THESIS

HYDROLOGIC DESIGN OF CROSS DRAINAGE STRUCTURES FOR ROADS IN MOUNTAINOUS AREAS

(A CASE STUDY OF RATTI-GALI BHATTIAN ROAD)

By

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(2004-PG-EHy-45)

For the Degree of

MASTER OF SCIENCE
IN
ENGINEERING HYDROLOGY

CENTRE OF EXCELLENCE IN WATER RESOURCES ENGINEERING
University of Engineering and Technology, Lahore, Pakistan

2006

ABSTRACT

Mountainous areas are usually characterized by undulating topography due to which a lot of flow paths are developed over the mountain sides. The area dwellers carve out travel paths/tracks to move from one place to another. With the passage of time these foot tracks become well-defined paths at which carts and vehicle can also move. These paths may follow along the contour lines of equal elevation as well as at some places there also exist up and down slopes. When a well-defined path is evolved for the passage of vehicle, then there comes the need of a carpeted road.

In a hilly area, while designing a road, it is very important to provide culverts/bridges at appropriate places. The design and construction of these bridges/culverts require appropriate hydrologic and hydraulic analysis. The absence or under capacity of culverts/bridges can lead to road damage at several places from rainwater which crosses the road in the form of concentrated as well as diffused flow. If the road is damaged, it can cause travel inconvenience, accidents and loss of precious lives. At places of concentrated flow, there is need of a culvert/bridge for the passage of runoff. For diffused flow side drains are required to divert this flow into the nearest culvert. The design of flows crossing these roads range from 10 to 100 years return period depending upon the traffic load and importance of the road. The amount of runoff generated from the input rainfall can be determined after studying the topography and physical characteristics of the area (bare, forested, cropped etc.). Shallow open surface drains are also usually provided on hillside of road to catch the diffused surface runoff and guide it to nearest cross drainage structure.

In this case study, a road named Ratti Gali-Bhattian situated near Murree was selected. Previous nine years rainfall data of Murree was analyzed to calculate peak flows of streams crossing the road. Most intense rainstorms were selected form the previous 9 years rainfall data. Depth-Duration-Frequency and Intensity-Duration-Frequency curves were developed to calculate the most intense rainfall in 5, 10, 15, 30 minutes 1, 2 and 3 hr durations for return periods of 5, 10, 25 and 50 years. Frequency analysis was performed

by using Gumble Method for rainfall data of one hour duration. The site was physically visited to locate the exact points of crossings of streams. Value of runoff coefficient C is estimated by using hydrologic characteristics of the catchment areas. Topographic sheets were used to delineate the catchment areas of the streams crossing the road. Time of concentration was calculated and finally peak discharge for each crossing point was calculated using Rational Method.

Total 24 number of channels crossing the road were identified. The length of each channel, elevation of remotest point and point of crossings and slope of the catchment areas were used to calculate the time of concentration for each channel. The largest and smallest channels in these catchment areas were of 790 and 60 meters respectively. Minimum and maximum catchment areas were of 0.31 and 32 hectares respectively. While slope ranges between 22% to 50%. Maximum time of concentration in this area is 5 minutes and minimum time of concentration is 0.5 minutes. Rainfall intensity for 5 minutes duration and for 10 and 25 years return period is 259 and 311 mm/hr respectively. Maximum, minimum and average spacing between the crossings was 375, 20 and 170 meters respectively. Channels were varying in width as 1 to 5 meter and in depth as 0.5 to 1.5 meter.

Mainly two hydrologic features, Woodland forest and residential, were seen in these catchment areas. Weighted value of runoff coefficient ranging from 0.40 to 0.52 was used. The range of flow per unit area was 0.29 to 0.45 m^3/s/hectare. The average flow per unit area was calculated as 0.37 m^3/s/hectare. Maximum, minimum and average flows in the area were 12.72, 0.1and 3.05 m^3/sec.

In Murree the most intense storms occur in the months of July-August and mountain slopes are lush green and fully covered with vegetation and woodland during this period. Side drains should be provided along hillside for 90-95% length of the road.

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