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Development of Rainfall Intensity Nomographfor Parbhani District, Maharashtra

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ABSTRACT: *It is necessary to know the maximum flood that a structure will have to handle during its life period for economic design. Rainfall intensity-duration-frequency relationship provides valuable information for the use of design engineers or hydrologists, in designing runoff controlling structures for moderating flood control projects. Inadequacy of such information will lead to wrong assumption and unjustified use of factor resulting in heavy expenditure. This study was confined to Parbhani(Marathwada region, Maharashtra). Rainfall charts of 23 years were analyzed in the form of annual maximum series of the selected duration viz; 5, 10, 15, 30 minutes and 1, 2, 3, 6, 12 and 24 hrs. Rainfall intensity duration and return period equation was developed for Parbhani station (assured rainfall zone). The values of "a" and "b" were determined by using graphical method and the values of "K" and "d" by least square method. The values of the constants K, a, b and d were found be 12.44, 0.1739, 1.0, 0.871 respectively. The nomograph was developed for Parbhani station from IFD relationship. The percent deviation in rainfall intensity values observed frommathematical and corresponding nomographic solutions is in the range of -18.2 to 15.7 percent, which lies within the accepted limit.*

Keyword: *Nomograph, Rainfall intensity- duration frequency, Return Period.*

INTRODUCTION

Rainfall intensity is an important parameter in the rational method which is used for determination of design rate of runoff. This runoff is used for designing soil and water conservation structures. The rainfall intensity in this equation depends on the rainfall duration and rainfall frequency. As the rainfall frequency increases, the rainfall intensity increases and as the rainfall duration increases the rainfall intensity decreases. Thus there is definite relationship between rainfall intensity-duration and frequency for a particular location. This relationship in the form of equation and nomograph can be developed with the analysis of rainfall charts for maximum number of year.

Since the relationship between rainfall intensity duration and return period is specific for a particular location and mainly depend upon the physical characteristic of rainfall, the relationship developed for one particular location cannot be superimposed on the other. Among other factors, the amount of runoff is determined by rainfall intensity, duration and amount. Farm terraces, culverts, bridges, and flood control structures are designed on the basis of safely conveying from rain storms of specified frequency, intensity and duration. Hence it is necessary to develop such relationship for small units in order that their reliability and applicability have greater practical significance.

MATERIALS AND METHODS

In order to linearize the frequency distribution, use of probability paper is made, Hazen (1914) suggested the use of probability paper for linearization of normal distribution. The linearization makes the extrapolation or comparison easy. Ram Babu *et al.* (1979), Ranade and Gupta (1988) used the log normal probability paper for frequency analysis. Frequency lines were plotted by using 'computing method' developed by Ogrosky and Mockus (1957) and use of annual maximum value to obtain independent events which are essential in hydrologic frequency

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analysis was made. While analyzing the rainfall data, the adequacy of the length of available record is needed to be determined for reliable results. The minimum acceptable years of record were determined, by using the equation suggested by Mockus (1960). The values for minimum acceptable years were found 20 years for all durations.

Various equations that were found to represent the Rainfall intensity-duration-return period relationship in India and abroad, are summarized and discussed by Raghunath *et al.* (1969).However most satisfactory general equation is of the form as given in equation 1.

$$I = \frac{KT^a}{(t+b)^d} \qquad (1)$$

Where,

I = rainfall intensity, cm hr^{-1}

T = Return period, year

t = Duration, hour

K and b = Derived constants

a and d = derived exponent

In present study raingauge charts of 35 years were obtained from 1977 to 2011 from Meteorological Observatory, Department of Agricultural Meteorology, MKV, Parbhani. Which lies at 76°47′ E longitude are 19°16′ Nlatitude and 409 m above mean sea level.Climatically the area falls under tropical zone with annual rainfall is in range 700 to 900 mm. The rainfall charts were analyzed in the form of annual maximum series for various durations *viz*. 5, 10, 15, 30, 45 minutes and 1, 2, 3, 6, 12, 24 hours. The maximum depth of rainfall for various durations was worked out by using "Original trace method" Ram Babu*et al.* (1979). The plotting positions were obtained by using the 'computing method' suggested by Ogrosky and Mockus (1957). The rainfall intensity-duration and return period equation was developed using steps Ram Babu *et al.* (1979).

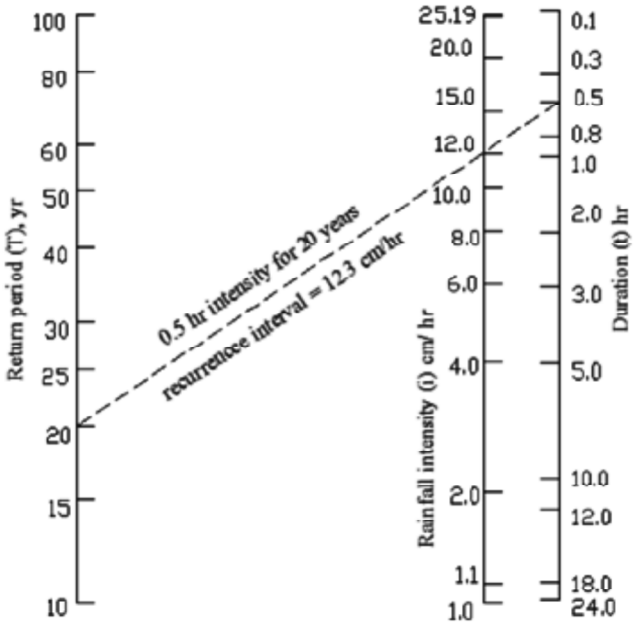

Figure 1: Nomograph for solving intensity-duration-return period equation at Parbhani

The values of rainfall intensities for all durations were plotted on Y-axis and values of return period on X-axis on log-log paper. The geometric mean slope ($\bar{m}$) for the set of frequency lines was determined. The geometric mean slope of the lines represents the exponent '*a*' in the intensity-duration-frequency relationship. A line representing the geometric mean slope was drawn at the base of a graph of frequency distribution lines passing through the origin. The solid lines parallel to this geometric mean slope line were drawn against the dotted lines for different durations. So as to cut the Y-axis against 1-year return period. The values of one year rainfall intensities for different durations were plotted on Y-axis against selected duration on X-axis of log-log paper. The points so plotted are not fall in a straight line. Marked all the points to fall in one straight line, suitable constant '*b*' is to be added to all the values of durations. After adding this constant in the values

Table 1
Comparison between calculated and nomographic intensities of rainfall (cm/h)

	'I'$_{cal}$, cm/h			*'I'$_{nomo}$, cm/h*			*Per cent deviation*		
Duration min / h	*10*	*25*	*50*	*10*	*25*	*50*	*10*	*25*	*50*
15 min	15.3	17.9	20.2	14	16.5	22.2	8.5	7.8	–9.9
30 min	13.0	15.3	17.3	10.5	12.8	14.2	17.7	16.3	17.9
1 h	10.2	11.9	13.4	8.3	10.2	11.8	18.6	14.3	11.9
3 h	5.6	6.5	7.3	4.8	5.6	6.6	14.3	13.8	9.6
6 h	3.4	4.0	4.5	2.8	3.4	3.8	17.6	15.0	15.6

of durations the points were aligned into a straight line. The constants '*K*' and '*d*' are determined by least square method. In this method the values of one year rainfall intensities for selected durations are used. A nomograph is an alignment chart consisting of a set of suitably graduated parallel scales. The procedure suggested by Luzzadar (1964) was adopted for development of nomograph. The stepwise procedure followed for the development of nomograph. In the present study there are three variables *viz*. rainfall intensity, duration and return period. Thus alignment charts should have three parallel scales, so graduated that a line which joins values on any two scales intersects the third scale at a point which satisfies the given equation. The developed nomograph for Parbhani is shown in Fig. 1.

RESULTS AND DISCUSSION

Based on the 35 years maximum rainfall intensity data for varying duration, a relationship between rainfall intensity-duration-return period was developed for Parbhani region. This relationship is found to be of the following form.

$$I = \frac{12.44T^{0.1739}}{(t+1.0)^{0.871}} \qquad (2)$$

By using the equation (2) the intensity for duration, t upto 24 hours and the return period, T upto 100 years can be determined.Per cent deviation of rainfall intensity values estimated from nomograph Fig.1 and those calculated from corresponding mathematical equations (1) for various durations for 10, 25, 50 years return period are given in Table 1.

The data revealed that the maximum deviation in the values of intensities obtained from mathematicalrelationship of intensity-duration-return period equation and corresponding nomographic solutions is in the range of -18.2 to 15.7%. Which is less than the accepted range of 20 percent .Thus the nomograph developed in the study can be used for obtaining the solutions of rainfall intensity-duration-return period relationship. Such handy tool will be of use for designers as well as field workers engaged in soil and water conservation for computing peak runoff rate using rational formula.

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