

# Design of River Regulator and its Comparison with Existing Anicut

Anila C George<sup>1</sup>, Athira R Thilakan<sup>2</sup>, Athulya Nanadakumar<sup>3</sup>, Gayathri Krishnakumar<sup>4</sup>, Gopikalakshmy K.M.<sup>5</sup>

Assistant Professor, Federal Institute of Science and Technology, Angamaly, India<sup>1</sup>,

Post Graduate Student, Federal Institute of Science and Technology, Angamaly, India<sup>2,3,4,5</sup>

**ABSTRACT:** A river regulator is a barrage constructed across a river comprising of a main diversion structure to raise the river's water level and control its flow. The Cheramangalam scheme was established at Malarcodpanchayath of Palakkad district and is depending on Malampuzha project for meeting the irrigation requirement of farmers during the peak hours. By constructing the cross regulator across Gayathri river in Melarcodpanchayath in Alathur Taluk of Palakkad district at a distance 500m, upstream of the existing anicut, for the additional storage of water and can be utilized for irrigation activities of Cheramangalam scheme. As a part of design of river regulator, rain fall data for past 37 years was collected. Gumbel's method was used to find out the maximum precipitation from the available rain fall data and to characterise the rain fall pattern of catchment area. Topographical characteristics of catchment area were determined by ArcGIS 10.1 software. The maximum flood is calculated using Muskingum's method. All the above data were used for the design of cross regulator across Gayathri River, and is designed in accordance with the Khosla's theory.

**KEYWORDS:** Cross Regulator, Anicut, Precipitation, Flood, Catchment Area

## I. INTRODUCTION

The construction of regulators across rivers can provide considerable benefits such as the supply of drinking water, irrigation water and flood protection. They vary depending on the extent of the inundation area, size of the population at risk and the amount of warning time available. This project has been depending on Malampuzha project during their peak irrigation periods in order to meet the water requirements as well as to supplement the river flow. Due to low rainfall, previous year's water level at Malampuzha dam did not reach its full reservoir level (F.R.L). This situation worsly affected the farmers of Cheramangalam scheme. Hence, for meeting the irrigation requirement of the farmers of Cheramangalam scheme, an additional storage facility has proposed. Construction of a regulator at a distance 1km upstream of the existing anicut, will create an additional storage of water and that can be utilized for irrigation activities of Cheramangalam scheme. Though, there have been great advancements in design methodologies, failures of hydraulic structures still occur. There are several methods for routing the flood resulting maximum discharge. Most of the methods require the length of the water way and its slope. The cross section details have obtained usually by conducting survey. Conducting a survey in the river upstream is very laborious and expensive. The present study approximates the length of the water way and its slope of the river upstream from ArcGIS 10.1.

## II. METHODOLOGY

Initially the available daily rainfall data for the past 37 years, obtained from the Indian Meteorological Department were analyzed to obtain the maximum precipitation that is likely to occur in the drainage basin using the Gumbel's method. Intensity-Duration-Frequency curves (IDF curves) were prepared from the maximum rainfall intensities obtained for various return periods from which the maximum precipitation was found out by taking into consideration the obtained time of concentration and the assumed return period. Once the value of maximum precipitation obtained, the corresponding maximum flood value found out using the Clark's method. Time area diagram and time of

concentration are the two important parameters that need to be considered in the Clark's method. Using the Arc GIS 10.1 software, the location of the site was delineated. Hence, the time of concentration and the time area diagram can be obtained. In this study, the Muskingum's method was used to find out the instantaneous unit hydrograph. This was then converted to flood hydrograph ordinates by accounting the base flow and the direct runoff ordinates, which was derived from the 1-hour unit hydrograph by accounting the value of effective rainfall. The maximum value of flood hydrograph ordinate thus obtained indicates the maximum flood entering the regulator. After obtaining maximum discharge from the flood hydrograph, the hydraulic design has done using the Khosla's theory.

### III. ANALYSIS OF THE PROBLEM

This part discusses the derivation of various input parameters. Malampuzha dam of Bharathapuzha river basin, Kerala has taken as the study area. For this study, only 37 years of daily rainfall data are available. Hence, instead of probable maximum flood, only the maximum floods that can be expected from 37 years of available data are considered. The computation of peak discharge is essential for the design of any hydraulic structure. The expected peak discharge depends on the duration and magnitude of maximum precipitation. In this study the maximum precipitation is determined from Intensity-Duration-Frequency curves developed from the available rainfall data.

The daily rainfall data for a period of 37 years (1977 to 2013) were collected from Indian Meteorological Department (IMD) with Malampuzha dam as the gauging station. The magnitudes of maximum values of 24 hrs, 48hrs and 72 hrs duration rainfall values were computed for each year during the data period of 1977-2013 and were tabulated. From the observed values of maximum rainfall, the mean and the standard deviation were found.

The probable maximum rainfall is computed using the mean and standard deviation from the Gumbel's method for different return periods. The return periods considered are 100 years, 200 years, 400 years and 1000 years. This maximum rainfall values are then converted to maximum rainfall intensities by dividing the corresponding magnitude of rainfall with the corresponding duration. Intensity duration frequency (IDF) curves were plotted for various return periods with maximum intensity as ordinate and duration as abscissa. The IDF curves developed were useful to compute the maximum precipitation for any duration and for any return periods. The return period and duration varies according to the type of hydraulic structure to be designed. When the importance of hydraulic structure is more, a return period of the order of 100 years or 1000 years will be selected. A very small return period of the order of 5 year or 10 year will be adopted for roadside culverts etc.

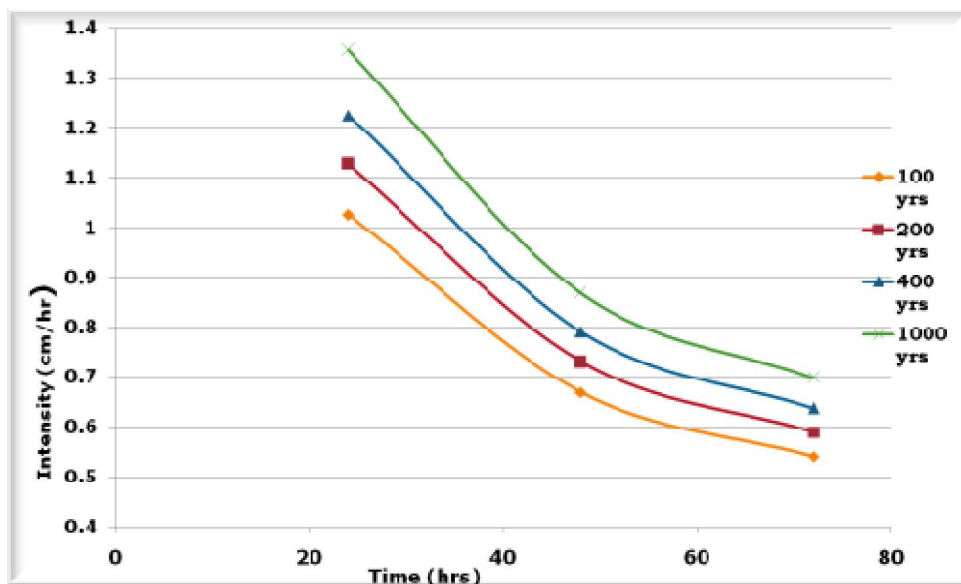


Fig. 1 Intensity Duration Frequency curves

From the IDF curves, it is found that as the duration increases intensity decreases. The precipitation for a 24-hour storm having a return period of 1000 years is obtained from Fig.1 as 1.36 cm/hr, which corresponds to a maximum precipitation of 326.4 mm in one day. Daily rainfall values were used in this analysis to obtain the maximum rainfall values. However, the time of concentration of a basin represents the time to peak of a hydrograph. Hence, the daily rainfall values were converted to rainfall values corresponding to the time of concentration.

Here the time of concentration of the area of the regulator is computed using Kirpich's equation. Length of basin 'L' is taken as 62 km and slope of the basin as 1 in 140. Using these two values, the time of concentration ( $T_c$ ) is obtained as 4.27 hours.

ESRI's ArcGIS is a geographic information system (GIS) for working with maps and geographic information. Georeferencing was the technique that was used in ArcGIS 10.1, since the region located in the toposheet lies in two different toposheets, it was essential to make that two toposheets into a single one. For that the coordinates i.e., latitudes and longitudes of four sides of two toposheets were given as inputs for georeferencing.

Project raster is the function that was used in ArcGIS 10.1 for projecting the toposheets such that after georeferencing both the toposheets merge as a single unit. The next step is to digitise the river. Digitising is carried out with the help of Editor in the ArcGIS 10.1 software. The each and every stream of river was taken into consideration and the longest route from the traced path was determined by computing the length of each path.

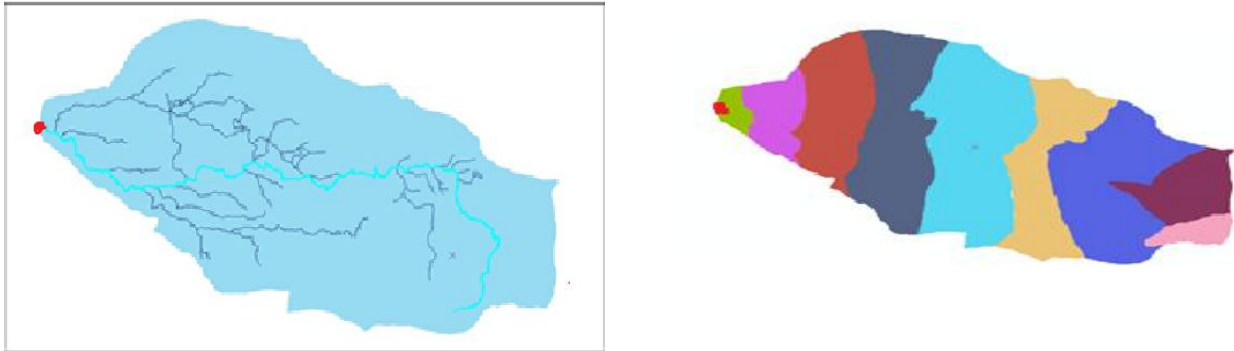


Fig. 2 Digitised Gayathri River and Isochronal Map

The catchment area of the Gayathri river was delineated using ArcGIS 10.1 software. The method adopted for the delineation process was to connect the highest points on the contours which are around the proposed site. The time of concentration of a drainage basin is the time required by the water to reach the outlet from the most remote point of the drainage area. When a storm has been progressing for a time equal to the time of concentration, it is assumed that all the parts of the basin start contributing to the discharge at the outlet.

$$T_c = 0.00195L^{0.77}S^{(-0.385)} \tag{1}$$

$$T_c = 0.0195 * 62000^{0.77} * 0.0071^{(-.385)} = 256 \text{ minutes} \tag{2}$$

The drainage basin was divided into zones (sub- areas,  $A_i$   $\text{km}^2$ ) by drawing isochrones. An isochrone is a line joining all points having same travel time. For e.g., a water particle on a 8 hour isochrone will take 8 hour to reach the basin outlet. For drawing isochrones, the profile of the longest water course was plotted as elevation vs. distance from the basin outlet. The total length of the main channel was then divided into N reaches. Curves were drawn connecting the points having equal time of concentration, which were called isochrones. The areas between the successive isochrones are found out and the time area diagram is prepared from the isochronal map.

The computation of maximum flood was done using the Clark's method. Muskingum's method was used for routing the inflows to obtain the instantaneous unit hydrograph. For the purpose of finding out the maximum flood, the entire catchment area of the reservoir was delineated. Isochrones are then plotted for varying travel times as in Fig. 2 and the inter-isochronal areas are found out using the ArcGIS software.

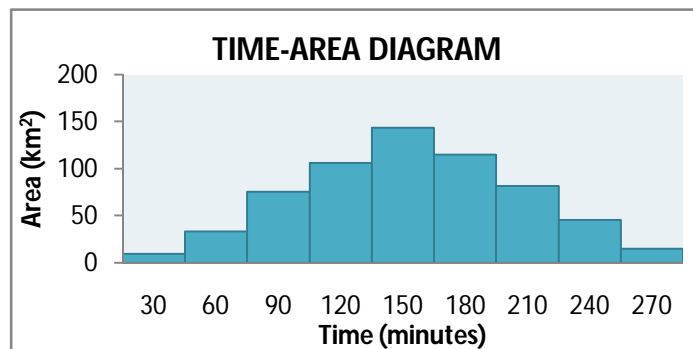


Fig. 3 Time area diagram

Once the inflow was obtained, it was possible to route the inflow to get the instantaneous unit hydrograph ordinates using the Muskingum's method. According to the Muskingum's method, the outflow, Q was obtained based on equation. The instantaneous unit hydrograph was plotted. Rainfall excess refers to the value of rainfall which is free

from all the losses. Rainfall excess is used to convert the 1 hour unit hydrograph ordinates to the direct runoff ordinates. The initial loss is assumed to be 10 mm.

Assuming loss = 10 mm, Rainfall excess = 326.4- 10 mm = 316.4 mm = 31.64 cm

The maximum rainfall is derived using 24 hour point precipitation. But the time of concentration for the catchment area of the regulator is obtained as 4.27 hours. Hence 24 hour point precipitation is converted to 4.27 hour point precipitation. For this a conversion factor of 0.570 is being considered as per the CWC 46.As per Flood Estimation Report for west coast regions, an areal reduction factor of 0.8519 is also accounted to convert the 4.27 hour point precipitation to 4.27 hour areal precipitation as per CWC Flood Estimation Report for west coast zones. Considering these two factors, the final rainfall excess comes to 15.36 cm.As per CWC Flood Estimation Report for west coast zones, the base flow rate is taken as 0.15 cumecs / sq.km. Therefore base flow =0.15x 625.357= 79.6m<sup>3</sup>.The obtained instantaneous unit hydrograph is first converted to 1 hour unit hydrograph by lagging the ordinates by 30 minutes up to 1 hour, i.e, by S-curve technique.The 1 hour unit hydrograph ordinates are then converted to direct runoff ordinates by multiplying the values with rainfall excess. The summation of direct runoff ordinates with base flow yields the flood hydrograph ordinates.

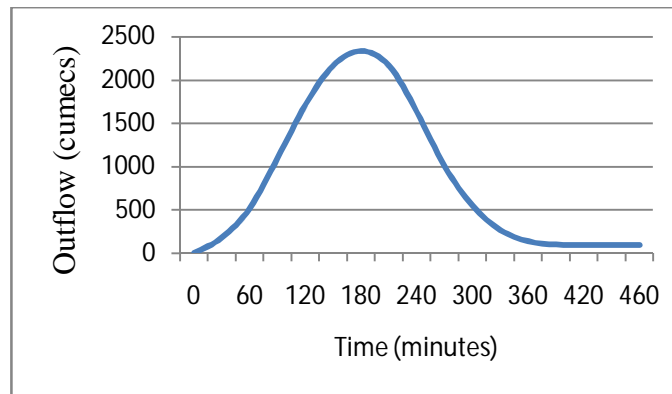


Fig. 4 Flood hydrograph

The maximum probable flood value was obtained as 2331.625 cumecs from the flood hydrograph.

Data used for design of regulator:

Assuming loss = 10%, Rainfall excess = 31.64cm, Base flow = 79.6 cm<sup>3</sup>, Full supply discharge = 2331.659cumecs, depth of water = 2.6m , Full supply discharge (FSL u/s) =224.6m , Full supply discharge (FSL d/s) = 223.8m, crest level= 222m.

**IV. RESULTS**

Khosla’s theory was used for the design of the regulator, the design procedures were followed according to the theory and several design elements like length of the waterway, downstream floor level, length of d/s floor, Cut-off, total floor length, uplift pressures and floor thickness were found out. Length of regulator was obtained as 236m. Fig. 5 gives the cross sectional details of the cross regulator.

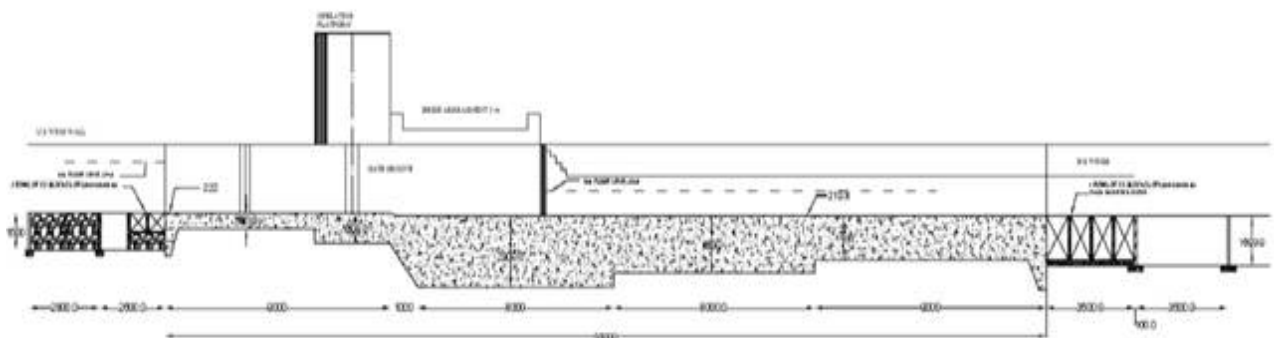


Fig. 5 Cross section of the river regulator

## V. COMPARISON AND CONCLUSION

By the construction of the new river regulator downstream of the confluence of two rivers namely Chulliyar and Meenkara River, the water shortage for irrigation for the farmers in MelarcodePanchayath could be solved extensively even if ample amount of water supply is not obtained from the Malampuzha Dam.

## REFERENCES

- [1] G. Al Mashidani, Pande, B.B Lal, M Fattah (1978), "A simple version of Gumbel's Method for flood estimation", Hydrological Science Bulletin, pp. 373 – 341
- [2] Guang-Te and V P Singh (1992), "Muskingum method with variable parameters for flood routing in channels", Journal of Hydrology, Vol. 134, pp. 57 -76
- [3] Santhosh Kumar Garg (1996), Hydrology and Water Resource Engineering, Khanna Publishers, New Delhi
- [4] K.C.Patra (2001), Hydrology and Water Resources Engineering, Narosa Publishing House, New Delhi
- [5] JK.R.Arora (2007), Irrigation, Water Power and Water Resources Engineering, Standard Publishers Distributors, New Delhi
- [6] H.M.Raghunath (2007), Hydrology- Principles, Analysis, Design, New Age International Publishers, New Delhi
- [7] Mark Boucher (2009), "Rainfall Intensity- Duration- Frequency Curves", Contra Costa County Flood Control and Water Conservation District
- [8] MostafazadehR ,Bahreman A, Sadoddin A "Simulating the direct runoff hydrograph using clark instantaneous unit hydrograph ,journal of soil and water conservation(2009)" page no 105-122
- [9] Vivekanandan.N conducted studies on the "Assessment of Probable Maximum Precipitation Using Gumbel Distribution and Hershfield Method ,Bonfring International Journal of Data Mining", Vol. 3, No. 1, March 2013".
- [10] Romulus Costache "The journal of GeographiaTechnica, "Using GIS techniques for assessing lag time and concentration time in small river basins",vol 09 ,Issue 1,2014.