Paper No. 245
Year 194[illegible]

RAINFALL RUNOFF

S.D. KHANGAR AND N.D. GULHATI

Paper No. 245
Year 1941

RAINFALL RUNOFF

By

S.D KHANGAR AND N.D. GULHATI

The design of storage and drainage schemes requires evaluation of rainfall runoff from a given catchment area. In 1885 the design of inlet structures and syphons on the Lower Chanab Canal was based on 31 cusecs per square mile or catchment area. However with the passage of time the intensity of flood reaching these works has fallen. It is thus necessary to have a definite solution for calculation of runoff. To determine the volume of runoff for storage schemes, it is also required to know the frequency with which a rainfall of a given intensity would occur.

Meteorological department keeps record of rainfall by means of Symon's Rain Gauge. Punjab Irrigation department also maintains a number of Rain Gauge Stations. These rainfall records only supply total daily rainfall, but give no information of the duration or intensity. Since 1930, an Integrating Rain Gauge has been installed at Lahore which record variation of storm with time. A mere record of total daily rainfall without a knowledge of its duration and time cannot be of much use in calculating probable runoff.

In the absence of adequate rainfall record, indirect methods for obtaining the probable form of rainfall curves have to be applied. All rainfall curves for any total rainfall will generally fall below the graph of the most intense rainfall. The graph of the heaviest storm obtained by Integrating Rain Gauge at Lahore conforms with the graph obtained analytically for the most intense rainfall.

Intensity of rainfall varies from place to place. The rainfall record at Charapunji for different stations leads to the following conclusions :

1. That the rainfall recorded at any rain gauge is a true index of the intensity of the storm for a limited area around it, and
2. That there may be areas between neighbouring rain gauge stations that may receive no rainfall ar all, or very much in excess of, or less than that recorded by any of those stations.

Various investigations have been made for correlating variation in the intensity of rainfall with area but these have not led to any definite results.

Estimation of total rainfall in an area can be obtained by closely and uniformly spaced rain gauge stations. It is recommended that rain gauge stations in the irrigation areas of Punjab should be spaced not more than 7 miles apart in either direction, and atleast 10% should be of the integrating type.

Rain gauges are installed in the open. The rainfall that can produce runoff is always less than that recorded by a rain gauge. No accurate estimate exists of the quantity which should be deducted on this account. From observations made in America it was concluded that 70% of the rainfall recorded in open, reaches the ground. the amount of water held by foliage crops will vary with:

(i) The intensity of rainfall
(ii) wind action during and after the storm
(iii) Thickness and nature of foliage and kind of crop

The losses are due to evaporation, transpiration by plants and absorption into subsoil.

Thus, Runoff = Ground rainfall - Absorption and Evaporation. Buckleys and Harrington experimently estimated that evaporation and transpiration losses are of the order of 1/100 and 1/130 inch per hour respectively. The loss due to infiltration into the soil is the principal loss. Kennedy observed by experiments that absorption losses vary considerably for different kinds of soils. Also the absorption losses decrease with the duration of flood. In general absorption losses depend on temperature changes, packing of soil, soil moisture content, shrinkage and swelling of soil. Further work in this area is required to establish the infiltration rate.

Topography of the catchment area also effects the rainfall runoff in different ways. When the width of catchment measured from the drain to the watershed is narrow, it results in higher intensity runoff as compared with wider catchment. A steep slope has the same effect. The effect of natural or artificial pondage in the area is considerable. In cultivated areas field dowels provide immense storage capacity depending upon the height and strength of the dowels and sometimes there is no runoff.

To determine runoff for any storm the factors involved are so varied and interdependent that only a simplified case under ideal conditions can be considered. The assumptions are that area considered is small, absorption losses and velocity of storm are uniform over the catchment area, there is no vegetation, natural or artificial pondage and the quantity of water flowing over the catchment during the storm is ignored. The area is divided into a number of strips and sheetflow runoff is assumed although actual flow is in the form of small streams and there are obstructions to flow. The runoff is then determined by drawing graphs of the rainfall in strips against time. The design discharge of a drain should generally be based on intensities likely to occur once in three years. At present no graph of rainfall exists to establish the frequencies of rainfall of various degrees and therefore indirect methods have to be adopted for determining the probable runoff. In rivers, a discharge which has a frequency once in three years is about 1/4th to 1/3rd of the maximum flood discharge ever recorded. On this analogy, from the maximum intensity rainfall hydrograph, the discharge for a drain may be designed.

Corrections are to be applied to the simplified case to determine the actual runoff. The correction to absorption losses can be accounted for by a modification of the absorption line along the ideal curve. Difference in infiltration capacity of various soils can be approximated by weighted average infiltration rate. The velocity of flow in the beginning and at the end of the storm would be less than theoretical whereas the peak flow velocity would be higher than theoretical value. It is not proposed to make any allowance for natural pondage over the catchment as the initial pondage may be nil. For the application of correction on account of cultivation, it is considered that banjar areas are wholly effective, while 10% of canal irrigated area may be considered equivalent to banjar area, and 80% of barani and chahi area may be regarded as banjar area, Experience shows that effective area of drain in flat irrigated tract does not exceed a strip of 1.5 miles width on either side of drain. The determination of average height of hydrograph depends upon inlet time. To solve a particular problem it is necessary to first assume a value of time, draw a hydrograph, determine height of hydrograph and then recalculate time. If the calculated time does not agree with the assumed value, repeat the process until the difference is negligible.

When considering large catchment area, the intensity of rainfall may not be uniform and the flood discharge flattens out as it proceeds down a drain. The actual flattening that occurs in a particular case would depend upon the intensity of discharge, the duration of peak, size of the channel and amount of spills form the channel. The runoff per square mile for larger area would therefore be less than that for smaller catchment. It has been analysed that runoff varies as two-third power of the area.

It is suggested that the number of rain gauge stations and integrating rain gauges should be increased to determine more accurately the frequency of storm of high intensity. Some observations are necessary to have a good estimate of the inlet time. The observation of runoff should be extended to areas other than Lower Chanab Canal, presently being done to establish a general equation for Punjab drainage system.

Note :

Paper No. 245 appeared in the Proceedings of Engineering Congress 1941, Vol. XXIX at pages 129 to 173. This lengthy paper has 8 Plates and 18 Figures. Discussions are recorded at 27 pages from 174a to 174aa. The paper has detailed formulae and arguments to which the reader may refer.