NEED FOR STANDARDIZATION OF TERMS USED IN STUDIES OF THE TRANSPORTATION AND DEPOSITION OF SEDIMENT

by

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As any part of the field of science develops, the terminology used in it evolves, becoming more extensive and more exact in its meaning. This is not an incidental consequence of the evolution, but a necessary and essential part of the process; and, within limits, the progress can be accelerated by assisting in the development of the terminology. The science of the transportation and deposition of sediment is over two centuries old, but most of the progress has been made in the last fifteen years. Along with this growth there has been an expansion of the terminology, but there is need of a still further extension of it and, particularly, of more precise definitions. No doubt it would be possible to carry efforts in this direction too far and thereby obstruct, rather than foster progress; but it is believed that the science has developed to a point where judicious efforts in this direction will bring forth very beneficial results.

One of the terms which needs to be standardized is the general term for the materials transported and deposited. In the engineering field this is usually concerned with mineral particles moved by water. In the geological field it includes also material moved by wind and glaciers. In the engineering field "silt" and "solids" have been used in this general sense. The term "silt" is objectionable, however, since in earth mechanics, agricultural soil studies, and in geology, the term is also used to designate a fine material composed of particles of a certain size range. The term "solids" is better, but sediment problems are concerned only with the transportation and deposition of the non-floating solids, and do not deal with floating ones such as ice and drift. It is believed that the solution of this matter is already on the way, in the broadening by the geologists of the term "sediment" to include not only material

deposited by water but also material being transported. The New Standard Dictionary (1937) gives the following definition of sediment: "Fragmental material transported by, suspended in, or deposited by water or air, or accumulated in beds by other natural agents; any detrital accumulation, such as loess." This definition has been adopted by some engineers and engineering organizations, but any acceleration of its adoption by other engineers would be a foreward step.

An area in which there is great confusion is that of definitions of the various modes of transportation. It was early recognized that there are three main ways in which sediment is transported by a fluid. As early as 1848 these were described by Baumgarten.[1] They have also been pointed out by MacMath [2] and by Gilbert.[3] According to these authorities, sediment is moved by: (1) rolling or sliding, (2) discontinuous hopping or bouncing and (3) suspension. The common term "suspension" so well fits the action of the third of these forms of movement that its use for this purpose has been universally adopted. For the hopping or bouncing stage, the term "saltation" was introduced by McGee [4] and was adopted by Gilbert, to whom it is usually ascribed. This term also has been generally accepted. A definite name does not seem to be given to the rolling and sliding process. Gilbert did not directly give a name to the rolling and sliding portion of the load. Since some engineers believe that these three main forms of movement follow different laws, it is desirable to have a convenient, explicit name for this type of movement also. Even if further studies show that separate laws do not apply to the three types of motion, a definite term for this form of motion would still be desirable. For those cases where sliding is negligible the movement could be spoken of as "rolling," or, if it was desired to include both, "rolling-sliding" might be used. Another possibility is to use "in contact" or "contact" load, signifying that the motion is in nearly continuous contact with the bottom.

[1] Baumgarten, M., "Sur la portion de la Garonne qui s'étend en aval de l'embouchure du Lot daus le département de Lot-et-Garonne, et sur les travaux qui y ont été exécutes de 1836 à 1847." *Annales des Ponts et Chaussées.* p. 1-157, 1848-2.

[2] MacMath, R. E., "Silt Movement by the Mississippi — Its Volume, Cause and Conditions." *Journal of the Assoc. Eng. Soc.* Vol. 1, p. 268, 1881-1882.

[3] Gilbert, G. K., "The Transportation of Debris by Running Water." *U. S. Geological Survey Prof. Paper 86.*

[4] McGee, W. J., "Outlines of Hydrology." *Geol. Soc. of America*, Bulletin No. 19. p. 199, 1908.

Gilbert grouped all transportation into two forms: one, called "traction," included sliding, rolling, and saltation, and the other, "suspension." This is a useful combination and "traction" can well be adopted into the terminology.

Probably the least definite of the terms used in the field of sediment transportation and deposition is "bed load" as it is used with many different meanings by the various authorities. Kramer,[5] in describing his experiment on the movement of material along the bed of a flume, used it as synonymous with the German word "Geschiebe" but did not explicitly define either. Straub [6] used it extensively, interchangeably with "detritus," for the heavy material on or near the bed of streams, but also did not define it. O'Brien [7] defined it as "material carried by a stream or channel in such a manner as to be caught in a trap of reasonable length and proper design." Einstein, Anderson, and Johnson [8] suggested that bed load be defined as "that part of the total sediment load composed of all particles greater than a limiting size, whether moving on the bed or in suspension and including all bed material in movement." This limit is usually the lower size limit of that material for which the rate of transportation is a function of the stream discharge. It is also the lower limit of the sizes of material found in the bed in appreciable quantities. Recently, in a paper by Dr. Einstein,[9] it was defined as follows: "Bed load is considered as the motion of bed particles in quick steps with comparatively long intermediate periods of rest. Thus bed load movement is a slow down-stream motion of a certain top layer of the bed." Certainly, with all these conflicting uses of the term "bed load" there is need of study of the possibilities of classification and standardization.

Some years ago the term "geschiebe" was introduced into American engineering practice from the German. This term means "that which is shoved." Its meaning is synonymous with "bed load." Since it failed to come into general use, although there are many

[5] Kramer, Hans, "Sand Mixtures and Sand Movement in Fluvial Models." *Trans. A. S. C. E.* Vol. 100, p. 798, 1935.

[6] "Missouri River." *House Document 238, 73rd Congress, 2nd Session*

[7] O'Brien, M. P. and Rindlaub, B. D., "Transportation of Bed Load by Streams." *Trans. Amer. Geo. Union*, Vol. 15, Part II, p. 597, 1934.

[8] Einstein, H. A.; Anderson, A. G.; and Johnson, J. W., "A Distinction between Bed-Load and Suspended Load in Natural Streams." *Transactions, A. G. U.* Part II, p. 632, 1940.

[9] Einstein, H. A., "Formulas for the Transportation of Bed Load." *Proc. A. S. C. E.* Vol. 67, No. 3, p. 353, March, 1941.

points in its favor, it would probably be unprofitable to try to reintroduce it.

In order to open up a discussion which it is hoped will lead to a more explicit meaning of the term "bed load," the author would like to have consideration given to the following general definitions: Bed load is the coarse sediment which is being moved on or near the bed. Bed load would therefore include the sliding, rolling, and saltation load plus the coarser portions of the suspended load, if any is present. It is believed that this definition is in substantial agreement with the more extensive use of the term. Since this proposed definition of "bed load" includes in it part of the suspended load, the remainder of the load cannot be called "suspended load," and it is recommended that the term "non-bed load" be used.

There is also need of a name for the type of material included in the Einstein-Anderson-Johnson definition of bed load, since it is quite well established that there is a division of the load of many streams into two portions, one portion composed of sizes readily available in the bed and carried in quantities proportional to the discharge and the other portion composed of finer material, not readily available in the bed, the discharge of which is independent of the stream flow. The first class is what Einstein-Anderson-Johnson included in "bed load" and the latter they called "wash load." It is believed that it would be better to use the term "bed-material load" for the portion which they called "bed load" but to adopt their term "wash load" for the other portion. The use of the term "bed material load" gives an exact and self-explanatory term for this part of the load and eliminates the anomaly of calling a material "bed load," a considerable proportion of which may be carried in the upper half of the flow.

The use of the terms "bed-load sampler" and "suspended-load sampler" to designate the two types of sediment samplers is probably too well established to attempt to change, but it is apt to be somewhat in conflict with any definition of bed and suspended load which may be adopted, unless bed and suspended load are defined as material caught in bed- and suspended-load samplers, respectively. The material collected in a bed-load sampler is dependent on the type of sampler and the materials used in its construction and, therefore, with any other definition such an instrument will sample all the bed load only by coincidence. Since it probably will never be possible to separate particles moving in saltation from those in

suspension, a so-called suspended load sampler will sample both in the rare cases when it takes a sample in a zone where saltation load is moving. If these limitations of all forms of sampler are kept in mind, no great difficulty should arise in using the current terms for the classification of these sampling instruments.

Another need for definition or standardization is in the terms for expressing the amount (weight or volume) of material transported by a stream in a unit time. Gilbert used the term "load" in this sense. According to him one might say for example: "the load of the stream is ten pounds per second." Gilbert did not use the term "bed load" or "suspended load," but these are now so generally used that it is unlikely that they will be abandoned. The current use is to attach the word "load" to "bed," "suspended," "saltation," "traction," etc. to designate the material being transported in that specific manner. When it is necessary to designate the amount carried per unit time a word such as "discharge" would have to be added, as for example, "sediment discharge," "bed-load discharge." In view of the widespread use of the term "load" with other meanings, it is suggested that the word "discharge" be used when the amount of material transported per unit time is meant.

Summarizing, the author would recommend the term sediment for the general classification of non-floating material moved by a fluid and would recognize four types of movement of sediment: sliding, rolling, saltation, and suspension. The first two could be combined as "rolling-sliding" or "contact" and the first three as "traction." "Bed load" would be defined as coarse sediment in motion on or near the bed. "Bed-material load" would be defined as the sediment load composed of sizes readily available in the bed, and "wash load" as that composed of sizes not readily available in the bed. The total load could thus be divided into parts in four different ways as follows: (1) rolling-sliding or contact load, saltation load, and suspended load; (2) traction load and suspended load; (3) bed load and non-bed load; and (4) bed-material load and wash load. The word "load" should be used only in referring to a material in motion and the word "discharge" should be used in referring to the amount of material moved in terms of volume or weight per unit time.