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CIVIL ENGINEERING.

On Sub-Marine Foundations; particularly the Screw-pile and Moorings. *By* MR. A. MITCHELL, of Belfast, Assoc. Inst. C. E.

Considering that the entire subject of the various sorts of piling, of solid stone foundations, of coffer-dams, of masses of concrete, and the numerous modes adopted by ingenious men for overcoming local difficulties, would occupy too much time, and scarcely possess novelty, the author restricted himself almost entirely to the description of the works executed by him with the screw-pile, as that had been chiefly employed for supporting structures on loose sand or mud banks, wholly or partially covered by the sea, where it had been previously considered very hazardous, if not impracticable, to erect any permanent edifice: and in his narrative, he scrupulously avoided all comparison with other modes of proceeding, even when they had the same object. The origin of the screw-pile was the screw-mooring, which was designed for the purpose of obtaining, for an especial purpose, a greater holding power than was possessed by either the ordinary pile or any of the usual mooring-anchors, or blocks, of however large dimensions. It was proved by experiment, that if a screw, with a broad spiral flanch, were fixed upon a spindle, and forcibly propelled by rotary motion to a certain depth into the ground, an enormous force would be required to extract it by direct tension; and that the power employed must be sufficient to drag up a mass of earth of the form of the frustrum of a cone reversed—the base being at the sur-

face of the ground, and the section of the apex being equal to the diameter of the screw. The extent of the resisting mass must, of course, depend upon the natural tenacity of the soil. Even in this reasoning, it must be evident that a vertical force was calculated upon; but as, practically, that seldom if ever occurred, the angle of tension and the curve of the buoy-cable again gave the moorings greater power. This was found to be correct in practice, and the application of the moorings became very extensive. An arrangement was made with the port of Newcastle-on-Tyne, by which, for the sum of 2500*l*, the right of fixing these moorings in the Tyne was given; and Mr. Brookes, the engineer, showed that last year, whilst in the neighboring port, damage was done to the shipping to the extent of nearly 30,000*l*., no injury was sustained in the Tyne, entirely owing to the sound holding of Mitchell's screw-pile moorings. It naturally occurred to Mr. Mitchell, that the same means of resistance to downward pressure might be used; and he proposed to apply it for the foundations of lighthouses, beacons, and other structures, which, for maritime purposes, it might be desirable to place upon sand and mud banks, where hitherto it had been considered impracticable to place any permanent edifice. In the year 1838, a plan for a structure of this nature for a lighthouse, on the Maplin Sand, at the mouth of the Thames, was laid before the corporation of the Trinity House, supported by the opinion of James Walker, Esq., their engineer. The nine iron piles, 5 inches diameter, with screws 4 feet diameter, were accordingly driven 22 feet deep into the mud, and, with proper precaution, they were allowed to stand for two years before any edifice was placed upon them. The lighthouse was subsequently constructed, and, as was testified by Mr. Walker, had stood perfectly until the present time. Pending this probation, it was determined to erect a lighthouse to point out the entrance to the harbor of Fleetwood-on-Wyre, and under the advice of Captain Denham, R. N., the screw-piles were adopted. The spot fixed on was the point of a bank of loose sand, about two miles from the shore; seven iron piles, with screws of 3 ft. diameter, were forced about 16 feet into the bank, and upon them timber supports 48 feet in vertical height were fixed to carry the house and lanthorn. This structure was completed in six months, and was perfectly successful, never having required any repairs to the present time. A similar lighthouse was erected near Belfast; and since then several others, with a great number of beacons, have been fixed in situations heretofore deemed impracticable.

A project was started by the Earl of Courtown, in the year 1847, for adding to the length of the pier at the Harbor of Courtown, on the coast of Wexford, which had proved an entire failure, from the channel between the solid pier being continually choked up with sand. Iron piles, with screws of 2 feet diameter, to be driven from 11 feet to 15 feet into the sand, and blue clay, were decided to be used in order to form an open jetty through which the sand could be washed by the current, and the platform would be used for loading and discharging the shipping. The surf was so heavy on the coast that the usual barges or floating rafts could not be used for putting the piles

down—so an ingenious plan was designed by Mr. Mitchell, for projecting a stage forward from the solid part, rigging a large grooved wheel upon the top of the pile, passing an endless rope-band around it, and round a pulley fixed 150 feet back, and then, by a number of men hauling upon the band, a rotary motion was communicated to the pile, which screwed it down very fast. By these means one bay of the pier, 17 feet long, was finished daily, even in very rough weather. The entire length of the jetty was 260 feet, its breadth 18 feet, with a cross-head 54 feet long, with landing stages at each end, and two lines of railway throughout. The entire cost of this extension was 4150*l.*, or about 47*l.* 10s. per lineal yard—an extremely small sum compared with the cost of stone piers; but even that was more than the expense would be now, as the system of work is better understood, and materials are now cheaper. The account of the difficulties incurred in the execution of these works was most interesting, and ample testimony was borne by engineers of eminence, and men whose maritime experience gave weight to their opinion, of the superiority of Mr. Mitchell's screw-piles and moorings over every other system for holding buoys or for supporting beacons and light-houses, and their use was suggested for the foundation of bridges, viaducts, and numerous railway and other works, as well as a multiplicity of applications which had not hitherto been thought of.

Mr. W. A. Brookes gave an account of the method of laying down the moorings at Newcastle-on-Tyne, under his directions. A heavy chain, formed of 3¼ inch round iron, in links of 3 feet long each, was stretched along the bed of the river, in the direction of the current. To this chain beneath each tier, was attached a 2½ inch mooring-chain, fixed to the head of a screw mooring; another screw being also placed beneath each tier, and driven down between 10 and 20 feet into the clay, and sometimes full a foot into the shale rock. The screws were 4 feet in diameter, and were placed in depths varying from 15 feet to 24 feet at low-water spring tides. They were screwed down to the depth of 15 feet in an hour and a half, and sometimes 21 feet in two hours. Each mooring-screw was intended to have borne the strain of four heavy ships; but, during the last winter, the port was so crowded, that more than double the proper number of vessels were moored upon each: and yet there were no signs of weakness; and whilst nearly 30,000*l.* of damage was done at Sunderland, during a heavy storm, no casualties occurred at Newcastle, which Mr. Brooks stated was entirely owing to the sound holding of the screw moorings. He argued, therefore, that the small sum of 2500*l.*, paid by the harbor commission of Newcastle for the right to put down these moorings, was a very wise expenditure.

Mr. T. Smith, Pilot Master of the Port of Shields, corroborated Mr. Brooks's statement.

Captain Washington, R. N., had, in the course of his surveying duties, seen the screw moorings in almost every position, and had heard them universally eulogized, as being the best and safest moorings hitherto known. He strongly recommended their employment. He had also examined carefully the screw-pile lighthouses, and had

every reason to be satisfied with them, as affording a means of placing lighthouses and beacons where they were before impracticable, and enabling floating lights to be generally superseded by fixed lights, which latter he proved, from documentary evidence, to be one-third less annual cost than the former, and certainly more useful to sailors; for, in spite of all the care, attention, and even lavish expenditure of the Trinity Board to moor the lightships securely, they did go adrift just at the time when they were most required. He, therefore, advocated fixed lights in every situation where a foundation could be obtained; and he believed that, with the screw-pile, there were scarcely any situations where this could not be accomplished.

Messrs. Walker, Cubitt, Rennie, Murray, Moorson, Mitchell, Scott, Russell, and others, took part in the discussion, adducing instances of the efficacy of the moorings and the piles, and of their applicability to numerous engineering works, for which they expressed their intention of employing them. The high price hitherto charged for the right of using them had somewhat retarded their general introduction; but it was explained, that Mr. Mitchell had feared to entrust to others the fixing of them, lest a failure might ensue before his system was perfected, which, however, he now thought it was. Now, however, as the right of granting licenses for their use was transferred to men of business who had purchased it, there was no doubt of their being brought within the reach of every application.—*Proceed. Inst. of Civ. Eng.*

Civ. Eng. & Arch. Journ.

Remarks on the Formation of the Entrances to Docks, situated upon a Tideway. By Mr. J. B. Redman, M. Inst. C. E.

After illustrating the subject by the example of the position and direction of all the principal dock entrances on the borders of the Thames in the port of London—showing that the variation in the opinions and practice of engineers had been very great—the paper detailed the ordinary methods of docking and undocking ships, and the precautions to be taken in constructing entrances, which should be best adapted for facilitating these operations; and, although it was difficult to lay down any positive rules upon the subject, as the engineer must, in almost every case, be guided by local circumstances, yet in ordinary cases the following general rules were recommended:—For graving docks, an angle of about 45°, pointing up the stream; for wet docks, an angle of about 60°, in the same direction; and a right angle, with the stream, for building ships. These, it was believed, would be generally found the most available.

In the discussion upon Mr. Redman's paper, the merits and defects of the several dock entrances in the Thames and in other situations were examined, and the general result appeared to be, that although the engineer must be guided by local circumstances, yet, that in situations where the river was sufficiently wide, and the position of the land permitted, an acute angle pointing up the stream, was the best for docking vessels with the flood—that the reverse would be best for