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A preliminary study of storm maximization by moisture charge method

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ABSTRACT. In this note the maximization of rain storms for moisture charge has been attempted for the southern half of the Indian Peninsula from Lat. 8°N to near about Lat. 12°N. It has been seen that during the period 1951 to 1960 some 56 major rain storms affected this region. All these storms were maximized for moisture charge on the basis of 24-hr persisting highest dew point of record and the storm dew point data of the 16 selected meteorological observatories in this region. This study has revealed that the average maximization factors range from 2 to 26 per cent and these are generally low during the months of October to December when the rain storm activity over the region is maximum.

1. Introduction

In the case of major important hydraulic structures, virtually, cent per cent safety is required. These are, therefore, designed for probable maximum flood. The rational method of estimating probable maximum flood is by the unit hydrograph method in which both the design storm rainfall as well as the unit hydrograph ordinates are maximized. The maximization of design storm is required to provide for the optimum combination of moisture charge and dynamic efficiency (*i.e.*, convergence and vertical motion) of the storm. The maximization of the unit hydrograph intended to provide for the greater hydraulic efficiency during a probable maximum flood.

The method which is commonly employed for maximization of observed rain storms is based upon the following two assumptions (U.S. Weath. Bur. 1960) —

(*i*) Rainfall can be expressed as the product of available moisture and the combined effect of storm efficiency and inflow wind, and

(*ii*) The most effective combination of storm efficiency and inflow wind has either already occurred or has been closely approached in the major storms of record.

Under the above assumptions all that is required to be done for obtaining probable maximum storm is to adjust the biggest storm of record over or near the basin for optimum moisture charge. The optimum moisture charge is taken as the moisture content of a saturated column of air with pseudo-adiabatic lapse rate and with surface dew point equal to the maximum dew point of record for that basin for that part of the year.

2. Scope of the study

This study has been undertaken with a view to determine the range of maximization factors over the southern half of the Indian Peninsula between Lat. 8°N and about Lat. 12°N. Sometimes due to want of sufficient time, for undertaking such studies and/or lack of dew point data the design engineer is tempted to use *ad hoc* maximization factors. The practice hitherto followed in such circumstances has been to maximize the design storm by about 20 to 50 per cent (or even more) on an *ad hoc* basis for obtaining preliminary estimates of probable maximum flood in the absence of systematic study of maximization factors. With a view to find out the appropriate range of maximization factors over the southern half of the Indian Peninsula after maximization of all the recorded major rain storms that occurred over this region during the 10-year period, 1951 to 1960. The study has been carried out primarily to help the design engineer to make a predesign evaluation of the maximization factor he should adopt while making a rough estimate for his project. In no case these factors should be adopted as final for any particular project. In such cases actual values of maximization factor obtained for the basin in question should alone be adopted.

3. Procedure followed

All the major rain storms that affected the southern half of the Indian Peninsula from Lat. 8°N to near about Lat. 12°N were first picked up from the daily rainfall data of this region for the 10-year period for 1951 to 1960. The criteria in selecting major rain storms was that at least one station or more should have recorded at least a rainfall of 5 inches or more in one observational day during the storm duration. It was noticed that during this 10-year period about 56 rain storms occurred over this region. Table 1 gives the list of

TABLE 1

List of rain storms and their respective maximization factors

Storm spell period	Maximum one-day rainfall at storm centre		Maximization factor
	Station (District)	Rainfall (inches)	
4–7 Jan 1954	Sirkali (Tanjore)	5·25	1·05
10–12 Jan 1954	Tiruchendur (Tirunelvelli)	7·00	1·00
13–15 Mar 1954	Chindambaram (S. Arcot)	7·97	1·13
30–31 Mar 1951	Erode (Coimbatore)	5·90	1·26
11–14 Apr 1951	Kesavaram (Chingleput)	5·80	1·17
12–15 Apr 1958	Bhavanisankar (Coimbatore)	5·46	1·14
17–20 Apr 1953	Neramanangalam (Kottayam)	5·00	1·15
23–24 Apr 1954	Marungapuri (Tiruchi)	5·20	1·21
18–23 Apr 1955	Vedaranyam (Tanjore)	7·98	1·28
29–30 Apr 1956	Kottayam (Kottayam)	6·50	1·35
4–7 May 1958	Berijam (Madurai)	6·76	1·20
2–5 May 1960	Kottayam (Kottayam)	10·95	1·22
20–26 May 1952	Vayalur (Chingleput)	15·85	1·35
19–25 May 1957	Palghat (Palghat)	9·30	1·22
29–31 May 1951	Pelandorai (S. Arcot)	6·01	1·20
7–11 Jun 1953	Paithandam (Trivandrum)	5·45	1·12
14–15 Jun 1955	Arukutti (Cochin)	7·35	1·30
13–15 Jun 1956	Trichur (Cochin)	10·21	1·24
22–30 Jun 1955	Anamalai (Coimbatore)	8·56	1·22
16–17 Jun 1956	Trichur (Cochin)	10·21	1·18
23–30 Jun 1960	Kottigehar-tollgate (Chingleput)	10·25	1·20
10–12 Jul 1952	Rayakottah (Salem)	6·37	1·10
13–15 Aug 1952	Pala (Kottayam)	6·30	1·40
7–9 Aug 1955	Vakkadi (N. Arcot)	5·75	1·18
1–5 Aug 1958	Tirukoilur (S. Arcot)	5·70	1·15
29–31 Aug 1951	Ponneri (Chingleput)	5·13	1·12
20–22 Aug 1956	Kancheepuram (Chingleput)	5·73	1·10
11–12 Sep 1953	Nidamangalam (Tanjore)	7·54	1·17
18–21 Sep 1953	Port Nove (S. Arcot)	7·80	1·17
16–19 Sep 1960	Gudi-Banda (Kolar)	7·32	1·15
2–5 Oct 1952	Neyyattinkara (Trivandrum)	5·90	1·12
3–11 Oct 1958	Mahabalipuram (Chingleput)	11·80	1·07
21–24 Oct 1951	C.P.P. Channel (Trivandrum)	6·80	1·02
16–17 Oct 1952	Nidamangalam (Tanjore)	9·43	1·23
15–18 Oct 1953	Kangayam (Coimbatore)	8·11	1·12
20–26 Oct 1953	Sulurpet (Nellore)	9·74	1·05
17–22 Oct 1954	Tirutaraipundi (Tanjore)	14·32	1·15
24–30 Oct 1955	Lalgudi (Tiruchi)	6·40	1·13
20–28 Oct 1957	Peermade (Kottayam)	7·46	1·05
27–28 Oct 1959	Kodanad (Nilgiris)	6·33	1·06
29–31 Oct 1951	Neriamangala (Kottayam)	5·05	1·05
6–13 Nov 1957	Tiruchendur (Tirunelveli)	6·66	1·02
3–9 Nov 1957	Pisattur (Chingleput)	9·35	1·07
5–7 Nov 1959	Naganattinam (Tanjore)	8·39	1·10
2–4 Nov 1960	Poondi (Chingleput)	8·20	1·20
8–15 Nov 1960	Tirupundi (Tanjore)	11·93	1·11
16–25 Nov 1951	Cuddalore (S. Arcot)	10·53	1·05
15–19 Nov 1953	Kulusekarapatnam (Tirunelvelli)	5·77	1·08
25–26 Nov 1955	Ambassamudram (Tirunelvelli)	5·34	1·14
17–24 Nov 1956	Valangiman (Tanjore)	9·60	1·08
17–26 Nov 1958	Cholavaram (Chingleput)	10·10	1·00
26–29 Nov 1953	Mudukur (Tanjore)	7·45	1·10
6–12 Dec 1952	Kuranjipadi (S. Arcot)	12·80	1·05
9–14 Dec 1954	Tirupundi (Tanjore)	14·00	1·03
1–4 Dec 1955	Vittanam (Ramanathpuram)	7·30	1·18
19–21 Dec 1957	Tirupundi (Tanjore)	7·45	1·02

Fig. 1

such rain storms together with their respective one day heavy rain centres. The daily dew point data for 0830 and 1730 IST and the daily minimum temperatures were collected for the 16 selected meteorological observatory stations in and near this region (Fig. 1) from the *Indian Daily Weather Reports* of this period. From this data the highest persisting 24-hr dew point data for each fortnight of the 12 months for all the 16 stations were compiled using the technique given in WMO Technical Note (*see* Ref.). Similarly in the case of each rain storm, persisting 24-hr storm dew point data were also collected for those stations which were found to be quite close to the heavy rain centre of the storm. Care, however, was taken that the dew point stations thus selected were located upwind of the heavy rain centre and the dew point temperatures did not exceed the minimum temperature of the 24-hr interval, as the dew point at any time cannot exceed the concurrent air temperature (U. S. Weath. Bur. 1948, 1959). However, whenever this happened, the minimum temperature itself was taken as the persisting 24-hr dew point. The highest persisting 24-hr dew point was picked up for the same period of the year during which the storm occurred. These dew points (*i.e.*, the highest as well as the storm dew point) were then reduced to 1000-mb level pseudo-adiabatically to make them comparable. U.S. Weather Bureau diagram as modified by Pramanik and Hariharan (1951) was used to determine the precipitable water content for the highest as well as for the storm dew point temperatures. For each rain storm the maximization ratios were then worked out for nearby dew point stations upwind of the rain centre. The average maximization ratio based on the individual ratios of each station (close to the rain centre) was taken to be the maximization ratios for that particular storm. In this way the maximization ratios were worked out for all the 56 rain storms and the same are given in the Table 1. The maximization ratios of individual storms were then arranged according to different months of the year. The average and the highest maximization ratios for the region were then worked out for each fortnight of the different months of the year and the same are given in Table 2. Since the number of rain storms in each month is not the same, the fortnightly averages are not based upon the data of equal number of rain storms.

From a perusal of Tables 1 and 2 the following conclusions can be broadly drawn —

(1) The highest storm maximization factor of 40 per cent was obtained for the August 1952 rain storm which had its heavy rain centre in the Kottayam district.

(2) The range of the highest and the average maximization factors for different months was found to be between 2 to 40 per cent and 2 to 26 per cent respectively.

(3) A large number of rain storm centres found to be located within Tanjore district. In these storms the highest maximization factor was found to be of the order of 28 per cent.

(4) Comparatively the high values of storm maximization factor were found to occur in those months during which rain storm activity over this region is the least, *i.e.*, months other than October, November and December.

TABLE 2

The highest and the average fortnightly maximization factors for different months

	F.F.	S.F.	F.F.	S.F.	F.F.	S.F.	F.F.	S.F.	F.F.	S.F.	F.F.	S.F.
	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
Highest maximization factors	105	No rain storm	No rain storm		1·13*	1·26*	1·17	1·35	1·22	1·35	1·30	1·22
Average maximization factors	102	No rain storm	No rain storm		1·13*	1·26*	1·15	1·25	1·21	1·26	1·22	1·20
	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
Highest maximization factors	1·10*	No rain storm	1·40	1·12	1·17	1·17	1·12	1·23	1·20	1 14	1·18	1·02*
Average maximization factors	1·10*	No rain storm	1·24	1·11	1·17	1·16	1·09	1·09	1·10	1·07	1 09	1·02*

*Based on the data of one storm only, F.F. — First fortnight of the month, S.F. — Second fortnight of the month

The above study only shows the range of maximization factors for the major rain storms which affected region during 1951 to 1960. These factors cannot be applied directly to obtain the design depths for basin for evaluating design flood. In such cases the technique given by Paulhus and Gilman (1953) has to be used.

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