Computation of Runoff in King Khalid University

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Abstract— **Many hydrologic methods are available for estimating peak flows from a basin, and no single method is applicable to all basins. The Rational Method is commonly used to estimate the design-storm peak discharge. The concepts of the Rational Method are sophisticated and considerable engineering knowledge is required to select representative hydrologic characteristics, such as time of concentration and runoff coefficient, which will result in a reliable design In this paper rational method has been used to compute the runoff generated in King Khalid University, Graiger Campus. The various components comprising the university ie., Buildings, Library, Workshop, Canteen, Store, Auditorium, Sport building, Administrative block, Animal Centre, tent, Masjid, Parking, Grass , Soil, Tiles, Mosaic, Road Bituminous are taken into account while computing runoff. The input parameter required for runoff computation is Rainfall intensity, Area and Runoff Coefficient. The runoff coefficient (C) is a key parameter for the rational method.)The computed runoff is found to be maximum in the month of April and minimum in the month of October**

Keywords— **Rational Method, Runoff, Runoff Coefficient, Rainfall Intensity.**

I. Introduction

Computation of runoff values for use in designing certain hydraulic structures (e.g., crossroad culverts, drainage ditches, urban storm drainage systems, and highway bridge crossings) is an important and challenging aspect of engineering hydrology (Viessman and Lewis ,2003). Various methods are available to compute runoff volumes from urban watersheds. The rational method is commonly used by hydraulic and drainage engineers to estimate design discharges, which are used to size a variety of drainage structures for small urban (developed) and rural (undeveloped) watersheds (Viessman and Lewis 2003). In its most common form, the rational method is written as Q_T=CiA, where Q_T peak discharge for recurrence interval T; C rational runoff coefficient; I rainfall intensity; and A watershed area. The drainage area,A can be determined from a topographic map and is generally the most reliable of the three inputs to the rational formula. The rainfall intensity, i is selected from rainfall intensity-duration-frequency tables using a recurrence interval equal to that for the desired peak discharge and a duration equal to an appropriate rainfall averaging time. The watershed time of concentration, t_c, is most commonly used as the rainfall averaging time. The time of concentration is defined as the travel time for water to flow from the most hydrologically remote point in the watershed to the watershed outlet. There are a variety of empirical equations for tc that consider the length, the slope, and sometimes the roughness of the flow path; the method used to estimate tc affects estimates of Q_T using the rational method.

The rational C, or runoff coefficient, should be considered an empirical constant of proportionality between the peak flow Q_T and the product of i and A Wong 2002; Pilgrim and Cordery 1993. If C is treated as an empirical coefficient then the rational method is simply a stochastic predictive equation that is used to estimate the peak discharge for a given recurrence interval using a characteristic rainfall intensity, i, and the watershed drainage area as predictors. As such, the characteristic rainfall intensity, i, does not represent a real rainfall event. A common misconception is that the rational C is the ratio of the runoff volume to the rainfall volume. It has been demonstrated that this interpretation of the method leads to a very poor prediction of peak flow rates for individual events Hotchkiss and Provaznik 1995.

Correct application of the rational method for design requires appropriate values of the runoff coefficient. The trick, of course, is knowing what rational C is appropriate for a given watershed. For the purpose of design, engineers typically rely on tables of rational C values as a function of land cover. Such tables are found in almost every introductory engineering hydrology textbook and are incorporated into design standards for local and state government agencies. Although these tables are commonly available and widely used, the empirical basis for the rational C values is often not documented. Most textbooks and design standards refer to a 1969 sanitary and stormwater sewer design manual produced jointly by ASCE and the Water Pollution Control Federation. The Water Pollution Control Federation WPCF 1969 publication provided a table of rational C values for different land uses but did not provide any background on how these values were selected. A more recent analysis of the rational method was performed by Hotchkiss and Provaznik 1995 for 24 small agricultural watersheds in south central Nebraska. The rational C values for each basin were determined both using storm-dependent data to compute a ratio of the peak flow rate to the rainfall intensity and using a frequency-based approach.

II. Study Area

The Computation of runoff is done inside the King Khalid University Graiger Campus, Abha, Kingdom of Saudi Arabia. Abha is the capital of Asir province in Arabia. It is located in the Southern Region of Asir. It is situated at (2,200 meters) above sea level .The climate of Abha is cold semi-arid climate. The city is generally mild throughout the year, though it's noticeably cooler during the "low-sun" season. Abha seldom sees temperatures rise above 35 degree Celsius during the course of the year. The city averages 600 mm of rainfall annually, with the bulk of the precipitation occurring between February and April, with a secondary minor wet season of July and August. The map shown below in figure depicts the location of Study Area

Fig.1Study Area

III. METHODOLOGY

The Rational Method Equation

The equation that is the centerpiece of the Rational Method is: Q= CiA, where Q is the peak surface runoff rate, from a watershed of area, A acres, and runoff coefficient, C, due to a storm of intensity, i. In order to calculate a value for peak runoff rate for a given drainage area, values are needed for the three parameters, A, C, and i. Each of these parameters will be discussed separately .

The Drainage Area, A

The drainage area, A, is often determined from a map which includes the drainage area of interest. It may be necessary to first determine the boundaries of the drainage area using a contour map. Once the boundaries are known, the area can be determined using the map scale.

The Runoff Coefficient, C

The runoff coefficient is the fraction of rainfall striking the drainage area that becomes runoff from that drainage area. It is an empirically determined constant, dependent on the nature of the drainage area surface. An impervious surface like a concrete parking lot will have a runoff coefficient of nearly one. A very tight clay soil will also have a relatively high runoff coefficient, while a sandy soil would have more infiltration and a lower runoff coefficient. In addition to the nature of the surface and the soil, the slope of the drainage area has an effect on the runoff coefficient. A greater slope leads to a higher runoff coefficient. There are many tables of values for runoff coefficient for a variety of types of drainage areas in handbooks, textbooks and on the internet. The table at the right shows some typical ranges of values for runoff coefficient.

The Design Rainfall Intensity, i

The design rainfall intensity is the intensity of a constant intensity design storm with the specified design return period and duration equal to the time of concentration of the drainage area. Once the design return period and duration are determined, the design rainfall intensity can be determined from an appropriate intensity-duration-frequency graph or equation for the location of the drainage area. As you can see, determining a value for i is the most complicated part of using the Rational Method.

IV. COMPUTATION AND RESULTS

The input data required for runoff computation are rainfall intensity, Area ,and Runoff coefficient. .The Various Components of King Khalid University along with area in meter square and runoff coefficient is given in table 1

TABLE I
Area and Runoff Coefficient of Various components

Components	Area m^2	C
BUILDING A	33250	0.95
BUILDING B	22103	0.95
Library	4600	0.95
Workshop	5760	0.95
Canteen	5150	0.95
Store	5000	0.95
Auditoriam	8500	0.95
Sport Building	4775	0.95
Admin	4700	0.95
Animal Centre	1700	0.95
Tent	8400	0.9
Masjid	3000	0.95
Parking	17320	0.8
Grass	35500	0.15
Soil	13700	0.12
Tiles	6550	1
Mosaic	57500	0.9
Road bituminous	170725	0.8

The Monthly Variation of Average precipitation days, Mean temperature, Relative humidity, Rainfall are shown in fig2 to 5 respectively.

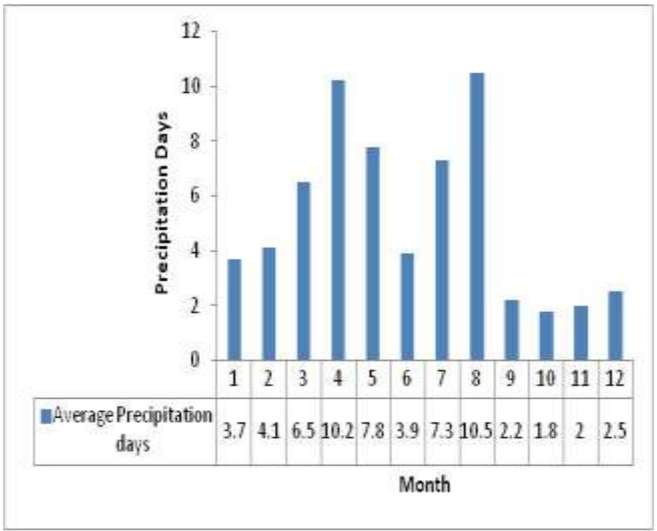

Fig. 2 Monthly Precipitation days

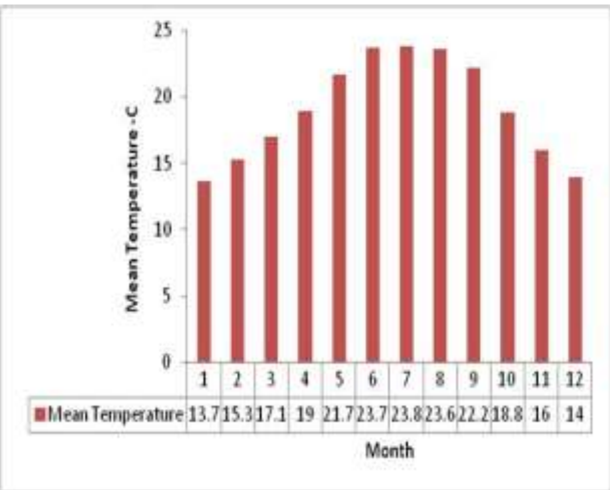

Fig.3 Monthly mean Temperature

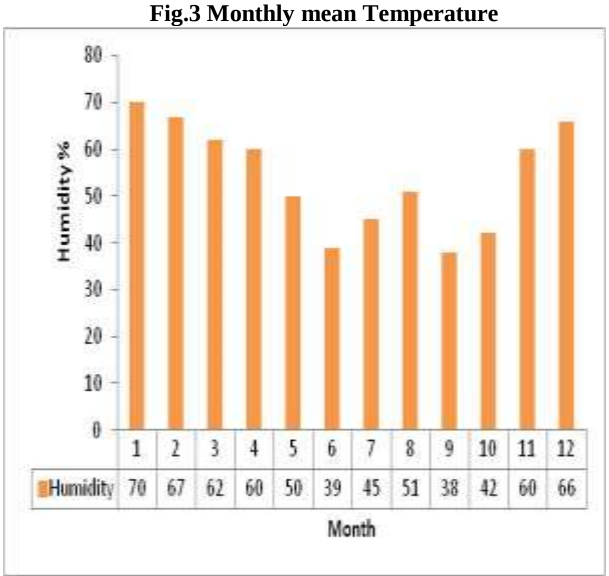

Fig.4 Monthly Relative Humidity%

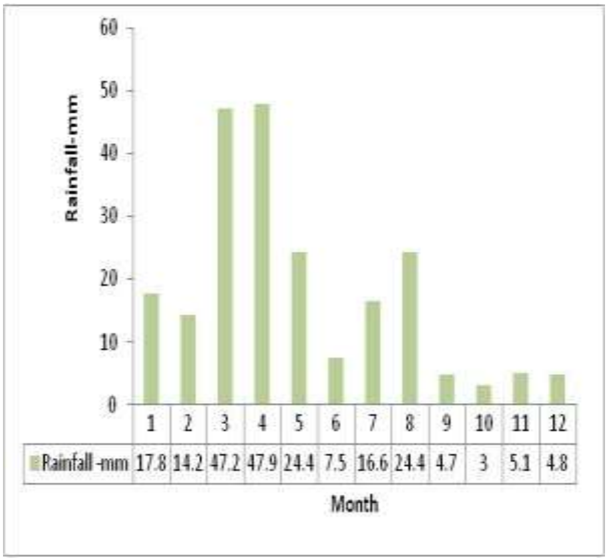

Fig. 5 Monthly Rainfall in mm

Using the above input data the monthly runoff of various component can be easily computed using rational equation. The computed yearly % runoff is given in fig.6. and the monthly runoff by each component is given in fig 7.Moreover the computation of runoff is tabulated in table 2.

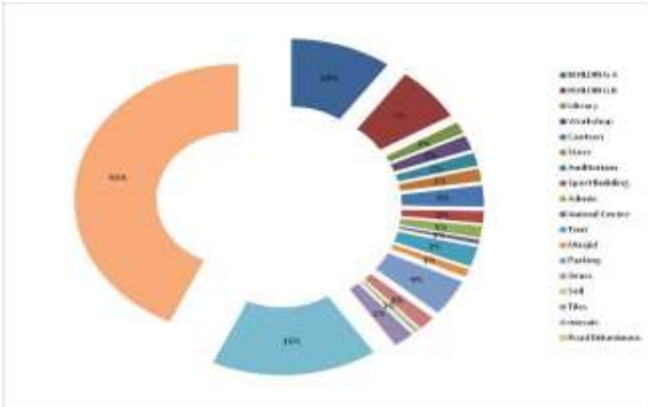

Fig. 6 Yearly % runoff

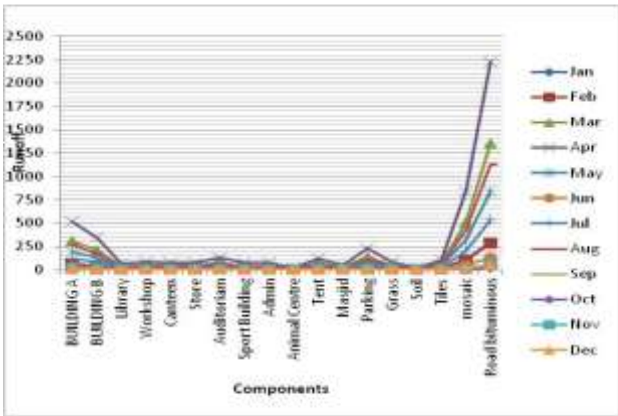

Fig.7 Monthly Runoff of Different Components

TABLE 2 MONTHLY RUNOFF OF DIFFERENT COMPONENT

Components	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BUILDING A	67.10815	65.67944	312.6144	514.434	193.9269	30.79781	123.4766	261.0554	10.88716	5.502339	10.73975	12.22742
BUILDING B	44.61027	43.66053	207.811	341.971	128.9133	20.4729	82.08127	173.5371	7.237259	3.65769	7.139269	8.1282
Library	9.284135	9.086479	43.2489	71.16982	26.82898	4.26075	17.08247	36.11594	1.506193	0.761226	1.4858	1.691613
Workshop	11.62535	11.37785	54.15515	89.11699	33.59455	5.3352	21.39022	45.22343	1.886016	0.953187	1.86048	2.118194
Canteen	10.3942	10.17291	48.41997	79.67926	30.03679	4.770188	19.12494	40.43415	1.686282	0.852242	1.66345	1.893871
Store	10.09145	9.876607	47.00968	77.3585	29.16194	4.63125	18.5679	39.25645	1.637167	0.827419	1.615	1.83871
Auditoriam	17.15547	16.79023	79.91645	131.5095	49.57529	7.873125	31.56544	66.73597	2.783183	1.406613	2.7455	3.125806
Sport Building	9.637336	9.43216	44.89424	73.87737	27.84965	4.422844	17.73235	37.48991	1.563494	0.790185	1.542325	1.755968
Admin	9.485965	9.284011	44.1891	72.71699	27.41222	4.353375	17.45383	36.90106	1.538937	0.777774	1.5181	1.728387
Animal Centre	3.431094	3.358046	15.98329	26.30189	9.915058	1.574625	6.313087	13.34719	0.556637	0.281323	0.5491	0.625161
Tent	16.06134	15.7194	74.81961	123.1222	46.41352	7.371	29.55228	62.47974	2.60568	1.316903	2.5704	2.926452
Masjid	6.054871	5.925964	28.20581	46.4151	17.49716	2.77875	11.14074	23.55387	0.9823	0.496452	0.969	1.103226
Parking	29.4373	28.81058	137.1297	225.6588	85.0669	13.5096	54.16355	114.5131	4.775701	2.413626	4.71104	5.363613
Grass	11.31305	11.0722	52.70032	86.72295	32.69206	5.191875	20.8156	44.00855	1.83535	0.927581	1.8105	2.06129
Soil	3.492705	3.418346	16.2703	26.77418	10.0931	1.6029	6.426449	13.58686	0.566632	0.286374	0.55896	0.636387
Tiles	13.91558	13.61932	64.82387	106.6733	40.21277	6.38625	25.60416	54.13258	2.257567	1.140968	2.227	2.535484
mosaic	109.9437	107.603	512.1581	842.8005	317.7116	50.45625	202.2924	427.6887	17.8365	9.014516	17.595	20.03226
Road bituminous	290.1664	283.9888	1351.701	2224.342	838.5131	133.1655	533.8956	1128.768	47.07457	23.79135	46.4372	52.86968

V. CONCLUSION

The rational method has been used to design hydraulic structures for decades and practicing engineers show no inclination to discard the method. The longevity of the rational method caused Yen 1992 to question why the method has endured: has it endured because it is fundamentally sound or because the field of hydrology has not progressed? If the rational method is treated as a stochastic predictive equation, with the rational C acting as an empirical coefficient of proportionality between Q_T and the product iA, then it is fundamentally sound.

After computing the runoff discharge of various component of king Khalid university abha catchment area using rational method following conclusion can be drawn:

1- More the catchment area with high runoff coefficient, the runoff will be higher as from result the catchment area for bituminous road is higher so the runoff is higher.
2- Maximum runoff take place in the month of April and minimum in the month of October. It is because rainfall and Precipitation days.
3- Among the building area the building A is producing maximum runoff and masjid least as the area of building A is maximum and Masjid least.
4- From the pie chart, it is clearly observed that maximum 43% of runoff take place from bituminous road and least value of 1% given by each of store, library, sport building, Masjid and Soil respectively.

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