The straight line column formula was adopted, as representative of the latest conclusions on column tests, to supersede the Gordon-Rankine formula which is more complicated and is in no sense preferable within the allowable limits of l/r.

As to the general scope and completeness of the new specifications, the reader can best judge that for himself.

[NOTE—These specifications were prepared for the Ontario Railway and Municipal Board by Prof. Molitor and H. W. Middlemist, consulting engineer for the board. Copies of the complete specifications can be obtained upon application to H. C. Small, secretary, Ontario Railway and Municipal Board, Parliament Buildings, Toronto.—EDITOR.]

SPECIFIC GRAVITY OF NON-HOMOGENEOUS AGGREGATES.*

By Prevost Hubbard and F. H. Jackson, Jr.

THE object of this investigation was to study methods in common use, or those which gave promise of being most satisfactory, for the determination of apparent and true specific gravity of mineral aggregates, with a view to ascertaining if possible what method is most generally applicable to all classes of materials, and also the most accurate. The methods studied were as follows:

1. The ordinary displacement method as conducted by the U.S. Office of Public Roads and Rural Engineering;
2. The Chapman method for single specimens;
3. The Goldbeck method;
4. The Hubbard-Jackson method;
5. The Chapman wire-basket method;
6. The Le Chatelier method for fine aggregates; and
7. The Jackson method for fine aggregates.

The determination of the specific gravity of material composed of mineral particles is not ordinarily considered a difficult matter, and until recently but little attention has been paid to the subject in so far as non-bituminous road and paving materials are concerned. Certain discrepancies in results obtained in the laboratories of the U.S. Office of Public Roads and Rural Engineering have, however, indicated to the authors that the entire subject of the specific gravity of these products should be investigated with a view to ascertaining, if possible, what method is most generally applicable to all classes of materials, and also the most accurate.

The method most commonly used in determining the specific gravity of such substances as rock is to first weigh a specimen of rock in air and then in water, and from these results to calculate the specific gravity by the usual formula applied to what has been termed the displacement method. It is, of course, evident that unless the average of a large number of determinations upon different specimens is taken as representing the specific gravity of the material, any method employing a single specimen must, of necessity, be accurate only for material which is of a homogeneous nature. Certain rocks, as well as many slags, gravels, etc., are composed of non-homogeneous material, so that a single small specimen can only represent by accident the average of the material as a whole.

In addition to lack of homogeneity in the material itself, there must also be considered lack of homogeneity in the size of particles present in a given lot of material, such as crushed rock, crushed slag and gravel. Both kinds of non-homogeneity may exist in a sample of material whose specific gravity is desired. In such case it may be found that in general all particles above a certain size are more or less alike in character, and that particles below this size vary greatly from these larger particles, as well as among themselves.

Another factor which must be considered is the difference which often exists between the specific gravity of a mass of material and the specific gravity of the substance of which the mass is composed. For instance, it is evident that a rock which is sufficiently porous to absorb water, as almost all rocks do to a greater or less extent, must of necessity when dry contain spaces filled with air. The specific gravity of the mass, then, including the air spaces, is less than that of the substance of which the mass as a whole is composed. The term "apparent specific gravity" has been applied in the first instance and "true specific gravity" in the second. It is evident that the apparent specific gravity may be less than or equal to the true specific gravity, but can never exceed it.

It is often desirable to ascertain the apparent specific gravity of a material. When this is so, it would then seem reasonable to suppose that the most accurate determination of apparent specific gravity could be obtained from determinations made upon particles of the material as it is purchased and used. The reason for this is, that as the size of particles is reduced the proportion of voids or air spaces in the structure of the material becomes reduced, for if reduction were carried to the point of destroying the structure, a large number of mineral particles would be obtained free from all voids or air spaces, and the average specific gravity of all these particles would then represent the true specific gravity of the substance composing the original mass.

The converse is true regarding a determination of the true specific gravity of a material. In other words, as the size of particles is decreased it should be easier to determine the true specific gravity than where the original structure is more nearly preserved. It may be argued that in any displacement method, by allowing a specimen to remain in water until absorption is complete, the voids will be filled, and if in some manner the water filling these voids is measured, a correction may be obtained which will make possible the determination of the true specific gravity of the material. It is probable, however, that this is not the case, as the absorption of a large fragment may be relatively less than that of a small fragment, owing to the fact that water first absorbed from the outside may imprison air which is present within the structure and prevent its escape. From a mechanical standpoint, however, there is a limit in connection with the fineness of particles best suited to obtaining true specific gravity, namely, the fact that a mass of very fine particles is more apt to entangle air, which cannot be removed by agitation, than is a mass of larger particles. By any displacement method, therefore, the entangled air would vitiate the determination to some extent.

In accurately determining the amount of absorption of a mass of mineral matter where the absorption is weighed, there must also be a certain limit to the size of particles used, for it is necessary to surface-dry these particles after the absorption is complete before weighing them, and any error resulting from imperfect drying must be relatively greater for a mass of very fine particles than

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*Abstract from paper read before the American Society for Testing Materials.