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Development of Huff curves for Peninsular Malaysia

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SUMMARY

Huff curves are commonly used in drainage design. The basic objective of the present paper is to report about the development of Huff curves for Peninsular Malaysia. Hourly rainfall data from 13 stations in Peninsular Malaysia were used in the study. Data from about 5800 storms were divided into quartile storms to derive the Huff curves. A comparison of Huff curves using correlation coefficients revealed that the Huff curves from different stations are very similar to each other. The Huff curves from the 13 stations were averaged to derive the Huff curves for Peninsular Malaysia. The Huff curves from the United States are partially similar to those from Peninsular Malaysia in the sense that Huff curves for some quartiles are close to each other whereas they are not for others. The rainfall information presently used for design in Malaysia is very dissimilar to the Huff curves derived in this study.

1. Introduction

Hydrologic and watershed models are commonly used in drainage design. Common engineering practice in using these models is the specification of a rainfall event as a "design storm". Design storms are often used in urban drainage design for drainage and storm water management projects. However, the models and their use require short time interval (e.g. time intervals less than 24 h) rainfall information as inputs. Usually, these data are unavailable. Consequently synthetic storms are used. Two types of design storms may be used; synthetic storms or actual storms based on historical data. Actual storm data are used to derive the synthetic storms. Chow et al. (1988) have discussed in detail the development of synthetic storms. An application oriented discussion of drainage design and the use of synthetic storms is found in Rao et al. (2003).

A type of design storm particularly useful for estimating runoff from watersheds was developed by Huff (1967) in Illinois. Huff curves are dimensionless cumulative hyetographs with specified probabilities of occurrence. Initially, Huff curves were used to characterise temporal rainfall distributions in an area. The use of Huff curves was extended later to the simulation of rainfall hyetographs, which in turn are used as inputs to rainfall-runoff models. Considerable research has been conducted on Huff curves (Bonta and Rao, 1987, 1988, 1989; Bonta, 1997, 2004). As recognition of the greater use of Huff curves, National Oceanic and Atmospheric Administration (NOAA) has provided them for use in an easily accessible form. An example is shown in Fig. 1 (Bonnin et al., 2006).

Huff (1967) used 12 years of data from 49 rain gauges over an area of 1037 km^2 in eastern Illinois to develop the original Huff curves. Topographically, this area is a flat prairie with elevations ranging from 198 to 277 m. Storm durations ranged from 1 to 48 h, and the storm data greater than the rain–gauge network mean of 12.7 mm, or when one or more gauges recorded more than 25.4 mm were used. Huff (1990) updated the Huff (1967) study by including 12 additional gauges in a 25.9 km^2 in the Illinois area, and six gauges in the Chicago area (Huff and Vogel, 1976).

Presently, Huff curves are not available in Malaysia. They would be quite useful for drainage design in Malaysia. The primary objective of the research reported herein is to develop a set of Huff curves for use in Peninsular Malaysia.

At present, in Malaysia, the rainfall information presented in *Urban Stormwater Management Manual for Malaysia, vol. 4, Design fundamentals* (DID, 2000) is used as a primary reference for drainage design. This manual was published in 2000 by the Department of Irrigation and Drainage (DID), Ministry of Natural Resources and Environment, Malaysia. It would be of interest to compare the characteristics of rainfall as shown in the Huff curves developed in the present study with those in the DID manual. This is the second objective of the study.

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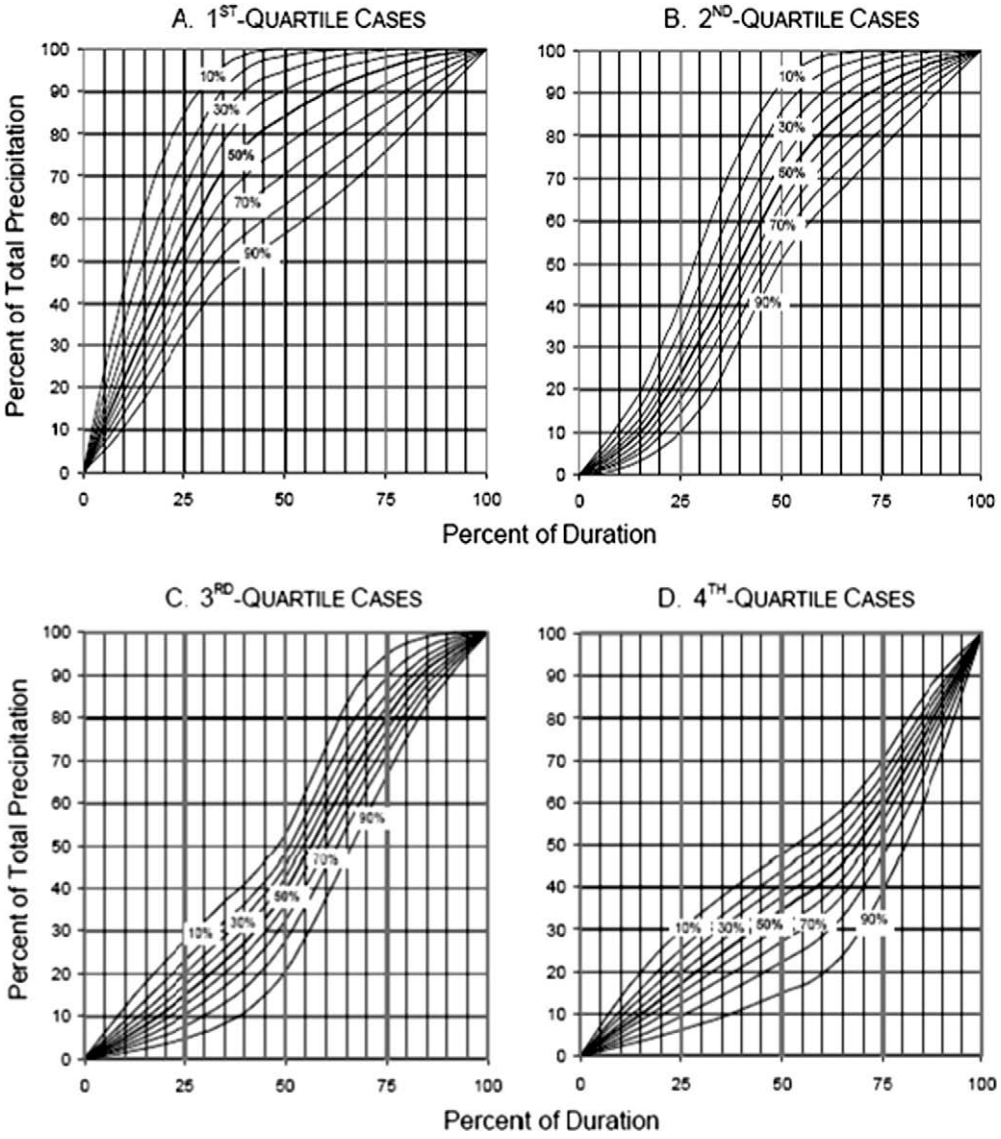

Fig. 1. Huff curves for 6-h storms (Bonnin et al., 2006).

2. Data used in the study

Rainfall data used in the present study are collected, documented and distributed by the Department of Irrigation and Drainage (DID) of the Government of Malaysia. Rainfall measured by 13 rain gauges was used in the study. The period of data available ranged from 25 to 40 years dating back from 2008. The details of rain gauges are shown in Table 1. The locations of the rain gauges are shown in Fig. 2.

3. Developing Huff curves

The reported data were checked for accuracy, consistency and errors. There were several instances where, for various reasons, data were not available. These cases were different from "Missing data" which usually occurred because of malfunctioning rain gauges. There were instances of "Truncated data", when the rainfall depth was far greater than normally measured rainfall depth. These were usually indicated by numbers larger than 999 mm in an hour. There were cases of "repetitive data" when the same rainfall was recorded over a long period of time. The repetitive data were altered to zero rainfall. After the data were checked they were used for further analysis.

These problems with the data are common wherever rainfall data are collected. The situation in Malaysia about the accessibility and accuracy of data is similar to most of the countries in the world. The problems with the data are due to both equipment failure and operator problems. The reported data are used in the study.

Before the Huff curves are constructed, storms must be identified and separated based on the record of rainfall data. These storms are the basic data used in the development of Huff curves. In this study, storms were identified based on the following criteria: (a) total storm duration of 3 h or more, (b) total rainfall depth of 25.4 mm (1 inch) or more, (c) minimum hourly rainfall depth of 1 mm (i.e. values less than 1 mm are treated as zero values.), and (d) continuous bursts of rainfall separated by periods of no precipitation ("dry-periods"). Storms separated by dry periods were selected. Usually in Malaysia, a period of intense rainfall is followed by a period of low intensity rainfall before the rain stops completely. In our study, the low intensity rainfall was also included as a part of the storm. The dry period is well defined and