

to withstand the blows from floating ice, without relying upon the adhesion of the cement, or depending upon the retreating and pointed form of the ice-breaker for any further assistance than to keep the pier clear of jams.

THRUST OF SAND BARS.

Another disturbing cause to which the piers are exposed is the thrust of a sand bar on one side, while the other side is washed clean by the scour. The greatest exposure of this kind would occur at Pier No. 4; if the sand-bank on the north side of this pier were forty feet high, and the rock was swept clean on the south side, the thrust of sand to be sustained on each horizontal foot, estimated by formula (c.), would be 14,432 pounds, and the thrust upon the whole pier, 70 feet long, would be 1,010,240 pounds. The moment of this thrust, tending to overturn the pier, will be equal to this pressure multiplied by the height of the equivalent centre of application above the base of the pier, or one-third the height of the sand-bank, 13.33 feet; which gives for the overturning moment 13,469,833 pounds.

The weight of the pier, allowing for the buoyancy due to the immersion in an extreme flood, is not far from 6,000,000 pounds. The moment of weight tending to resist overturning is equal to this amount multiplied by one-half the breadth of the base of the pier, or 11.25 feet, giving for this moment of resistance 67,500,000 pounds, or about five times the greatest overturning moment due to the thrust of the sand bar.*

STRENGTH OF FIXED SPANS OF SUPERSTRUCTURE.

The strains on the fixed spans of the superstructure were computed by the simple method usually employed in calculating the strains on the different members of an isolated span. The strains upon the panel ties and braces in all the spans were estimated as if both chords were horizontal; the results thus obtained were not strictly correct in the cases of the three longest spans, but

* No allowance has been made in this calculation for the bond formed by the beton with the bed rock, whereas, even if the adhesion of the mortar be considered as nothing, by excluding the water from the base of the pier, it makes the entire weight of the pier, without deduction for immersion, available to prevent its overthrow.