International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 6(D); June 2018; Page No. 13359-13362
DOI: http://dx.doi.org/10.24327/ijcar.2018.13362.2379

Research Article

RAINFALL ANALYSIS FOR THE DEVELOPMENT OF IDF RELATIONSHIPS- A CASE STUDY OF VALSAD CITY

Vivek D.Chaiwala and Kushang V Shah

Civil Engineering Department, Parul University of Baroda

A R T I C L E I N F O

Article History:

Received 11th March, 2018
Received in revised form 6th April, 2018 Accepted 26th May, 2018
Published online 28th June, 2018

A B S T R A C T

Rainfall Analysis is first approach for designing hydraulic structures. This research work includes the most accurate methodology for developing Rainfall Intensities-Duration-Frequencies (IDF) relationships. Valsad city is taken as study area to obtain IDF relationships. For this, first necessary step is proper understanding of rainfall pattern and development of IDF curves. Daily Rainfall data (1987-2017) from State Water Data Centeris collected forValsad city. Data was analyzed by Flood Frequency analysis & Gumbel's extreme value distribution to derive probabilities of daily maximum rainfall events using spread sheet., Rainfall intensities were derived for 60, 90, 120, 180,240, 360, 480, 720, 1440 min of duration, this intensity duration relationship were plotted with log-log plot for 5, 25 & 50 year return period. This particular return period can adopted for storm water management and flood forecasting. Relationship of rainfall intensity with concentration time for a given frequency of occurrence for 10 min & 15 min intervals were plotted to generate IDF curves.

INTRODUCTION

Today's world is facing mainly natural hazards like earthquakes, cyclone, flood etc. flood is main reason of disaster and for prevention of it becomes necessary to study and analyze its changing pattern of rainfall for different regions to forecast its effects and its utilization for proper planning, management and design of Water resources & Hydraulic structures.

Here for Valsad city and its analysis of daily rainfall data to evaluate the effect of climate change and establish Rainfall Intensity-Duration-Frequency relationships which ultimately gives proper management of water resources and design considerations of hydraulic structures for flood management of Valsad.

Study Area

Historically, Valsad Co-Ordinates: 20.610°N, 72.926°E is a small town covered with forest, with production as a major regional industry and it is also covered rivers like Auranga River, Waki River. It was a part of regional kingdom before colonial era. It was made a district during the Bombay Presidency era, and was governed under Bombay State during the colonial era, following independence (prior to the creation of the state of Gujarat).

Auranga Riveris a river in western India in Gujarat whose origin is Near Bhervi village. Its basin has a maximum length of 97 km.

Figure 1 Study area

Corresponding author:* **Vivek D.Chaiwala
Civil Engineering Department, Parul University of Baroda

The total catchment area of the basin is 699 square kilometres (270 sq mi). Most of the precipitation here falls in July, averaging 778 mm.Kaprada, DharampurPardi, Umergam and Vapi towns in the district are the worst-hit with continuous rains- July 29, 2014, 11:42 PM IST.

METHODOLOGY

Past years rainfall data (1987-2010) from SWDC center (Gandhinnagar) were collected for rain gauge station of SWDC situated at Vadodara city to analyze rainfall pattern and to develop IDF curves relationship.

Annual rainfall Analysis (1987-2010)

The statistical analysis of the collected daily rainfall data gives an average Annual rainfall Value. This analysis further shows moving average & climate change analysis.

Monthly Rainfall Analysis (1987-2010)

The number of rainy days for each month and year were worked out for period of 1987-2010 23 years) and the change was observed by plotting them along with the average values for the period. The change in the maximum daily rainfall pattern over a large span can be determined by working out an average value for each decade and a plot prepared to observe the change. The analysis was also carried out for monthly rainfall pattern for the study period along with the number of rainy days in each month.

Daily rainfall Analysis (1987-2010)

Using Daily rainfall data, one day maximum annual rainfall values are worked out.

Probability Analysis for One Day Annual Maximum Rainfall

The purpose behind frequency analysis of an annual series is to obtain a relation between the magnitude of the event and its probability of exceedance. It is a simple empirical technique to arrange the given annual extreme series in descending order of magnitude till the last event for which m equals the total number of record N and to assign an order number m (5542-2003). The probability P of an event equaled to or exceeded is given by the Weibull formula,

$$P = m/N+1 \tag{3.1}$$

The recurrence interval or return period,

$$T = 1/P \tag{3.2}$$

According to (IS: 5542-2003) 15 % increase shall be made in the daily maximum raw data and then after the data can be used for analysis.

Development of IDF curves

All city data are analyzed to obtain extreme short rainfall intensity values.

IDF by using Daily Rainfall data (1987-2010)

The daily rainfall values after correction according to IS: 5542-2003 were converted into hourly rainfall data using following method.

Shorter Duration Rainfall Data generation using SWDC Daily Rainfall Data Series

The extreme value series is used to generate shorter duration series (60, 90, 120, 180, 240, 360, 480, 720, 1440) by employing the IMD formula given as:

$$Pt = [P24\ (t/24)\ (1/3)] \tag{3.3}$$

Pt = rainfall of t mins duration in mm, P24 = daily rainfall value in mm, t = time duration in mins

Derivation of rainfall intensity

Rainfall intensity for Pt for different duration of time is obtained using standard formula,

$$i = Pt / D \tag{3.4}$$

Where, D = Duration of event in hours

Derivation of IDF curve by Gumbel's Extreme Value Distribution:

Method refers following equation to evaluate Rainfall intensity (XT) in mm/hr

$$(XT) = Xm + Kt\ s. \tag{3.5}$$

Xm = Mean, s = standard deviation, Kt = Frequency factor for return period T.

Where, Kt = √6/□ [0.5772 + ln {ln(T/T-1)}] (3.6)

Determination of Constants

The values of intensity and duration obtained from (3.5) were used to obtain the constants in the intensity equation suggested by CPHEEO manual, India by equation,

$$Log\ (i) = log\ (a) - n\ log\ (T) \tag{3.7}$$

Where, i = Rainfall intensity in mm/hr, T = Duration event of the storm in minutes, „a‟ & „n‟ are constants The log-log plot can be obtained using intensity (i) and duration (t) values from table for 1 year and 2 year return period.

IDF curves for 5 year, 25 year and 50 year Frequency

Using the constants of the rainfall intensity equation obtained from log log plot, the IDF curves were developed for 5 year return period 25 year return period as well as 50 year return period.

RESULTS OF ANALYSIS

Results of Annual Rainfall Analysis

Annual Rainfall analysis gives following results:
Average annual rainfall - 1827.05958 mm, Maximum rainfall period – July and August

Minimum Rainfall – 881.20 mm, Maximum Rainfall – 3032.00 mm

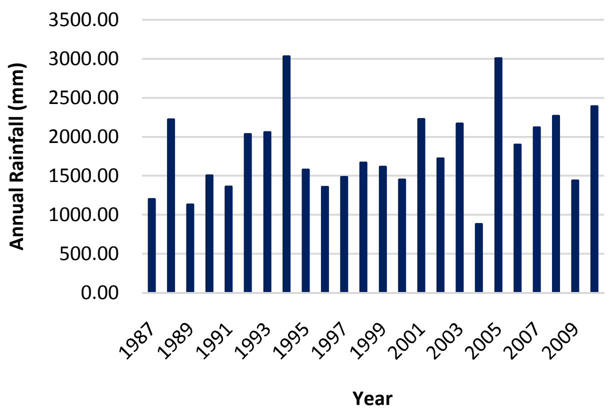

Figure 1 Annual Rainfall of Valsad City (1987-2010)

Results of Monthly Rainfall Analysis (1987-2010)

The Change was observed by plotting monthly rainfall values and Rainy days with monsoon period (months). Average number of rainy days for the study period 9.8 days per month and the average monthly rainfall is 1827.06 mm.

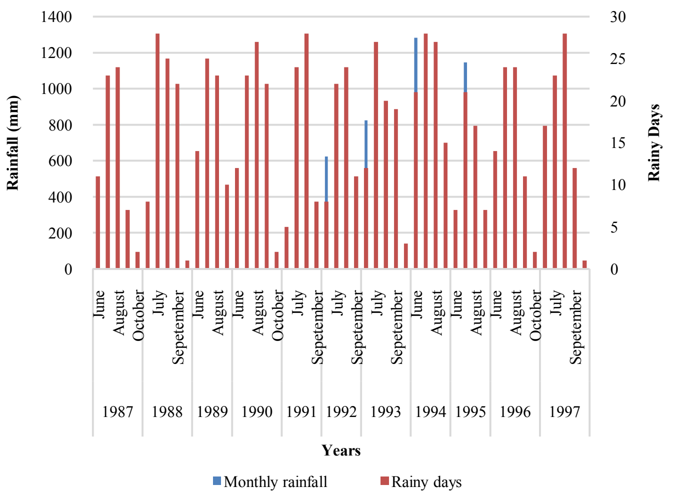

Figure 2 Monthly Rainfall Analysis (1987-1997)

Same plot can be obtain for year 1998-2010.

Results for Daily Rainfall Analysis and Probability Analysis for One Day Annual Maximum Rainfall (1987-2010)

Probability (P) for Maximum one day maximum Rainfall of 1420 mm (corrected daily maximum according IS:5542:2003) is 0.0213 and Return period (T) is 47 years .

Probability (P) for Minimum one day maximum Rainfall of 393 mm (corrected daily maximum according IS:5542:2003) is 0.9787 and Return period (T) is 1 year.

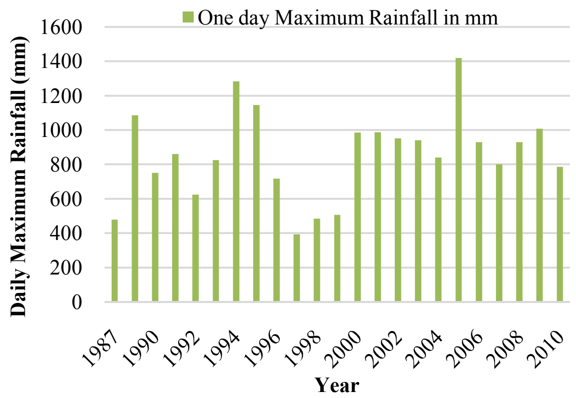

Figure 3 One-Day Annual Rainfall

Results showing Development of IDF curves

Derivation of IDF curves follow Gumbel's extreme value distribution, by applying equations (3), (4) the extreme value series (rainfall intensities) were presented for shorter duration series (60, 90, 120, 180, 240, 360, 480, 720, 1440) to have Mean and standard deviation.

Table 1 Mean and standard deviation values

Mean	342.0	261.0	215.4	164.4	135.7	103.5	85.5	65.25	41.10
Standard devation	101.7	77.6	64.0	48.9	40.3	30.8	25.4	19.4	12.2

These values of mean and standard deviation were applied in equation (5) to have rainfall intensities in mm/hr in which frequency factor can be obtained from equation (6) which are -0.7195 , -2.0448 and -2.5936 for 1 ,2 and 3 years return periods (Mentioned in CPHEEO journal, India for parameter considerations of storm water management system) respectively. Table shows the intensity duration relationships for 5,25, and 50 years return periods.

Table 2 Intensity duration frequency relationships

for years	5 years	25 years	50 years
60	268.8405	134.0115	78.17956
90	205.1637	102.2699	59.66217
120	169.3589	84.42198	49.25003
180	129.245	64.42603	37.58481
240	106.6894	53.18251	31.02558
360	81.41927	40.58585	23.67695
480	67.21012	33.50288	19.54489
720	51.29092	25.56749	14.91554
1440	32.31126	16.10651	9.396202

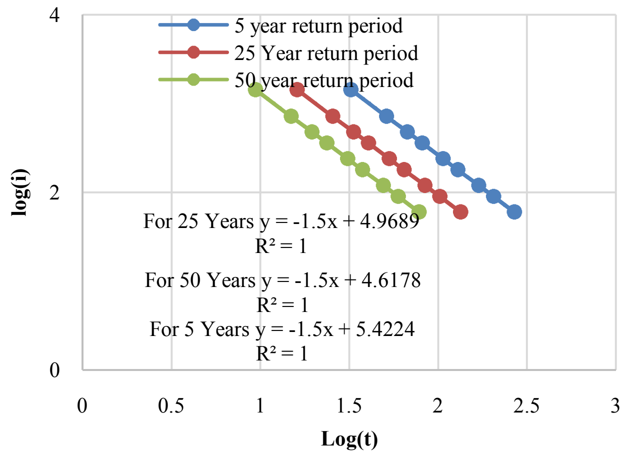

Figure 4 Log-Log plot 5, 25 &50-year Return period

Values of Intensity and duration obtained in previous table were used in equation (7) and its log log plot gives constants 'a' and 'n' value '264484.4 ' and '1.5' for 5 year return period , '93089.35' and '1.5' for 25 year return period & '41476.3' and '1.5' for 50 year return period. Using these constants, IDF curves were developed 10 mins and 30 mins intervals. (figure 4.5.2 & 4.5.3)

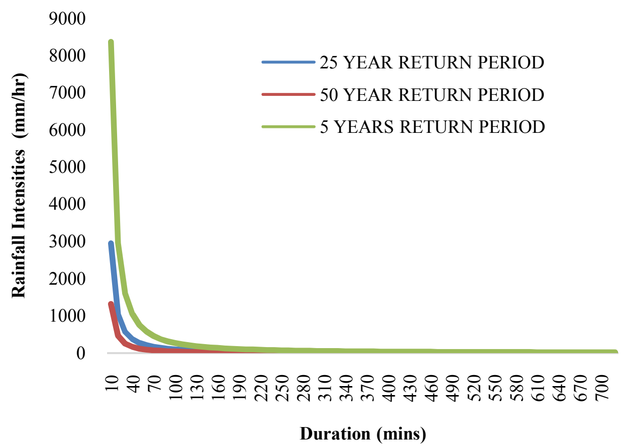

Figure 5 Intensity-Duration-Frequency Curve for 10 min interval

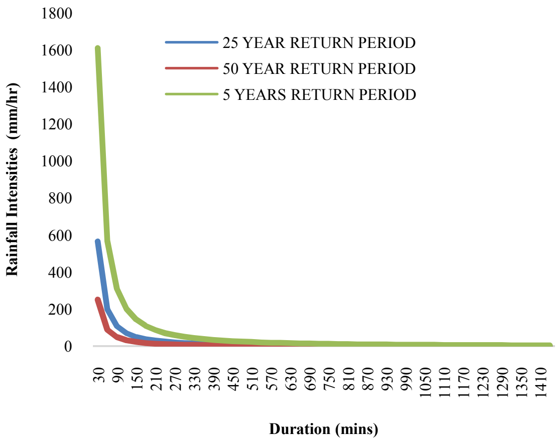

Figure 6 Intensity-Duration-Frequency Curve for 30 min interval

CONCLUSION

- Results of log log plot shows very accurate linear relationships. This indicated that the empirical formula obtained to estimate intensity in the study area is good for short durations. log log plot gives constants 'a' and 'n' value '264484.4 ' and '1.5' for 5 year return period , '93089.35' and '1.5' for 25 year return period & '41476.3' and '1.5' for 50 year return period with 1 R2 error.
- As observed in this study, Gumbel's Extreme Value Distribution method shows the best approximation of rainfall intensity for return periods of 5, 25 and 50 years, gives proper relationships of rainfall Intensity-Duration-Frequency. The results shows a good match as the correlation.
- For the design of appropriate Storm water Management plan, IDF curves can be considered.

References

CPHEEO(1993),"Manual on sewerage and sewage Part-A Engineering", New Delhi

IS (5542-2003), "Guide for storm analysis".

Davis C. V. and Sorensen K.E. (1970), "Hand book of Applied Hydraulics," Third ed., Mc Graw Hill Book Co. New York

Chow V.T., Maidment D.R and Mays L.W. (1988), "Applied Hydrology", McGraw Hill Pub Co., New York, USA. P. 572

H.M. Raghunath (2006), "Hydrology, Principals, analysis, design "revised 2nd edition

Claire T. Dedrick, Edmud G. Brown Jr, Ronald B. Robie (1976), "Rainfall analysis for drainage design" Volume-I short duration precipitation Frequency Data, Department Water Resources-Bulletin No. 195

C. W. Chang, S. Hiong (2013), "Estimation of sub-daily IDF curves in Singapore using simple scaling"

Cunnane C. (1989), "Statistical distribution for flood frequency analysis", Operational Hydrology Report No. 33, WMO-No. 718, Geneva, 73p + 42p

S. D. Chawathe (2013), "Manual on rainfall analysis for stormwater drainage system", 2nd edition

Umesh C. Kothyari and Ramchandra J. Grade (1992), " Rainfall intensity-duration-frequency formula for india " *J. Hydraul. Eng*.118:323-336

Yarnel, David L. (1935), "Rainfall intensity-Frequency data", U.S.Dept. Agr. Mlsc. Publ.204, Washington D.C

Zameer Ahmed, D. Rammohan Rao, K. Ram Mohan Reddy and Ellam Raj (2012), " Rainfall Intensity Variation for Observed Data and Derived Data- A case studt of Imphal" Vol. 7, No. 11, *ARPN Journal of Engineering and Applied Science* ISSN 1819-6608

F. Y. Logah, K. Kankam-Yeboah and E. O. Bekoe, "Developing Short Duration Rainfall Intensity Frequency Curves for Accra in Ghana", International Journal of Latest Research In Engineering and Computing (IJLREC) Volume 1

Rambabu Palaka1, G. Prajwala, K.V.S.N. Navyasri, I. Sitaram Anish, "Development of Intensity Duration Frequency curves for Narsapur Mandal, Telangana State, India", IJRET: *International Journal of Research in Engineering and Technology*, eISSN: 2319-1163, pISSN: 2321-7308

P. E. Zope, Eldho T. I., V. Jothiprakash, "Development of Rainfall Intensity Duration Frequency Curves for Mumbai City, India", Journal of Water Resource and Protection, 2016

K. Subramnya, Engineering Hydrology, 3rd edition, 2008

AKPAN, S. U. and OKORO, B. C., "Developing Rainfall Intensity–Duration–Frequency Models for Calabar City, South-South, Nigeria", *American Journal of Engineering Research* (AJER), e-ISSN : 2320-0847, p-ISSN:2320-0936Volume-02

How to cite this article:

Vivek D.Chaiwala and Kushang V Shah (2018) 'Rainfall Analysis For the Development of Idf Relationships- A Case Study of Valsad City', *International Journal of Current Advanced Research,* 07(6), pp. 13359-13362.
DOI: http://dx.doi.org/10.24327/ijcar.2018.13362.2379

****