Investigation of empirical relationships for flood peak estimation in Cyprus – Extended abstract

Introduction

Usually, for the preparation of a hydrological study, empirical equations and methodologies are utilized.. Basically, for the calculation of the time of concentration the Giandotti or Kirpich relations are used, and for the estimation of flood peaks the Rational Method appears to be the most widely accepted implement.

The purpose of this study is the processing of raw data and basin physiographic characteristics of Cyprus, in order to investigate existing as well as new empirical relations time estimate of concentration in areas where there are no data of flow measurements.

Data

The data available for this project are, basically, the following:

- time series of maximum monthly flows of 124 flow stations
- physiographic features of the island such as: digital terrain model, geological map, Corrine land use, drainage network, monitoring stations network and hydrological basins
- meteorological stations network and rainfall intensity – duration – frequency curves (IDF curves) of Cyprus.

These data were granted after consultation with the officials of the Water Development Department of Cyprus (WDD). The public services from which the data were collected are:

- Cyprus Water Development Department
- Meteorological Service of Cyprus
- Geological Survey
- Department of Forestry
- Department of Lands and Physical Planning

Editing - Methodology

The current project can be divided into two subsections.

The first section includes the editing of the field data and the physiographic maps of Cyprus. To begin with, a qualitative analysis of the available time series of the 124 stations enabled us to select the basins (stations) whose data fitted the profile of the study. The criteria by which the choice was made are:

1. That the area was not urbanized
2. To have a lengthy series of flow measurements available, more than 20 years
3. To ensure that there was no dam upstream of the station
4. That the size of the basin was acceptable (not too small or too large)

The above analysis gave a total of 34 stations (Table 4-4) which can be used for the following investigation.

The qualitative analysis follows the use of Geographic Information System (GIS). By using GIS several geomorphological features of river basins (Table 8-1) were identified, namely those necessary to carry out hydrological calculations. Also, a treatment of physiographic maps was made, which revealed the map of runoff curve number for Cyprus (Figure 7-3).

Finally, for each of the 34 basins the individual (C1, C2, C3, C4) and total runoff coefficient C (Table 8-2), the runoff curve number CN (Table 8-4) and the length of main streams were calculated, in order to allow the application of empirical methods for the estimation of the time of concentration (Table 8-5) and then providing the flow peaks.

The second section discusses the processing of the results of the hydrological calculations. Certain simplifying assumptions had to be made to allow the use of the different methods.

- The number of years of the time series were used instead of the return period (N = T)
- The runoff curve number, CN, is used as an indicative value of the roughness of the streams as far as the estimation of the time of concentration is concerned.
- The rain incidents used are those which give $Q/A_{basin} > 1$ $m^3/s/km^2$ in order to ensure that the duration of rainfall is greater, or at least equal, to the time of concentration ($t_r \geq t_c$)

To begin with, the existing empirical formulas calculating the time of concentration (Giandotti, Kirpich, SCS, Passini) were examined in order to find out whether they adjusted well to the data of Cyprus. This study showed that only the Giandotti equation provides an acceptable coefficient of determination (CE~ 0,50).

Then, an attempt was made to determine a new empirical equation, in order to estimate the time of concentration, by linear regression and optimization of the coefficient of determination, based on the

measured runoff data and physiographic characteristics of Cyprus. Several equations were tested and finally a method is proposed for the determination of the time of concentration and flow peaks. The new method gives a satisfactory coefficient of determination (CE ~ 0.80).

Results - Conclusions

This project provides a new empirical methodology for calculating the time of concentration of hydrological basins of Cyprus. This methodology suggests the following equations:

$$t_c = \frac{4.23\left(A / L_{\max}\right)^{0.429}}{\sqrt{S_{mean}} * CN^{0.29}} \qquad \text{equation 1}$$

t_c [hr], A [km^2], L_{max} [km], S_{mean} [m/m]

$$t_c(T) = \frac{t_c}{T^{0.02}} \qquad \text{equation 2}$$

$$c(T) = 0.43c + 0.1\ln(T) \qquad \text{equation 3}$$

Methodology: Calculate the time of concentration and then correct it based on the return period of the rainfall event, according the above equations (eq.1&2). Using the time of concentration, it is possible to calculate the critical intensity of rainfall as given by the rain IDF curves for Cyprus. In addition, the runoff coefficient can be estimated based on the regulations of Transportation Works (OMOE-ASYEO), and then corrected according to the return period of the event (eq.3). Lastly it is possible to calculate the flow peaks of the flood by using the Rational Method.

The key findings that emerged from this project are:

- The runoff coefficients that appear to apply to Cyprus basins are quite smaller than those calculated based on the lists of regulations OMOE - ASYEO which apply to Greece.

The equations for calculating the time of concentration which appear to be better adjusted in Cyprus, give times which are considerably larger than those obtained by existing, widely accepted, empirical methods (e.g. Giandotti).