

**APPLICABILITY OF RATIONAL FORMULA IN
HYDROLOGICAL ANALYSIS OF HIGHWAY
CROSS DRAINAGE STRUCTURES**

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DECLARATION

Declaration of the candidate

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Applicability of Rational Formula in Hydrological Analysis of Highway Cross Drainage Structures

Abstract

The peak flow estimation at Highway –Waterway intersects has substantial effects on Hydraulic design aspects of culverts and bridges. Fair and accurate estimation of peak flow would be the basis in deciding the size of cross drainage structures to ensure proper transfer of runoff collected at inlet towards the downstream.

The history of hydrology modelling varies from well-known Rational Formula to sophisticated computer aided models. Rational Formula has been used for over 150 years and still remains as the most widely used method due to its simplicity in approach. The present study considered five numbers of flood estimation techniques; Rational Formula, Fuller Formula, Snyder's Method, Flood transportation and HEC-HMS for catchments located in four road segments where area varies from 9 – 6663 hectares (ha). All catchments are ungauged and prediction of flood flows for ungauged basins is extensively discussed in past decades and still remains a question due to accuracy and validity of assumptions made in the analysis.

The study focused on different methods of time of concentration, runoff coefficient and design discharge estimations. Three empirical relationships along with Irrigation Department guideline (1984) were considered for the computation of Time of Concentration. Time of concentration results of Kirpich equation was substantially lower than other methods while UK Flood Studies Report equation was identified as the highest. Only the Bransby – William equation showed fair agreement with Irrigation Department Guideline.

Peak flow estimations of flood transportation technique is highly sensitive for the drainage area ratio and relatively low drainage area ratios correspond to culvert and bridge sites caused significant deviation from other methods. Fuller formula estimations were also considerably deviated from other methods.

The difference in peak flow estimation methods was not significant up to catchment area of 100 ha. Peak flow estimations of cross drainage structures in studied road segments revealed that Rational formula can be applied up to 770 ha. As a comparative assessment catchments larger than 770 ha to be modeled using Rational formula and alternative flood estimation methods.

Key Words: Time of Concentration, Rational Formula, HEC-HMS, Fuller Formula, Flood Transportation

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LIST OF ABBREVIATIONS

Abbreviation	Description
A, F	Area
AMC	Antecedent Moisture Condition
ASTER	Advanced Spaceborne Thermal Emission and Reflection
BPR	Bureau of Public Roads
C	Runoff Coefficient
CAg	Catchment Area of gauged site
CAu	Catchment Area of ungauged site
CN	Curve Number
Cp	Peak Parameter
Ct	Time Parameter
d	Depth of rainfall
D	Duration of Unit Hydrograph
D'	Storm Duration
DDF	Rainfall Depth Duration Frequency
DEM	Digital Elevation Model
DRH	Direct Runoff Hydrograph
ESDAC	European Soil Data Centre
FAO	Food and Agriculture Organization of the United Nations
f_c	Final/Equilibrium infiltration capacity
FR	Ferralsols
GIS	Geographic Information System
GPS	Global Positioning System
GTOPO	Global 30 arc-second Elevation
ha	hectares
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
hr	Hour
HSG	Hydrologic Soil Group
HydroSHEDS	Shuttle Elevation Derivatives at multiple Scales
I	Rainfall Intensity
Ia	Initial Abstraction
ID	Irrigation Department ,Sri Lanka
IDF	Rainfall Intensity Duration Frequency

IL+ULS	Initial loss plus Uniform loss rate
IWMI	International Water Management Institute
K	Frequency factor
km	kilometer
km ²	Square kilometer
L	Length
Lca	Center of Gravity of a Catchment Length
LV	Luvisols
mi	Mile
NRCS	U.S. National Resources Conservation Services
P	Excess Rainfall
Q	Peak Flow
q _{pi}	Peak runoff of unit hydrograph
Q _{pi}	Flood hydrograph peak
RBE	Reddish Brown Earth
S	Slope
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
T	Return Period
T _b	Time base
t _c	Time of Concentration
t _p	Time lag/Basin time lag
TR	Technical Release
UH	Unit Hydrograph
USGS	United States Geological Survey
V	Velocity
W ₅₀	Width in hrs of unit hydrograph for 50% of q _{pi}
W ₇₅	Width in hrs of unit hydrograph for 75% of q _{pi}
X	Mean
Y _r /Y _R	Year
y _T	Reduced variate
σ	Standard Deviation

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