

undocking ships. In ordinary widths of rivers, therefore, the end would be attained by forming a bay sufficiently deep to render the water still in front of the dock, the wing walls being so much splayed as virtually to give the directions up and down the stream as circumstances required. The peculiar positions of the docks at Ipswich, by Mr. Palmer, the alterations of the Duke's Dock at Liverpool, by Mr. Cubitt, and other cases, were sustained in support of the arguments of the speakers, who all united in praising the industry and talent of Mr. Redman, in bringing forward the subject in the complete manner he had done.—*Ibid.*

*Ibid.*

*An Account of the Effect of the Storm of the 6th of December, 1847, on the Coast near Edinburgh, as illustrating the Principles of the Construction of Sea Defences. By W. J. M. RANKINE.*

The principle example given was the sea wall of the Leith branch of the Edinburgh and Dalkeith Railway, built by the author in the year 1837, from Mr. Walker's designs. Just after it was completed, a violent storm occurred, which injured almost every similar work within its range, but produced no ill effect upon that structure. On the 6th of December 1847, a still more violent storm occurred, which did great damage all around, but the railway wall still escaped without injury. The total length of the wall was about 750 yards; its height was 13½ feet above the beach at the highest point, diminishing to about 6 feet at the ends. The height of the top was 4 feet above equinoctial spring tide level. Its least thickness was 5 feet and its greatest 10 ft.; the back was vertical, but the face had an inclination at the lower part of 5 inches in the foot, gradually becoming curved as it rose upwards, until at the top it overhung slightly. The foundation course was composed of large flat stones, laid horizontally 4 feet below the surface of the beach, upon a stratum of fine sand and gravel, firm when dry, but movable when wet. The face was of hammer-dressed ashlar, about 2 feet thick; the back of rubble, 18 inches thick. The interior was filled with concrete. The coping was composed of stones each weighing about half a ton, connected by means of cast-iron dowels. The stone used was Craiglieth sandstone. The face-joints were laid in cement for a depth of 4 inches. The foundation was protected by a pitching of trap boulders, laid on the natural level of the beach. They were partially disturbed by the storm referred to, and the author ascribed this to their weight being insufficient to resist the vertical oscillation of the waves.

The second example was a vertical sea wall near Trinity, the foundation of which was protected by a dry stone bulwark sloping at angles of from 30° to 40°. The wall was injured by the storm, but the pitching was breached at several points.

The third example was another wall near Trinity, of a hyperbolic section. The lower part had a slope built dry up to a little below high-water mark. At this point there was a sharp curve, and the upper part was nearly vertical, and laid in mortar. The waves ex-

tracted the stones of the curved portion, and the upper part, being undermined, was destroyed to a great extent.

The last example was the bulwark of the Granton line, the lower part of which sloped at about  $20^\circ$ ; the upper portion was curved, and was covered by a heavy projecting string-course and parapet. It was built dry, and the stones of the lower part weighed not less than half a ton each. This bulwark suffered damage to a slight extent on its upper portion.

These examples were stated to confirm the following principles:— That the principal action of the waves in front of a sea wall was a vertical oscillation, produced by the combination of the direct and the reflected waves; that a sloping bulwark gave rise to a sloping oscillation, tending to overturn any portion which projected above the line of slope; that where the strength of a sea wall depended on the pressure of the superincumbent masonry, and the adhesion of mortar and cement, the position of greatest stability was vertical; and that when the strength depended on the weight of the individual stones, the position of greatest stability was a very flat slope.

In the discussion which ensued, instances were adduced of the duration of vertical walls under the attacks of heavy seas, and, on the other hand, of their destruction when flat slopes had effectually resisted the waves; and it was agreed that in this, as in all other cases of engineering, no empirical rules should be laid down, but that the skill of the engineer should be exerted to adopt such forms of construction as were best adapted to the locality and the circumstances.—*Ibid.*

*Ibid.*

### *Description of the Tubular Bridge to convey the Chester and Holyhead line of Railway over the river Conway.*

As this bridge which is constructed to carry the Chester and Holyhead line of Railway over the River Conway, is a unique example of engineering skill, we purpose giving a brief description of its nature, and of the effort made to raise it to its ultimate destination.

The idea furnished by the word "tube," gives no idea of its form, inasmuch as that is suggestive of a circularly-formed tunnel, whereas in fact, the bridge rather resembles a huge chest, such an one as the genii of the Eastern romances might be supposed to fabricate.

The TUBE is made of wrought-iron plates, varying in thickness from  $\frac{1}{4}$  inch to 1 inch, rivetted together, strengthened by T irons; and, to give additional strength to the whole, a series of cells is formed at the top and at the bottom of the tube, between an inner ceiling and floor and the exterior plates. It is to be observed that T irons strengthen the top and sides, and the iron plates which form the cells are rivetted and held in their places by angle irons. The upper cells, eight in number, in the transverse section, are nearly square, being 1 foot 9 inches high, and 1 foot  $8\frac{1}{4}$  wide. The lower cells, six in number, are 2 feet  $3\frac{1}{4}$  inches wide, by 1 foot 9 inches high. The space between wall and wall, if we may so speak, of the tube, is 14 feet, and the height of the whole, inclusive of the cells, is 22 feet  $3\frac{1}{4}$  inches at the