but maintenance charges and risk of leaky joints would be less.

Carrying the remaining side coils in a spiral round the tank, with a good circular sweep into the tank at the inlet and outlet ends and plenty of freedom in the U-bolts. This would give ample room for expansion and a good fall in the pipes.

Fitting each coil with a steam trap, enclosing the tank in hollow tile or other suitable construction, and installing two pumps in place of the single unit.

ROAD DRAINAGE AND FOUNDATIONS.*

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IT will be assumed that the "Drainage" referred to in the title is that provision made for taking care of the water so as to improve the foundation or protect it from injury, and is not intended to cover provisions to be made for the disposal of surface or storm water to be cared for in any event. Drainage, therefore, becomes a consideration in this paper incidental to foundations and reference to it will be made along these lines instead of by attempting the really impracticable separate consideration of it.

Let us, in approaching the subject of foundations, first divide the foundation into two classes—the natural and the artificial. The natural foundation must ultimately be that portion of the earth's crust on which the beginning of the artificial structure rests. It may be some distance below the surface of the roadway and be separated from the surfacing of the latter by various layers of construction, including an artificial foundation.

The requirements for a foundation are (a) that it shall be capable of supporting, under the most adverse conditions likely to surround it, the loads coming on it; (b) that it shall be homogeneous and uniform to an extent sufficient for the probabilities of the case; and (c) that the above qualities "a" and "b" shall be obtainable at the minimum cost in the long run.

Considering now natural foundations, *i.e.*, road beds on the soil in situ—when the proper grades shall have been reached by excavation or embankment it is evident that requirement "c" is complied with. Questions as to "a" and "b" above immediately arise. When the material is ledge, sand or sandy gravel, and perhaps some other materials, there will be slight if any need of further considering "a." There may be, however, need for considering a subordinate matter involved in "a," and that is the question of the probable permanence of the supporting power of the material under such conditions as may later arise. For instance, the incompressibility and supporting power of sand may be extremely high as long as there shall be no chance for the sand to flow. On the other hand, the tendency of the sand to flow may be tremendously increased by the assistance of water. Consequently the probabilities of the presence of other conditions which would seriously injure the supporting power of even such materials as sand and gravel must be considered, and such precautions taken by provisions for drainage perhaps as will prevent the existence to a dangerous degree of such conditions.

Drainage thus enters into the consideration of the foundation. If for no other reason, drainage must be provided in order that water shall not by its advent into the foundation injure the supporting power of the latter seriously. Again, if the amount of water normally present in the foundation is weakening its supporting powers, drainage may be provided to take away this water and thus at a moderate expense frequently to render satisfactory the natural foundation material, as well as to protect it from further weakening against the advent of more water under abnormal or exceptional conditions. With earths less desirable than sand or sandy gravel as foundations, in view of their weaker supporting powers or greater liability to weakness under adverse conditions, the necessities for proper consideration of their capabilities and of the probabilities and effects of adverse conditions are emphasized. Here, again, careful consideration of the possibilities of proper drainage, toward an economic and effective solution of the problems, enters.

So much has been said and written regarding the details of drainage that the writer will not attempt to go into these matters again here. He believes that, if he has made intelligible the reasons for drainage in connection with foundations, his readers will be perfectly well able to work out the details of construction for themselves. He would simply add one word of caution, and that is, the drainage provisions in every case should be not merely sufficient for the conditions existing at the time but should be ample to take care of any conditions that may seem possible of occurrence.

As provisions for the protection of natural foundation in its most stable form begin to be demanded, and as provisions for protection against adverse conditions are demanded and begin to accumulate, it will be seen that consideration of the substitution or interposition of an artificial foundation for the pavement enters, in order that requirement "c," as well as requirements "a" and "b," shall be met, and a permanently stable, uniform support for the pavement surface shall be provided at the minimum cost.

Perhaps a few words regarding requirement "b" should be said here before proceeding further. The desirability for uniformity in the foundation for a pavement is going to be more generally recognized. It is important because otherwise uniform wear of the surface is not likely to take place, and uniform wear of the surface, even if somewhat more rapid, is more desirable and less expensive to counteract than light or slow wear in some spots and heavy or rapid wear in adjacent areas. This latter condition means constant expense and trouble to keep the pavement surface in satisfactory shape. A uniform wear, however, requires little if any expense for keeping the surface in satisfactory condition, and if not too rapid, will not result in as much expense in the long run.

Most natural materials can be made into sufficient foundations for pavements if they are of the so-called "mineral kingdom." Vegetable matter ordinarily cannot be, and must be excluded from the foundation because of its tendency to instability. The question, however, as to whether to use the natural mineral material in place, or whether to substitute something else for it, is often mainly an economic one, and comprises, as will be seen, the question of whether or not the material is, and will be sufficient for the purpose in its natural state and the question of what it will cost to preserve it indefinitely in a satisfactory condition, or what it will cost to remove the material and substitute therefor something else more satisfactory. The decision should be on the safe side, if for no other reason, because of the probabilities of unexpectedly severe strains eventually coming on the foundation. The modern tendencies are toward the more severe use of roads and street, with greater demands on thei. foundations than heretofore, and these tendencies shou d be recognized. On the

*Paper read before the 3rd Canadian and International Road Congress.