ARTIFICIAL CONTROL SECTIONS FOR RIVER MEASUREMENT STATIONS.*

By John C. Hoyt, C.E.,
Hydraulic Engineer, in Charge Division of Surface Waters, U.S. Geological Survey.

THE elevation of the water surface of a stream flowing in an open channel is determined from point to point by a succession of controls that may conveniently be referred to as control sections. These control sections of the stream may be dams or weirs, crests of rapids or abrupt falls, bars of rock extending across the river, or, where the channel is permanent and the slope is uniform, long stretches of the river bed. The water surface above each control section is determined by the height of water at the control section.

Computations of daily discharge are based on the assumption that so long as the character of the river at the control section remains unchanged the discharge will remain constant for the same stage and will vary with the stage according to some definite law. It is, therefore, possible to determine the daily flow of streams with permanent controls by a comparatively few discharge measurements and daily observations of stage. Unfortunately, however, the beds of many streams are composed of materials which render them liable to frequent changes in cross-section, which destroy the relation between stage and discharge and make the determination of daily discharge difficult.

For the past two years the water resources branch of the U.S. Geological Survey has been experimenting with various types of structures for the improvement of the channels of changeable-bed rivers, in order to obtain permanent control sections. These experiments show that on many streams it is feasible to construct at a reasonable expense controls that will insure conditions sufficiently stable to permit the use of ordinary methods in determining the daily flow.

In the design and construction of a control, care must be taken not to modify the cross-section or alignment of the stream to such an extent as to change the natural conditions of approximate equilibrium. Therefore, the control should follow closely the natural bed of the stream and should not project far into the channel.

In addition to maintaining a constant relation between discharge and stage, the control section also determines the relative change in stage corresponding to a given increment in discharge. This relation is spoken of as the sensitiveness of the station. For example, a station at which the addition of 100 second-feet discharge will change the stage .02 of a foot would be considered less sensitive than one at which this discharge will change the gauge height a tenth of a foot or more. The accuracy of records for a station will vary with its sensitiveness.

The most successful control so far constructed consists of a low submerged dam which in many places may be made on a reef or bar of gravel or boulders by grouting with cement. In other places it may be necessary to excavate the bed and build a concrete structure or to drive sheet piling across the section nearly flush with the bottom. Such structures will tend to prevent scour and at the same time so limit the channel that the natural current reduces the probability of silting.

Structures which project far into the cross-section of the stream will usually destroy the sensitiveness of the station and, in addition, will so interfere with the natural condition of flow that counteraction is set up, making them hard to maintain.

The construction of artificial controls make it possible to obtain accurate records of the flow of streams on which, prior to the use of such controls, accurate records could not be obtained except at great expense. The cost of constructing control sections on ordinary small streams ranges from $10 to $100; the cost of operation of a station with a permanent control is reduced to a minimum by the small number of meter measurements that are necessary.

*Cornell Civil Engineer.

RETAINING WALLS FOR SOFT FOUNDATIONS.

IN railway work the occasion frequently arises where a retaining wall is to be built on soft and insecure underlying ground, and where the whole of the railway company's right-of-way is valuable, under these conditions the proper selection of the type of wall is somewhat of a problem. In such a case the functions of a retaining wall are:—

(1) It should retain the railway embankment laterally.

(2) It should be vertical or nearly so to avoid reduction of width of right-of-way.

Of the several types in use, *viz.*, the heavy front batter mass wall on natural foundation, the block wall, the cellular wall and the mass wall on piles, the following advantages and disadvantages are noteworthy:

The block wall is economical; settlement in an irregular manner will not be conspicuous; it may be constructed in several stages; it does not occupy much space before filling. As disadvantages the heavy front batter causes a waste of property which will encourage encroachments, and unless built with a smooth front batter will encourage trespassing. Because of its loose-jointed nature, the block wall does not, under some circumstances, possess as much of a potential factor of safety against the unforeseen contingency as a monolithic structure.

The heavy batter mass wall is economical but will cause criticism if it settles or tips appreciably, and is subject to the same objections as the block wall on account of the heavy front batter.

Advantages of the cellular wall: It occupies the right-of-way in such a way as to afford little opportunity for encroachment. It may settle considerably, but offers great resistance to overturning or sliding. It permits of ready driving of a pile trestle directly over it. Disadvantages: It occupies considerable space before filling and may thus interfere with the use of tracks. Settlement may also give an unpleasing appearance.

The mass wall on piles gives maximum security, but is expensive and may lead to difficulties, because of possible damage, which the pile driving may do to adjacent buildings on insecure foundation, a consideration which was given much weight in the search for a substitute for the structure on piles.

These conclusions are from the result of an investigation carried out by the Chicago, Milwaukee and St. Paul in the course of about 1½ miles of grade separation work in Milwaukee. Improved ground, attended by considerable settlement, led to a study of various types and to tests of the block and cell walls. Of the two, the cell wall is being favored in Milwaukee on account of the fuller utilization of the right-of-way. A full report of the tests performed appears in a paper read before the Western Society of Engineers by Walter S. Lacker, on February 8th, 1915.