BY CLIFFORD RICHARDSON, The Barber Asphalt Paving Co., New York

THE satisfactory nature of any type of pavement or road surface is primarily dependent on the rigidity of the foundation which supports it. Inadequacy in this respect reduces all forms of construction to a common level of inferiority. Rigidity in a road surface cannot be obtained without suitable under-drainage and, for this reason, drainage is a feature of primary importance in the construction of roads and pavements.

Historical

This fact has been recognized for at least a century, but it has seldom been carried out effectively. The ideas of the older engineers, McAdam, Telford and others, in regard to road construction and the importance of the relation of drainage thereto, ac.; widely scattered through the earlier literature of the subject. They were recognized and summarized in an increasing book by S. DeWitt Bloodgood, published at Albany, N.Y., in 1838, entitled, "A Treatise on Roads," in which it is found that sound principles had been established in the United States at that early date, by engineers who had an adequate comprehension of the subject, at least as far as the requirements of their day were concerned.

"The strength of a road depends on the nature of the material of which it is formed, and of the basis on which it is placed."

"McAdam's theory of road-making may be comprised in the following quotation from his Report to the Board of Agriculture, (vol. vi. p. 46):—Roads can never be rendered perfectly secure until the following principles be fully understood, admitted and acted upon, namely, that it is the native soil which really supports the weight of traffic; that while it is preserved in a dry state it will carry any weight without sinking, and that it does, in fact, carry the road and the carriages also; that this native soil must previously be made quite dry, and a covering impenetrable to rain must then be placed over it, to preserve it in a dry

state." "The erroneous opinion so long acted upon, and so tenaciously adhered to that, by placing a large quantity of stone under the roads, a remedy will be found for the sinking into wet clay or other soft soils; or, in other words, that a road may be sufficiently strong, artificially, to carry heavy carriages, though the sub-soil be in a wet state, and by such means to avert the inconveniences of the natural soil receiving water from rain or other causes has produced most of the defects of the roads of Great Britain. At one time, McAdam had formed the opinion that this practice was only a useless expense; but experience has convinced him that it is likewise positively injurious."

"Drainage: In proper construction in this part of the business of road making, great care is necessary. The utmost judgment of the skillful surveyor will be called into action to enable him to make the best use of the natural facilities of the country, and to overcome the obstruction that he will sometimes meet with. In passing over flat land, open main drains, cut on the field side of the fences, must communicate with the natural water-course of the country; they should be 3 feet deep below the level of the bed of the road, 1 ft. wide at bottom, and 5 ft. wide at top."

With the building of railroads, however, the construction of highways of the better type was gradually neglected, and but little attention was paid to the subject of drainage and foundations, with perhaps some exceptions.

and foundations, with perhaps some exceptions. In the seventies of the last century the condition of our roads was such that W. M. Gillespie, in a volume, pub-

*From "Municipal and County Engineering," Indianapolis, Ind. lished in 1872, entitled "A Manual of the Principles and Practice of Road Making," stated in the preface:----

"The common roads of the United States are inferior to those of any other civilized country. Their faults are those of direction, of slopes, of shape, of surface, and generally of deficiency in all the attributes of good roads. Some of these defects are indeed the unavoidable results of the scantiness of capital and of labor in a new country, but most of them arise from an ignorance either of the true principles of road making, or of the advantages of putting these principles into practice."

From this quotation it appears that road construction and maintenance were at a very low ebb at that period. They remained so until the bicycle came into common use. For the comfort of the riders good roads were demanded and a considerable effort was made to provide them. The difficulties of the present period, however, are to be attributed to the fact that motor vehicles and, particularly, motor trucks have become important features in the transportation of passengers and freight over our highways and streets. It is a form of traffic and travel which has made much more serious demands upon them and on the methods of their construction, especially as regards drainage and foundations. As a result the problems relating thereto demand, and are receiving, more attention to-day than they have ever had, although their consideration is, even now, too often neglected.[†]

Drainage at the Present Time

It is evident that the demands made by the traffic which is carried at the present time by our main arteries of communication are such that the greatest stability is necessary for the support of their surfaces, and this can only be accomplished on a soil which is firm or made so by suitable drainage. In arriving at such an end the following points must be given consideration:—

The travel and traffic to be carried. Character of subsoil. Drainage, natural or artificial. Climate. Location. Material available for construction.

The relative importance of these features will vary with different local conditions. There is no general rule which applies. In one case the character of the subsoil and the necessary drainage may be the ruling conditions, in another a severe climate, and in a third the material available for construction. Attention must be paid in a certain degree to all of them, however, in any case.

Location

As the solution of the problem of drainage and of the character of the foundation necessary for any particular road is dependent to a very large degree upon its location, the latter is, in this connection, an important consideration. It involves the application of both good judgment and experience, and due regard to the economic principles involved, that is to say, to the relation of the money expended and the results obtained. Like so many other problems which arise in building highways adapted to the use to which they are to be put, it is entirely a local one both financially and structurally.

Soil

As the support of a road surface is the soil upon which it, or its foundation, rests, the stability of the latter, or the imparting of stability to it, is a matter of primary importance.

Soil, as distinguished from sand, which is an aggregation of much coarser particles of mineral matter, is the fine residual of the weathering and decay of rock, associated with more or less organic matter of vegetable origin. Soils are of importance in road building since they form the initial foundation upon which the road is placed. Upon their character is dependent that of the drainage and artificial found-

†"Drainage Increasingly Vital with Growth in Heavy Traffic," by E. W. James—"Public Roads," Vol. 1, No. 3, July, 1918.