Mr. BRUNLEES desired to explain, that the embankments having been constructed of sand, were covered on the sea-side with clay, "rid," and pitching, generally not less than 4 feet in thickness. The pitching was carried 3 feet below the surface of the sand, and was 18 inches thick at the bottom, and 12 inches at the top of the slope. When less dimensions were adopted, the work was not deemed effective. The embankments were generally from 15 to 25 feet in height.

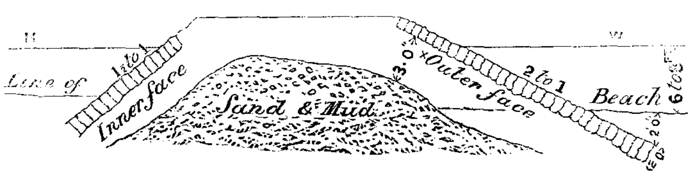
Mr. Brunlees then exhibited the model of a new kind of draw-bridge which he intended to use in the viaduct where the line crossed the navigable estuary of the Leven. This estuary being exposed to high winds, and the tides running very strong up it, a structure was required, whose light character would present the least amount of resistance to the winds and the occasional lash of the waves, while at the same time the moveable part of the bridge, should be of sufficient span to admit the passage of vessels, combined with ample strength to support a railway train, and be very quickly and easily opened and shut. The roadway being for a single line of rails, would rest on piers constructed of iron piles, shod with "Mitchell's" screws. The waterway for the vessels would be 36 feet wide, to be spanned by a moveable platform, formed on two light wrought-iron lattice-girders. The opening of the bridge would not be by the old plan of raising the platform into a nearly vertical position—or of swinging it to one side, which, with a blast from the Irish Sea, would jeopardise its stability and the efficiency of its working—but by causing it to slide under the fixed roadway, on one side the opening; thus forming a kind of telescope-bridge. The mode of accomplishing this was, first, by making the moveable platform 78 feet long, which was double the length of the open part, with an addition of 6 feet for surplus counterbalance; and then making provision for easily moving it beneath the fixed line, in the direction of the longitudinal axis. This provision consisted of a lower line of rails, fixed on beams having a slight declination at the counterbalance end. There were three pair of wheels attached to the girders, and these, resting on the lower line of rails, facilitated the movement of the platform; a rack and pinion, worked by one man, being sufficient to overcome the friction. The fixed roadway was formed of cross T irons for a length equal to the open space, thus affording clear space for the admission of the platform beneath it. When the bridge was closed, by passing the platform over the open span, in consequence of the inclination of the lower, or platform rails, the counterbalance end was on a somewhat lower level than the fixed line. To raise it to the same plane, an eccentric was placed under each girder, these eccentrics being connected by a shaft, and worked simultaneously by a rack-and-screw motion, which was only 13 tons. The advantages contemplated in this design were small expense of first cost, with great facility and certainty of opening and shutting, under all circumstances, and requiring no extra provision for foundations, the weight of the whole moveable platform, being dispersed over the bearings.

Mr. HEMANS said he had been engaged in the construction of several railway embankments, both through arms of the sea and across, or beside fresh-water lakes; in the Clontarf and Malahide estuaries, for the Dublin and Drogheda Railway; in Lough Athalia estuary, for the Dublin and Galway line; in Lough Owel, a deep lake in the county of Westmeath, and also in the Lake of Zurich, in Switzerland, the latter work being only just commenced.

He had tried various forms of slope and sections of embankments, and his experience led him to fear that the protection, described by Mr. Brunlees for the Morecambe Bay Embankment, was rather slight, and that as the work reached the more exposed parts of the bay it might prove insufficient. He thought the toe of the slope should be sunk deeper under the sandy beach, and be protected with heavier stones, at least 2 feet deep on the bed, and not less than 18 inches deep in any part of the pitching. He also considered that a thickness of 12 inches of puddle, under the pitching, was the least amount of protection that should be given to a bank composed of fine sand.

In the Clontarf estuary, half a mile across, on the line of the Dublin and Drogheda Railway, the section of the embankment (Fig. 5) had straight slopes of 2 to 1 on the sea side, and 1½ to 1 on the land side.

Fig. 5.

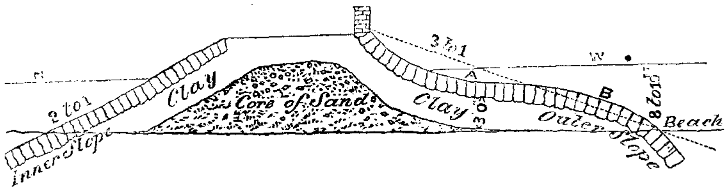


Section of Embankment in the Clontarf Estuary.

The large stones, at the foot of the slope, were sunk fully 2 feet under the general level of the beach; a thickness of not less than 3 feet of clay, covered with quarry chips, was tipped by waggons over the sand core, and formed the bed for the pitching. These slopes had stood very well, although the centre of the embankments had subsided considerably.

For another embankment on the same railway, where it crossed the Malahide Estuary, which was nearly a mile in width, another section was adopted (Fig. 6); the inner slope was straight, at an inclination of 2 to 1, and the outer slope was composed of a concave curve at the upper part, and a convex curve at the bottom; the toe, composed of larger stones, being well dipped into the

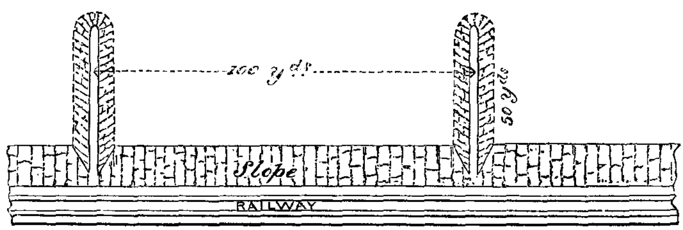
Fig. 6.



Section of Embankment in the Malahide Estuary.

beach. This form was certainly not so good as a straight slope. The tendency of the action of the waves upon it, especially on the portion from A to B, where the stones rested entirely on their edges, was to beat down the clay bed through the joints of the work; the stones then began to sink, the concave portion became dangerously hollowed, and the parapet wall necessarily suffered. Although this had not yet occurred, to any great extent, in the Malahide embankment, there was sufficient action to show the general tendency. This embankment was further assisted by groynes, at right angles (Fig. 7), to the face, the object being to

Fig. 7.

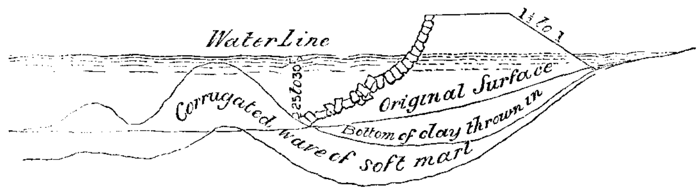


Protecting Groynes in the Malahide Estuary.

protect the toe of the slope from any continuous longitudinal current tending to undermine it. The groynes were completely cased with clay and stone pitching, and were used with success in the most exposed parts of the embankment.

In Lough Owel, Mr. Hemans was now constructing an embankment in a depth of 30 feet of water; the bottom was soft marl, which had subsided and slipped as shown in Fig. 8. Nearly double the quantity of earthwork originally estimated from the surface line had already been thrown in, and although 20 per cent. was allowed for subsidence, that allowance had been greatly exceeded. The pitching here had been very troublesome, from the difficulty of getting a footing. If an extended slope were attempted, the marl would slip away from its foot. The plan adopted, therefore,

Fig. 8.



Embankment in Lough Owel; showing the subsidence.

was, to throw in loose stones, until a foundation for a pitching, with a tolerably upright curved batter, was obtained, giving a slope of 1½ to 1 on the other face.

In the Lake of Zurich, where, although in shallow water, the waves were sometimes very troublesome, a straight slope with pitching of 18 inches in depth was adopted.

Mr. BRUNLEES said, there was not any appearance of the sand being washed away from the toe of any of the embankments; in fact, it was rather accumulating on the "base," which he attributed to the absence of any littoral current and the formation of groynes, or small weirs composed of rubble stones.

Mr. BROGDEN, Jun., said that experience had demonstrated the stability of the embankments. During the course of their construction there had been cause for anxiety, in heavy weather, but all apprehension might now be discarded, as the sand was gathering all along the embankments, the pitching stood well and there was not any subsidence. When the embankments were completed, and the stone weirs were formed, it was anticipated that the river channels would be confined to their several positions, and that considerable warping of land would be executed.

Mr. BRUNLEES directed attention to the formation of the embankment for the Londonderry and Coleraine Railway, across Rosse's Bay, in the River Foyle, which had been attended with considerable difficulty, owing to the unusual depth, and the treacherous nature of the alluvial deposit round the bay. Soon after the tipping was commenced at each end, the slob rose in front and on each side of the "tips." Platforms of brushwood and small trees, weighted with stones, were used for supporting the embankment, but without effect, and the only certain way of proceeding was to continue filling in materials, and raising the embankment, at intervals, until the whole of the slob was displaced. The embankment was about three-quarters of a mile in length, on a curve of 40 chains radius, and the original quantity estimated for it was 88,000 cubic yards. The actual quantity required was, however, 180,000 cubic yards. The depth at which the borings indicated hard material was about 30 feet below the level of high-water of spring tides. From the quantity of material used, it was evident that the embankment either sunk deeper than the supposed hard bottom, or slipped sideways on the blue clay. After the embankment settled, the toe for the pitching was formed by depositing a considerable quantity of stones. The embankment was formed with a straight slope of 2 to 1 on the face, or river side, and $1\frac{1}{2}$ to 1 on the back, or land side, the former being well pitched with stones nearly 2 feet deep, laid upon a thickness of nearly 3 feet of puddle. The top of the embankment was 7 feet above the level of high-water of spring tides, and after it had become consolidated, it had stood well since the opening of the Railway, in 1852.

Mr. SIMPSON,—President,—said, the experience he had in the formation of such embankments convinced him that the best protection was a good deep coating of well-puddled clay, and upon that a layer of quarry rid, into which the pitching, with close joints, should be well bedded; by these means the water was excluded from the earth and sand of the hearting, the clay could not be washed out through the joints, and there was not any subsidence of the pitching. He thought a slope of about 2 to 1 would generally be found sufficient.

In Holland the banks were most efficiently protected by the apparently simple means of stakes and wattling, on the face, and guarding the toe with puddled clay, and a small extent of stone pitching. The pile-engines used in driving the larger stakes, or piles, were very primitive in construction, but they were handled very adroitly by the men who had charge of these works, which demanded unceasing attention.