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For THE CANADIAN ENGINEER.

RAILWAY ENGINEERING.*

BY CECIL B. SMITH, MA. E., MEM. CAN. SOC. C.E., ASSISTANT PROF. OF CIVIL ENGINEERING IN M'GILL UNIVERSITY.

CHAP. V.

ROADBED CONSTRUCTION.

ARTICLE 27.—FOUNDATIONS.

The foundation of a structure is much more important than any other feature of its design, as on its security depends that of the structure itself. We may therefore be justified in examining closely into the bearing power of soils, the various methods of increasing it or distributing the load over greater areas, and the various methods of sinking or making foundations.

The bearing power of soils varies very much, being least for soft clays and unconfined quicksands, and increasing through sand, gravel, firm clay and hardpan to solid rock; it may be as low as one-half ton per square foot, and as high as 180 tons per square foot, but it is only with the lower values that we need deal. A good clay foundation will bear safely 2½ to 4 tons per square foot, and dry sand or gravel from 5 to 6 tons, while cases have been known of 10 to 11 tons per square foot being carried. In railway work 3 or 4 tons per square foot is usually all that we want to put on to a foundation; consequently, whenever good firm clay (which will not be watersoaked), sand or gravel are reached, the foundation may be considered safe, provided we have sounded several feet, and in case of important structures, many feet below the foundation bed, to see that the substrata are equally firm. Rankine's earthwork formula takes account of the depth of the foundation beneath the ground level, and one rule in use in the Western States is that the safe load per square foot on sand is 2 tons + 1 ton for each 10 feet in depth. No account has been taken of the friction of the soil on the sides of the structure below ground level. This is only of importance where the foundations are sunk by pneumatic caisson or open dredging, in which case it is variously estimated at from 200 to 600 pounds per square foot of surface exposed to side friction. If the caisson is of cast iron, about 300 lbs. for wrought iron, 900 lbs. for masonry, 300 to 600 lbs. for timber, and for piles 500 to 1,000 lbs. per square foot.

FOUNDATIONS ON LAND.

Where a firm foundation is obtainable within a few feet of the surface, all that is necessary is to dig a pit below frost level, or to any required depth and commence stonework at once, or often lay 1 or 2 feet of concrete to get a uniform bed to lay on, if the foundation is bouldery or uneven; but if, on the other hand, the foundation bed shows soft spots or uneven bearing power, the difficulty may be overcome by using a deep bed of concrete which will span over small spots (provided there is no danger of undermining by scour from an adjacent river, liable to change its channel), or by using a grillage of timber instead, in cases where the timber will always remain watersoaked, but not otherwise. Again, the same expedients may answer if the whole foundation is somewhat, but not very, soft, by spreading out over a larger area. When, however, it is found that the foundation is too soft for such methods even if thoroughly drained, and that it will not pay to dig down far enough to reach a firm one, recourse must be had to some artificial method of obtaining greater bearing power, the usual way being to drive piles, although in some cases where cost is no object or the piles would be subject to decay, large platforms formed of cross-layers of steel I beams or rails bedded in concrete (as in Chicago), have been used to great advantage, the transverse strength being such as to enable a very much enlarged area being used. When sufficient piles are driven to carry the load required they may be cut off level and capped by drift-bolting on a double layer of 12 inch by 12-inch timbers, as a base for stonework, or preferably either on the broomed heads of the piles or after sawing them off, a layer of concrete is placed and also rammed around and between the piles, in which case the earth between the piles will take a portion of the load, being much compacted by the driving, indeed, in cases where timber is scarce, a method has been adopted of pulling out piles after driving and immediately filling the holes with well rammed sand, the compacted earth and the sand pillars together carrying the load safely. Cast iron and

*This series of papers will be issued in book form as soon as they have appeared in THE CANADIAN ENGINEER.