確率降雨強度式に関する一考察

Intermediate Duration-Rainfall Intensity-Frequency Curves

高知大学　○G.D.Uligan・松田誠祐・大年邦雄・篠　和夫

INTRODUCTION: The common technique for estimating a design rainfall to develop an intensity-duration-frequency (IDF) curves mainly involves the frequency analysis of observed annual maximum rainfall values with various durations. The present study however, has developed the IDF curves not by frequency analysis of observed rainfall but by frequency analysis of time concentration of rainfall. This method provides an easy and better way of constructing an IDF curves for intermediate durations ranging from 1 to 24 h for any location in Japan.

DATA SOURCES AND METHODS: Data from the Japan Meteorological Agency(193 station), Shikoku(13 station) and AMEDAS(137 station ,1983-1992) are utilized in the analyses. The annual maximum 24 h rainfall(R_{24}) were extracted from the tabulated hourly rainfall data from 206 selected meteorological observatory throughout the country.

1. Time concentration(C_t) of a rainfall: Time concentration which represents the distribution of rainfall with time (Matsuda et al,1995)designated as C_t, is expressed as

$$C_t=\log_{10}(r_t/r_{24})/(\log_{10}(24/t)) \quad (1)$$

where r_t and r_{24} are the t-h and 24 h rainfall intensity in mm/h , respectively.

2. Frequency analysis and the Slade type III distribution : The magnitudes of 24 h rainfall event are separated at interval of 10 and 20mm for less than and greater than 100mm, respectively(±5% included). The conventional frequency analysis of time concentration values for the corresponding R_{24} was performed. The Slade type III probability distribution was utilized to transform time concentration into normal variables. A Simplified equation is

$$\xi^T = \alpha_t * \log_{10}\left(\frac{C_t}{C_{ot}} * \frac{g_t - C_{ot}}{g_t - C_t}\right) \quad (2)$$

where ξ^T=normal variable for a given return period T; α_t=fitting parameter to simulate the normal distribution; C_t=unit time concentration of rainfall; g=upper limit value of C_t and C_{ot}=numerical value obtained when the average ξ^T=0

RESULTS AND DISCUSSION

1. Time concentration(C_t): The degree of time concentration of rainfall for various unit time (1,2,4 and 8h) were calculated using Eq. 1. The slope of the time concentration becomes steep as unit time increases (Fig. 1). Consequently, C_t values also increased.

2. Transformation of C_t to normal variables: One important factor which influence the fitting of the transformed variables is the value of the upper limit g in the Slade type III distribution. Selection was based on which equation provided the best fit to the normal line(i.e. find the equation of the upper limit g that yields the smallest error for the cumulative frequency Fig. 2). The slope of the upper limit is inversely proportional to the unit time of the time

Table 1: Parameters of the Slade type III distribution.

t(h)	Upper limit(g)	Alpha(α)	Average(C_0)
1	2.795−0.725*Z	3.274	0.776−0.155*Z
2	2.198−0.441*Z	2.931+0.151*Z	0.942−0.194*Z
4	1.699−0.189*Z	2.863+0.173*Z	1.149−0.241*Z
8	1.583−0.158*Z	3.938−0.393*Z	1.362−0.278*Z

Note: $Z=\log_{10}(R_{24})$

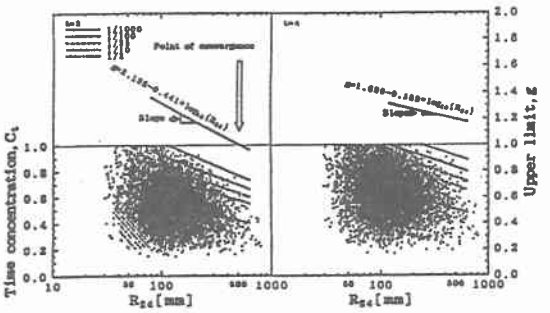

Fig. 1 Relationships between the time concentration, upper limit and R_{24}.

concentration. Values are summarized in Table 1. Probability of exceedance of time concentration(C_2 and C_4) for selected return period were calculated by substituting values(Table 1) in Eq.2(Fig 1).

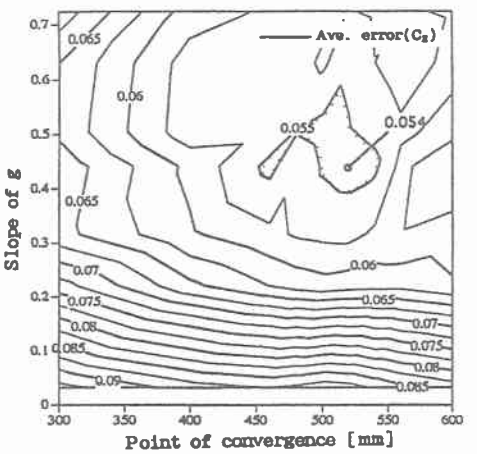

Fig. 2 Relationships between slope, point of convergence of g and average cumulative error.

3.Intensity-duration-frequency (IDF)curves: The steps used to construct IDF curves with a given 24 h rainfall magnitude and return period for an area are the following.

1. Obtain parameters of the Slade type III equation with respective rainfall duration in Table 1, and substitute values in Eq. 2 for a desired frequency of time concentration.

2. Again, substitute the foregoing values in Eq.1 for the average intensity.

3. Finally, plot the relationships between rainfall intensity, duration, and frequency. Figure 3 shows an illustrative example of the intensity-frequency curves developed for Kochi station, Japan.

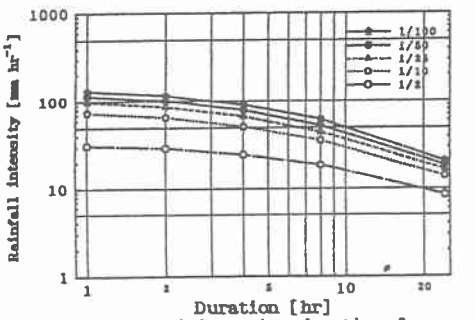

Fig. 3 Rainfall intensity-duration-frequency curve for Kochi, Japan.

CONCLUSION: A computational method is presented to develop IDF curves for durations ranging from 1 to 24 h. The results obtained contain much information of potential value for estimating the average rainfall intensity which is likely to occur at any station in Japan.

REFERENCES

-Japan Meteorological Agency (JMA):Annual Report 1994, No. 1, pp. 1-52, No. 6, pp. 132-133,Tokyo,Japan.

-Matsuda, S., Uligan, G.D. and Ohtoshi, K,1995: A method for estimating the probable 1 h rainfall based on the time concentration of a heavy rainfall, Annual Journal of Hydraulic Engineering, JSCE, Vol.40,pp.279-284,1996.