

Estimation of Probable Maximum Precipitation in Thailand Using Geographic Information System

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Abstract: Probable Maximum Precipitation (PMP) is essential in the design of hydraulic structures such as dams, weirs and flood control structures. Up to the present, PMP has been derived from any proper single storm which can have a large error. PMP values should be evaluated from many historic heavy storm events from all over the country. Since this can be done at the spots of storm occurring and the calculated PMP from all spots in the country can be correlated. The objectives of this study are therefore to evaluate PMP from historic heavy storm data from 1972 to 2000 by using meteorological method, then to correlate and to present the results using GIS. The maximized rainfall depths can be calculate from depth of heavy rainfall and dew point temperature, and then can be analyzed for each rainfall duration to obtain spatial rainfall distribution by using GIS. The depth-area-duration relationship of maximized rainfall can be obtained and this helps to develop enveloped curves. The results from this study are a set of contour maps of PMP for each rainfall duration for all over the country and the depth-area-duration relationships for the area of 100 to 50,000 km.² at duration of 1, 2 and 3 days.

Keywords: Probable Maximum Precipitation (PMP), Geographic Information System (GIS), Depth-Area-Duration Relationship.

1. Introduction

Design flood of hydraulic structures such as dams and weirs essential in order to maintain security of the construction and people around. Probable Maximum Flood (PMF) is selected [1]. Therefore Probable Maximum Precipitation (PMP) is a key factor to obtain design flood of a structure or a project related to people lives and their properties. In this study used meteorological method to obtain PMP in varieties of areas in Thailand and found top 5 heavy rainstorms in Thailand. They were rainstorm on 4-7 Jan. 1975; tropical depression on 24-29 Jul. 1999; 15-17 Aug. 1974; 11-17 Jul. 2000 and tropical storm Sarah on 16 Nov. 1973 which produced 3 days duration measured rainfall 971.4, 667.3, 624.5, 568.3 and 479.7 mm. Respectively.

In addition using Geographic Information System (GIS) to show probable maximum isohyets maps of the whole country. These data apply to planning and making decision for developing in water resources and related work.

2. Theory

Probable Maximum Precipitation (PMP) is expected maximum rainfall in a time frame of the study area, normally derived from data of rainstorm occurred in the nearby area. Therefore Probable Maximum Storm (PMS) is a design storm which calculated from PMP [5].

There are two major methods to obtain PMP: Statistic estimation and Meteorological method. In many countries they prefer Meteorological method [2] which contains 3 steps: Maximization of Storm Data, Storm Transposition and Relation among Depth-Area-Duration. Meteorological method is good for basin size bigger than 3,000 km². It able to be adjusted for smaller size basin also [4].

In this study used rainfall maximization to obtain PMP by the following equations [2].

$$\ln W = 0.06td - 0.02 \quad (1)$$

Where: W = Humidity in atmosphere (centimeter)

td = Maximum dew point temperature (Celsius)

$$PMP = P_{\text{actual}} \frac{W_{\text{max}}}{W_{\text{actual}}} \quad (2)$$

P_{actual} = Actual measured rainfall.

W_{max} = Humidity of maximum dew point temperature.

W_{actual} = Humidity of dew point temperature at the rainstorm area.

3. Materials and Methodology

1) Study area

Thailand locates at latitude 5 ° 37' - 20.5 ° 27' N and longitude 97° 22' -105° 37' E covers area 513,115 km²

2) Data

1. Statistic year 1972 – 2000 rainfall caused by monsoon, tropical storm and monsoon trough.

2. Monthly statistic year 1972 – 2000 maximum dew point temperature.

3) Procedure

Use Meteorological method to obtain PMP which cover study area size between 20 – 50,000 km²

1. Collect rainfall data from every rainfall station in all regions of Thailand duration of 1, 2 and 3 days raining.
2. Calculate rainfall maximization by equation (1) and (2)
3. Analyze isohyets for duration of 1, 2 and 3 days rainfall.
4. From 3. create table relation among rainfall, area and duration.
5. Plot a graph relation of rainfall and area in semilog and develop envelope curve.
6. From graph in 5. able to make table relation among PMP-Area-Duration.

4. Results

From year 1972 – 2000 there were 108 storms hit Thailand. Top 5 heavy rainstorms were selected and calculated rainfall maximization to obtain PMP as shown in table 1

Table 1. Probable maximum precipitation (PMP) of top five rainstorms in Thailand.

Storm Name	Area	PMP (mm.)		
		1day	2days	3days
1. Rainstorm 4-7 Jan. 1975	Koh Samui, Nakorn Sithamarat	442.0	826.7	1108.4
2. Tropical Depression 24-29 Jul. 1999	Trad, Klong Yai, Sa-Kaew	371.4	639.7	683.3
3. Tropical Depression 15-17 Aug. 1974	Sakonnakon, Nongkai	488.2	551.0	645.6
4. Tropical Depression 11-17 Jul. 2000	Klong Yai, Chantaburi, Sa-Kaew	281.7	409.1	589.2
5. Tropical Storm Sarah 16 Nov. 1973	Prachuapkhiri- rikhan	233.5	370.6	577.6

The major principles to calculate PMP by Meteorological method are rainfall maximization and relation among depth-area-duration. Do rainfall maximization by adjust heavy storm to be maximum because humidity cause accurate probable precipitation. If there are study rainfall duration of 30 minutes, 1-2-3-6 and 12 hours, it will lead to study in more detail. With adequate rainfall data from rainfall station, analyze data can derive flood design in duration less than 1 day.

Contours of PMP were generated by using GIS and shown as a map in Fig.1. This was one of the results

example of rainstorm on 4-7 Jan. 1975 which occurred in southern part of Thailand.

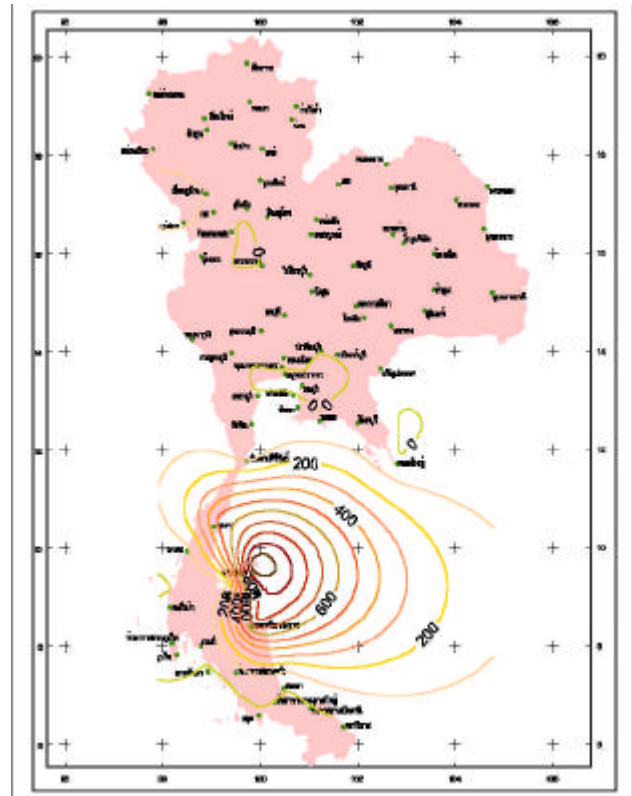


Fig. 1. Map of maximum isohyets in 3 days duration of rainstorm 4-7 Jan. 1975.

Envelope curves (Fig.2) presented the relation between rainfall and area which were derived from isohyets maps. Table relation among PMP-Area-Duration obtained from Fig.2 was shown in table 2.

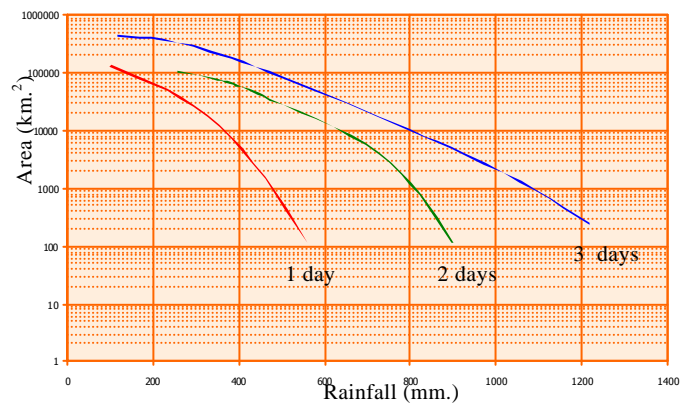


Fig. 2. Graph relation between area and rainfall 1, 2 and 3 days duration in southern region.

Table 2. Relation of PMP-Area-Duration in southern region.

Area (km. ²)	Rainfall (mm.)		
	1 day	2 days	3 days
100	610	915	1260
500	530	860	1150
1,000	510	830	1090
5,000	460	730	915
10,000	420	680	830
20,000	380	590	720

5. Conclusion

Between year 1972 – 2000 top five heavy rainstorms were selected and calculated for PMP of 3 days duration found 1108.4, 683.3, 645.6, 589.2 and 577.6 mm. respectively.

From table relation PMP-Area-Duration, for Northern region with area of 100 km.² and 1, 2 and 3 days duration, maximum rainfall are 258, 285 and 315 mm. For Northeast maximum rainfall are 555, 580 and 648 mm. Central region are found 239, 318 and 373 mm. Eastern are found 400, 620 and 640 mm. and for Southern region are found 610, 915 and 1260 mm. Therefore Southern of Thailand has the most maximum rainfall of 1, 2 and 3 days duration.

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