of late years; yet this work had been executed in a tropical climate, and at a distance of nearly 7,000 miles from this country, at a cost which would compare favourably with that of similar works at home. The Bell Rock lighthouse, of 28,530 cubic feet, cost £1 19s. per cubic foot; the Edystone, of 13,341 cubic feet, cost £2 19s. 11½d. per foot; and the Great Basses, of 47,808 cubic feet, cost £1 6s. 7¼d. per foot. No really fair comparison could, however, be drawn in the case

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of such structures, because of the variety of circumstances, and the different conditions to be dealt with. But, on the whole, remembering that Smeaton's admirable work, executed under the personal superintendence of that able engineer, cost £2 19s. 11½d. per cubic foot, he did not think such a work as that now on the Great Basses, fitted with all the modern improvements in engineering and optical science, at £1 7s. per cubic foot, could be considered costly. The subject of the windows of the service-room had received careful consideration. The late Professor Faraday used to say that the lighthouse commenced at the floor of the service-room, and that the lantern should be ventilated from the service-room windows. As it frequently happened, in stormy weather, that only the lee window could be kept open, it followed that with four windows there was more certainty of a lee window, and consequently of proper ventilation of the lantern. Without proper ventilation condensation occurred on the internal surface of the glazing of the lantern, and the efficiency of the light was thus seriously impaired. The system of ventilation, as arranged by Professor Faraday, was as follows:—The air was admitted at the windows of the service-room (in which was a stove for heating in cold weather), ascended through a perforated grating surrounding the lantern-floor, over the internal surface of the glazing (thus preventing condensation) to the space between the roof and the ceiling, by an annular aperture surrounding the latter, whence it reached the cowl, the circulation being invigorated by the heat of the funnel of the large central lamp. He knew of no case where there had been any indications of weakness from the adoption of four ventilating windows in the service-room, therefore he preferred four to three. His brother had estimated, as a consequence of the erection of the Great Basses lighthouse, that the voyages of passing steamers had been so shortened that the saving in coal, irrespective of time and wages and interest on capital, had already exceeded the cost of the lighthouse. The tower, as stated in the Paper, was constructed of Dalbeattie granite, and the rock was a hard red sandstone. The granite base was from the Cornish quarries of Cheesewring and Penryn.
