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For THE CANADIAN ENGINEER.

RAILWAY ENGINEERING.*

BY CECIL B. SMITH, MA. E., MEM. CAN. SOC. C.E., ASSISTANT PROF. OF CIVIL ENGINEERING IN M'GILL UNIVERSITY.

CHAP. V.

ROADBED CONSTRUCTION.

ART. 15.—WATERWAYS.

The construction engineer, after retracing the centre line, and checking levels, and establishing additional B. M.'s, if necessary, should verify and complete the list of structures fixed upon by the survey party.

The class of structure will depend upon the money and material available, but its cross-section, if it is a waterway, will depend on the *maximum* flow of water it is expected to carry, while if it is a cattle pass or public crossing, its *minimum* dimensions will be fixed by law. Many causes affect the maximum flow of water across a railway roadbed, at a given point, besides the drainage area; in the case of small streams or local watersheds, the building of the roadbed, and consequent roadbed and catch-water ditching, will concentrate the flow, from quite a large area, in a culvert that would naturally have had much less flow to accommodate; this should be anticipated. Then, again, the construction of a railway in a new country will induce such activity as will cause large tracts of forests to be cleared off, and in a few years these cultivated areas will allow storm waters to pass off more rapidly than when the same area was in forest, which should therefore be anticipated and provided for. If the drainage area is in a nearly level country, water will arrive at a given point more gradually than if the slope of the country is abrupt; and also the shape of the drainage area and distribution of tributaries has a marked effect on the maximum flow. If a long stream has few and small branches, the maximum flow will be much less than where there are more and larger tributaries and less main streams, the total area being the same, especially if they empty just above the railway. In this case the flood water from all of them may arrive about the same time. Stony ground, also, sheds water much more rapidly than mellow and highly cultivated ground, and small areas are more liable to *abnormal* floods than large ones, because cloud bursts seldom occupy large tracts of country.

All such considerations should be weighed along with that of acreage, which should be determined, roughly, by personal examination, for every area large or small draining toward and across the railway under construction. There are several empyrical formulæ, purporting to connect the square feet of waterway required with the acreage drained, but they, necessarily, contain a co-efficient which varies with so many causes, such as those just given, as to make them difficult of application, even leaving out of question, the variation in rainfall in different localities. Indeed, it is the greatest rainfall for short periods that is the most important factor, and records of this are usually deficient.

The carrying capacity of a box or arch culvert may be made a maximum by digging straight wide approaches and offtake ditches, and by building flaring wings at each end to avoid contraction, and may be abnormally increased by designing it to carry a head of four or five feet of water in an emergency, which of course, increases the velocity—this, however, is hardly safe practice.

Baker's "Masonry Construction" has these formulæ:

(1) *Myer's.*—Area of waterway in square feet = $C \sqrt[2]{\text{drainage area in acres}}$. In which $C = 1$ for rolling prairie, $1\frac{1}{3}$ for hilly ground, 4 for rocky precipitous ground. This formula, Baker considers, will give too large results for small areas, and too small results for large ones.

(2) *Talbot's.*—Area of waterway in square feet = $C \sqrt[4]{(\text{Drainage area in acres})^3}$. In which, $C = \frac{2}{3}$ to 1 for rocky precipitous ground, $\frac{1}{3}$ for rolling ground, landing floods and snow at same time, and $\frac{1}{5}$ to $\frac{1}{6}$ for long narrow valleys with little or no snow. This formula, used with judgment, will probably give as good results as can be expected, where there are so many varying conditions.

Aside from any data as to acreage, etc., the high water mark at some narrow point in the channel may be noted, information from old residents as to abnormal freshets gathered, the waterway under any existing highway bridges measured, and any other influences noted bearing on the maximum flow, such as the rain records for

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