HYDROLOCAL ANALYSIS AND DESIGN OF HEADWORKS OF JEERA IRRIGATION PROJECT

A THESIS SUBMISSION FOR PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

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Civil Engineering

By

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CERTIFICATE

This is to certify that the thesis entitled **"HYDROLOGICAL ANALYSIS AND DESIGN OF HEADWORKS OF JEERA IRRIGATION "** submitted by Mr Abhinav Gayari, Roll No. 109CE0038 in partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering from National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date: **(Prof. K.C. PATRA)**

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ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and indebtedness to my guide Prof K.C.Patra, Department of Civil Engineering, National Institute of Technology, Rourkela for introducing the present topic and for his guidance, constructive criticism and valuable suggestions throughout my project work.

.I am also thankful to all staff members of Civil Engineering Department of NIT Rourkela. Last but not the least, I would like to thank and express my gratitude towards my friends who at various stages had lent a helping hand.

Date: **(Abhinav Gayari)**

Abstract

Designing a dam is one of the most serious and risky projects of civil engineering. But with proper knowledge and data and with experience a stable dam can be designed to meet the necessary requirements. Also while designing a dam one should design it in an economic manner. Designing a dam unnecessarily big may result in wastage of investment and resource. So a proper study on hydrological features is relevant. Analysis of stability of slopes is of utmost importance as its failure may lead to catastrophic conseqences resulting in loss of lives and great economic losses. Failure of a mass located below the slope is called a slide. It involves both the downward and outward movement of entire mass of soil that participates in failure.

So in this project a proper hydrological analysis of the upper Jonk basin was carried out. The analysis were basically determination of average annual precipitation of the catchment, yield series and flood discharge. After obtaining a suitable data the cross section of the dam was designed.

Now in order to check the stability of the dam a series of hand calculation was done. It included stability of upstream slope, downstream slope, overall stability against shear and stability of foundation.

In the present day lots of methods are available to the modern engineer to obtain the stability of slopes.
A software named “PLAXIS “ was also used to determine the stability of the dam. In this project a comparative study of the two methods was done with special stress on the application of GA in the analysis of slope stability.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Purpose of the Project

The project is proposed to benefit Bargarh, Bhatli and Sohela blocks of Bargarh district, Odisha, which are chronically drought affected areas. These areas are inhabited mostly by poor people belonging to Below poverty line people. The only source of income for the inhabitants of this area is agriculture. Therefore the project is absolutely necessary to improve agricultural output and economy of the region to mitigate the misery of a sizeable population, mostly belonging to backward classes.

About the Project

The department of water resource of Odisha state has proposed a project of medium irrigation in Mahanadi basin on Jeera River, a tributary to Mahanadi River, at village Duanpali; block Bhatli, in Bargarh District of Odisha. The project envisages construction of a 1958 m long Homogeneous Rolled Earth Fill dam, besides a spillway of length 72m proposed at the central portion of the dam axis. This medium irrigation project will provide irrigation facility to 6000 ha of Gross CommandArea (G.C.A) and 4800 ha of Cultivable Command Area (C.C.A) with annual irrigation of 5840 Ha in a drought prone area of Western Odisha.

Location of the Project

The location is in Bhatli Block of Bargarh District which is near the village Duanpali and is about 15 km away from Sohela sub-division of Bargarh District at latitude 21 ◦ 23 ‘11” N and 83◦ 26’ 13”E. The nearest railway station of East Coast Railways is Bargarh, about 30 km from the dam site. The dam site is about 350 km from the state capital and the nearest airport Bhubaneswar.

1.2 What is Hydrology?

Water is one of the most important natural resources. Without water, there would be no life on earth. The amount and supply of water available for our use is limited by nature. Although there is plenty of water on earth,but it is not always in the right place, at the right time. Hydrology has evolved as a branch of science in response to the need to understand the complex water systems of the Earth and help solve water problems. So a hydrologists play a vital role in finding solutions to water problems, and divert them elsewhere to harness its use for purposes like Irrigation, Electricity generation etc.

Hydrologic Cycle

The water cycle, or hydrologic cycle, is a repetative process by which water is cycled by evaporation and transported from the surface of the earth and water bodies to the atmosphere and back to the land and oceans. All of the mechanical, chemical and biological processes involving water, as it travels through various paths in the atmosphere, over and beneath the earth's surface and through growing trees and plants, are of interest to those who study the hydrologic cycle.

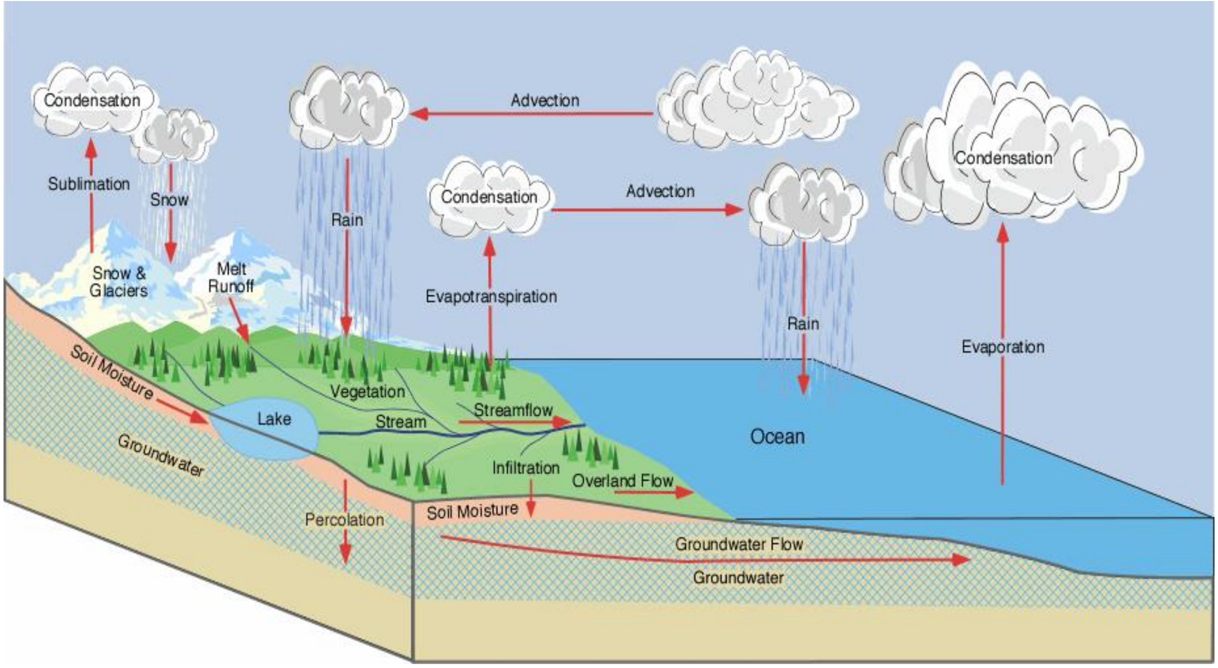


Fig. 1 Hydrologic cycle

1.3 What is an Earthen dam?

An earth dam is a dam built with highly compacted earth or clay materials. This dam can be classified as a type of embankment dam, because it is built in the shape of an embankment which blocks the water flow in a river. These dams have been built by various human societies for centuries, and they continue to be built it in some regions of the world when they appear to be suitable for the location and intended use.

Earth dams are very cost effective to build, which makes them appealing in some regions of the world. They can be made with local materials, econmising the expenses involved in acquiring and transporting materials to the dam site. In addition to soil or earth, earth dams also often contain rock, and may be filled with a core of rock or layer of sand. Clay is another important building material utilized in earth dams.

The design of an earth dam may either be solid and consistent all the way through, or it may include layers of material. Layered materials may create an avenue for drainage which is designed to relieve pressure in emergencies. The weight of the dam creates a tight seal which secures the bottom and the sideways of the dam, and the pressure of water behind the dam can also act to seal the dam in place.

Fig 2. C.J. Strike Dam, an earth dam in Idaho

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

Stability analysis of an earth dam under steady state seepage- 17 March 1996

Tien-kuen Hnang

The aim of the work described in this paper is to describe a numerical procedure for performing stability analysis of an earth dam after the filling of a reservoir. Firstly, the piezometric heads at different points in an earth dam after the filling of a reservoir are obtained with a trial-and-error procedure. Then, the numerical analysis of the dam is performed using the finite element method, with a cap model used for representing soil behaviors. A special technique to handle the effect of steady state seepage is introduced. An example of a reservoir completed recently in Taiwan is illustrated. The results indicate that the factor of safety against stability failure of the dam is adequate.

Optimal hydraulic design of earth dam cross section using saturated–unsaturated seepage flow model-- January 2003

Y.-Q. Xu
K. Unami
T. Kawachi

An optimal hydraulic design problem regarding an earth dam cross section is formulated as an inverse problem for the steady model of saturated–unsaturated seepage flows in porous media. In the problem formulation, the choice of soil material to be used in each point of the dam cross sectional domain is considered as the control variable to be identified. The performance index used to evaluate the appropriateness of the design is defined as the sum of two square integral norms, which represent reducing the saturated zone and minimizing material costs. It is also shown that the first norm bounds the total seepage discharge through the earth dam. Since the governing variational boundary value problem as well as the adjoint problem is well-posed, a deterministic approach is taken. A numerical scheme including pseudo-unsteady terms is developed to calculate the optimal solution in an ideal earth dam cross section to be designed utilizing two different types of soil material. The results show that an inclined clay core of less hydraulic conductivity should be located on the upstream side of the cross section. The unsaturated zone turns out to play an important role in the flow field and the optimal design.

CHAPTER 3

HYDROLOGICAL ANALYSIS

HYDROLOGICAL ANALYSIS

For hydrological analysis the study of catchment is necessary.
The catchment is Upper jonk Catchment.
Some of the features of Upper Jonk are:-
Catchment area is 187 sq. km, Slope is gentle, The aerial rainfall distribution is uniform over the catchment.

3.1 Estimating spatial distribution of rainfall over the catchment

The available rainfall data are point values but we need data cover the whole Upper Jonk catchment. The objectiv is to determine how the rainfall distribution is influenced over the catchment by the different rain gauge stations. There are many suitable methods. In this project two methods were being used : Arithmetic Average Method,Thiessen Polygon Method and the incorporation of the elevation effect on rainfall distribution(Not dne). These are introduced below.

a) Arithmetic Average Method

The advantage of Arithmetic Average Method is that it needs the simplest calculation. But it shows a big disadvantage over the others. The method is suitable if the climate and the relief is near uniform through out and the regional distribution of rain gauges is homogenous. So in this instance this method have appreciable inaccuracy, therefore it was used to compare this result with the other methods results.

The arithmetic average of the rainfalls is given by the equation:

$$\bar{h} = \frac{\sum_{i=1}^{n} h_i}{n}$$

where	$\bar{h}$	spatial average of precipitation
	h_i	rain gauge precipitation value
	i	number of rain gauges
	n	total number of rain gauges

Four gauge stations are used to measure the rainfall of the respective places..

- BICCHUNA
- DUANPALI
- ARJUNDA
- DONGRIPALI

The rainfall data were collected for each stations for different monsoonal season and Arithmetic average method is applied to obtain the average precipitation for each season.

CALCULATION

Data and calculations are showed as in the table below.

Average precipitation for the month of june.

Table 1.

RAINFALL IN mm FOR JUNE

	BICCHUNA	DUANPALI	ARJUNDA	DONGRIPALI	
YEAR	RAINFALL	RAINFALL	RAINFALL	RAINFALL	AVERAGE RAINFALL OF CATCHMENT
1991	52.06	91.7	21.32	16	45.27
1992	137.08	100	205.3	36	119.59
1993	89.14	87.7	83	8.22	67.01
1994	167.5	130.6	225	42.3	141.35
1995	207.2	230.1	245.3	69.3	187.97
1996	123	150	86	144	125.75
1997	98.6	166	58	143	116.4
1998	54.1	154	90.2	75.8	93.52
1999	149	259	137	86.1	157.77
2000	303.3	318	285	152.3	264.65
2001	172.9	499.4	593.2	860	531.37
2002	81.98	269.2	129.12	13	123.32
2003	150.3	241.3	239	317	236.9
2004	74.3	193.6	74	24	91.47
2005	140.5	150.5	119.5	126	134.12

Table 2.

RAINFALL IN mm for JULY

YEAR	BICCHUNA	DUANPALI	ARJUNDA	DONGRIPALI	AVERAGE RAINFALL
1991	262.11	339	338.28	258.1	299.37
1992	400.2	394.95	500.32	215	377.61
1993	256.29	255.7	318	142.34	243.08
1994	420.8	398.5	529	245.6	398.47
1995	455.9	418.5	565	257.8	424.3
1996	274.5	236.45	277.9	246.4	258.81
1997	224	368.2	303	185	270.05
1998	196.5	386.9	234	320.6	284.5
1999	196.7	208.5	267.3	351.3	255.95
2000	280.2	227.4	266	358.1	282.92
2001	307.8	493.5	481	423	426.32
2002	124.14	177.3	219.04	452	243.12
2003	237.6	192.4	579	402	352.75
2004	149.7	269.3	200	193	203
2005	460.5	375	545	431	452.87

Table 3.

RAINFALL IN mm for AUGUST

YEAR	BICCHUNA	DUANPALI	ARJUNDA	DONGRIPALI	AVERAGE PRECIPITATION
1991	320.2	305.22	368.66	333	331.77
1992	452.25	346.45	337.62	482.9	404.80
1993	510	166.8	284	280	310.2
1994	415	305.6	537.2	431.9	422.42
1995	445.6	335.7	575.1	485.3	460.42
1996	355.22	336.4	320.6	245.9	314.53
1997	278.9	343.1	401.3	676	424.82
1998	149.6	141.7	87.7	124.4	125.85
1999	294.3	287.4	250.4	194.3	256.6
2000	263	162.2	250.4	201	219.15
2001	270.23	233.6	346	165	253.70
2002	118.22	208	543	304	293.30
2003	186	292.4	586	127	297.85
2004	405.9	465.9	606	405	470.7
2005	235	245.5	210.5	212	225.75

Table 4.

RAINFALL IN mm for SEPTEMBER

YEAR	BICCHUNA	DUANPALI	ARJUNDA	DONGRIPALI	AVERAGE PRECIPITATION
1991	108.07	92.35	140.26	84	106.17
1992	103.1	104.3	131	290	157.1
1993	83.29	60	92.16	120	88.86
1994	125.8	120.3	150.2	255.2	162.87
1995	135.1	155.2	165.5	325.3	195.27
1996	261.7	181.1	94.3	152.3	172.35
1997	52.7	140.1	139	125	114.2
1998	161.4	344.5	334	260.2	275.02
1999	124.3	113.9	107.5	163.4	127.27
2000	168.8	109.9	193.6	117.7	147.5
2001	17.12	141.3	158	296	153.10
2002	126.2	152.7	401	300	244.97
2003	192.6	116.9	315	68	173.12
2004	38.8	46.7	78	65	57.12
2005	153.5	144.5	170	188.5	164.12

Table 5.

RAINFALL IN mm for OCTOBER

YEAR	BICCHUNA	DUANPALI	ARJUNDA	DONGRIPALI	AVERAGE PRECIPITATION
1991	52.08	28.25	52.08	37.02	42.35
1992	24.05	11	15	7	14.26
1993	0	0	0	0	0
1994	23.6	21.3	30.4	12.2	21.87
1995	38.3	35.2	45.6	25.2	36.07
1996	140	0	140	143	105.75
1997	29.9	5	13	5	13.22
1998	135.6	185	187.6	200.7	177.22
1999	66.6	50.1	66.6	132.6	78.97
2000	115.8	7	5	6.3	33.52
2001	47	12.3	47	20	31.57
2002	0	0	6	0	1.5
2003	308	290	208	310	279
2004	41	46.7	41	22	37.67
2005	98.5	116	91	105.5	102.75

Table 6.

ANNUAL MONSOONAL RAINFALL OF THE CATCHMENT

	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	ANNUAL RAINFALL
1991	**45.27**	**299.37**	**331.77**	**106.17**	**42.35**	824.93
1992	**119.59**	**377.61**	**404.8**	**157.1**	**14.26**	1073.36
1993	**67.01**	**243.08**	**310.2**	**88.86**	**0**	709.15
1994	**141.35**	**398.47**	**422.42**	**162.87**	**21.87**	1146.98
1995	**187.97**	**424.3**	**460.42**	**195.27**	**36.07**	1304.03
1996	**125.75**	**258.81**	**314.53**	**172.35**	**105.75**	977.19
1997	**116.4**	**270.05**	**424.82**	**114.2**	**13.22**	938.69
1998	**93.52**	**284.5**	**125.85**	**275.02**	**177.22**	956.11
1999	**157.77**	**255.95**	**256.6**	**127.27**	**78.97**	876.56
2000	**264.65**	**282.92**	**219.15**	**147.5**	**33.52**	947.74
2001	**531.37**	**426.32**	**253.7**	**153.1**	**31.57**	1396.06
2002	**123.32**	**243.12**	**293.3**	**244.97**	**1.5**	906.21
2003	**236.9**	**352.75**	**297.85**	**173.12**	**279**	1339.62
2004	**91.47**	**203**	**470.7**	**57.12**	**37.67**	859.96
2005	**134.12**	**452.87**	**225.75**	**164.12**	**102.75**	1079.61

From the table summing up the rainfall for five months the annual monsoonal rainfall was calculated.

Therefore from table

Max annual rainfall= 1396mm

Min annual rainfall=709.15mm

Average annual rainfall=958.51mm

b) Thiessen Polygon Method

The Thiessen Polygon Method was also used to find the spatial distribution of rainfall.

In this method the Upper jonk catchment was divided into 4 parts performing the following construction: drawing straight lines between the rain gauges and constructing perpendicular bisectors for each line.Accordingly we obtain required sub regions which areas in the catchment are closest to each rain gauge station.

Eech sub region belongs to one of the rain gauges. The spatial average precipitation in each region assumed to be identical with precipitation value of the regions rain gauge.

I have used Thiessen polygon method for the determination of average rainfall as it is easy and reliable methd.Advantage of this method over arithmetic mean is that,in this method weightage is given to all measuring gauges on the basis of their aerial coverage on the map ,thus reducing discrepancies in their spacing over the basin.

Procedure

1. All the gauges in and around the basin were accurately marked on a map drawn to scale as Arjunda(A), Duanpali(D), Bicchuna(B) and Dongripali(Dp).
2. Conseecutive stations were joined by straight to for triangles.
3. Perpendicular bissectors were drawn to these lines such that the bisectors formed a polygon around each stations.
4. Each stations on the map were thus enclosed by a polygon.A polygon represents an area for which the station rainfall is the representative.
5. Area of each polygon was measured by counting the unit boxes of the graph over which map was drawn.
6. Thiessen weights were computed by dividing the area of each polygon by the total basin area and checked for the sum of weights of all stations to be equal to unity.
7. Finally the average precipitation was calculated by using the relation,

$$P_{av} = \frac{A_1P_1 + A_2P_2 + A_3P_3 + A_3P_3 + A_3P_4}{A_1 + A_2 + A_3 + A_4}$$

$$P_{av} = P_1W_1 + P_2W_2 + P_3W_3 + P_4W_4$$

Where P_1, P_2, P_3, P_4 represents precipitation and A_1, A_2, A_3, A_4 area of 4 stations respectively and W_1, W_2, W_3, W_4 their thiessen weight or influence factor given by $\frac{A_1}{A}, \frac{A_2}{A}, \frac{A_3}{A}, \frac{A_4}{A}$.

Total catchment area of basin is 187 sq. km

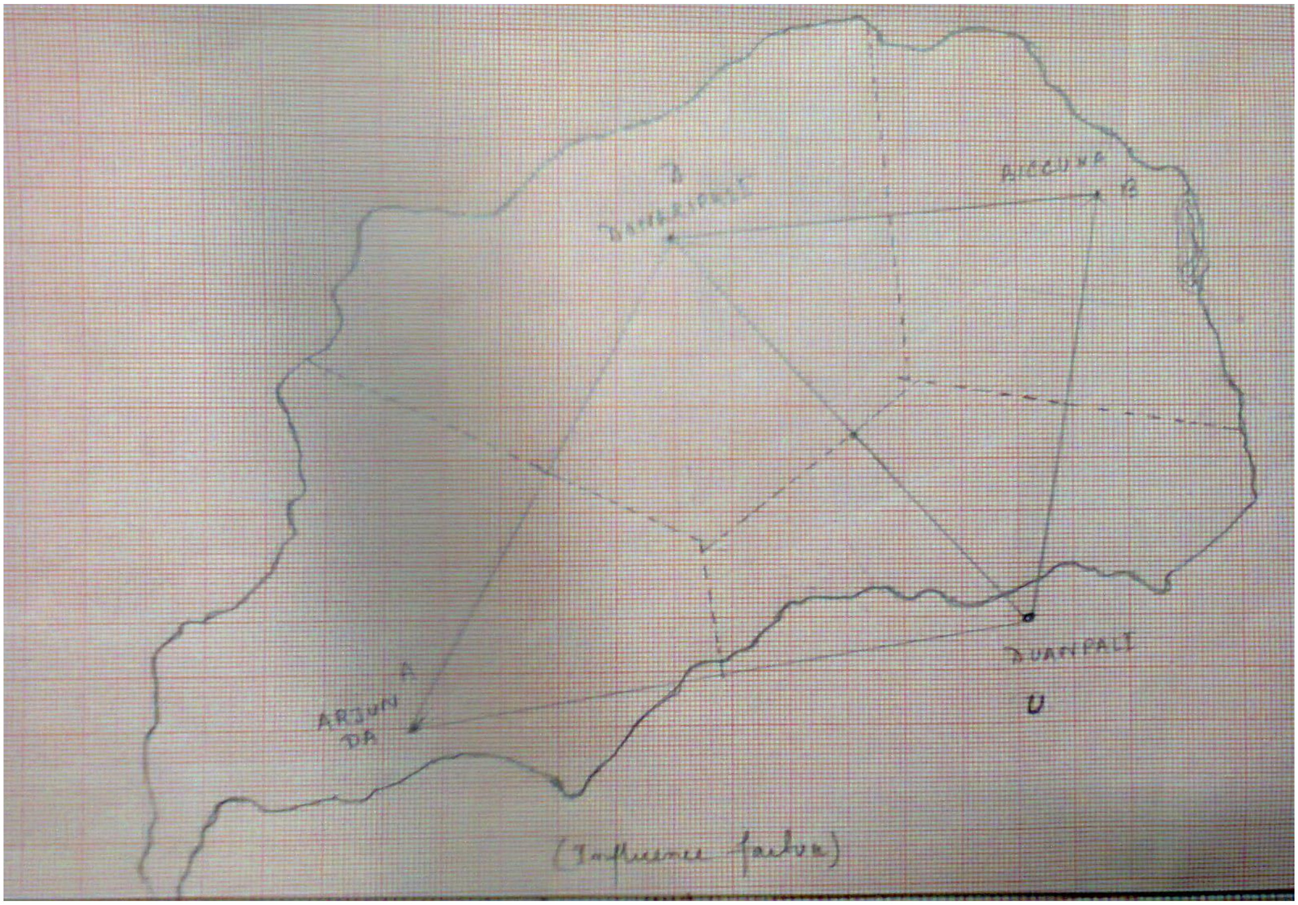


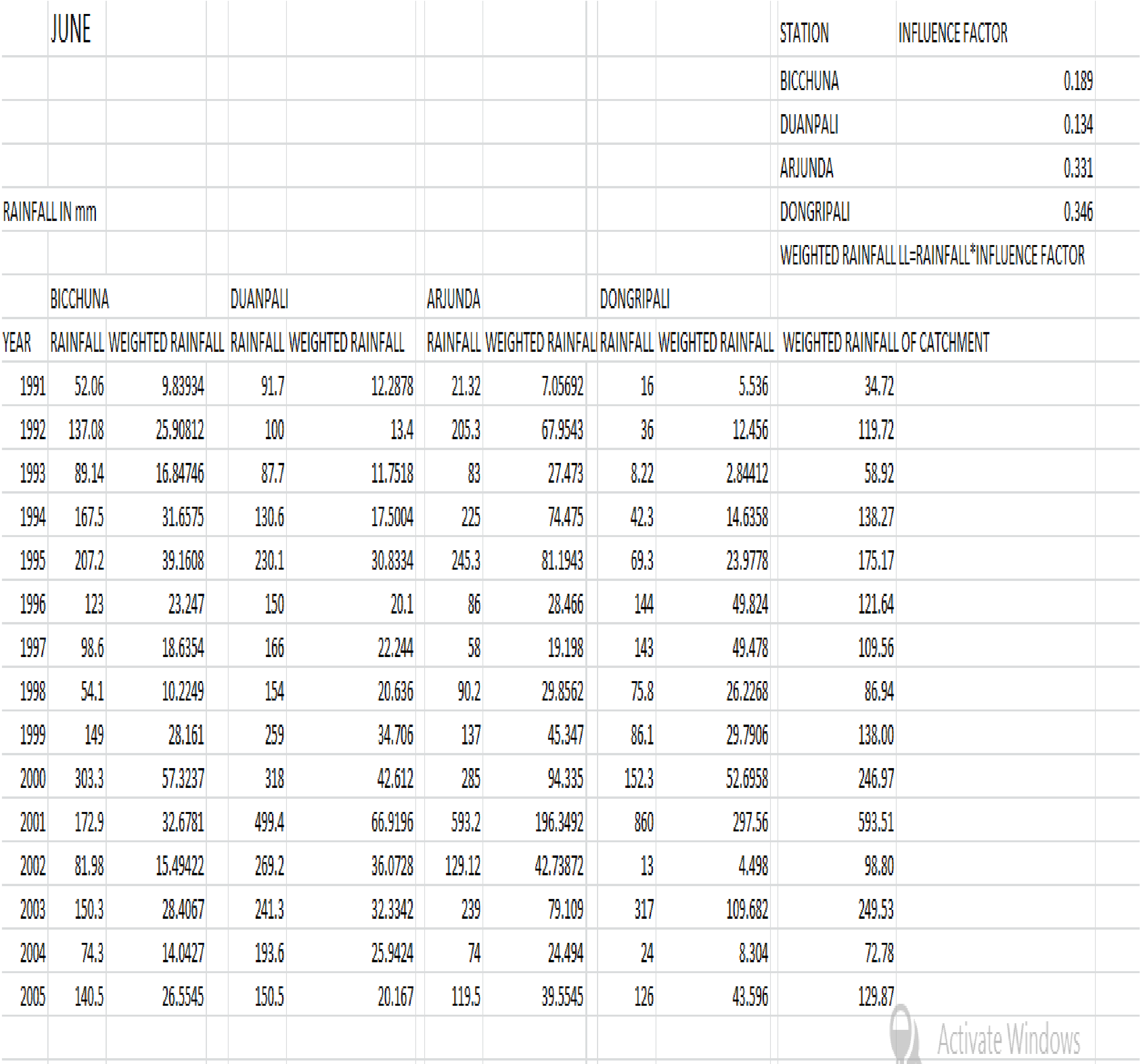
Fig. 3 Determination of weighted mean

STATION	INFLUENCE FACTOR
BICCHUNA	0.189
DUANPALI	0.134
ARJUNDA	0.331
DONGRIPALI	0.346

WEIGHTED RAINFALL=INFLUENCE FACTOR*RAINFALL

The tables for the determination of monthly average precipitation are given below.

Table 7.



JUNE

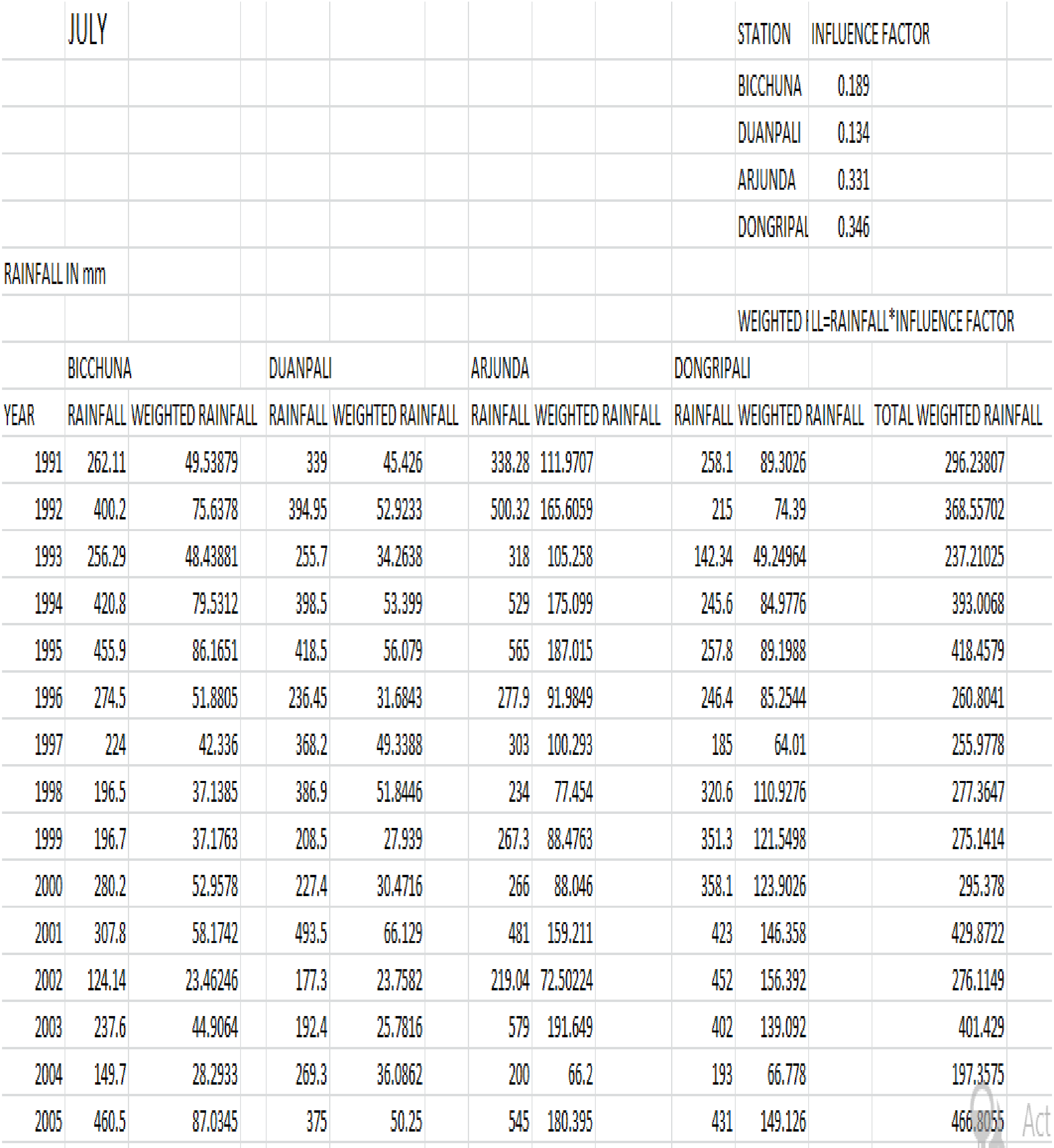
STATION	INFLUENCE FACTOR
BICCHUNA	0.189
DUANPALI	0.134
ARJUNDA	0.331
DONGRIPALI	0.346

RAINFALL IN mm

WEIGHTED RAINFALL LL=RAINFALL*INFLUENCE FACTOR

	BICCHUNA		DUANPALI		ARJUNDA		DONGRIPALI		
YEAR	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFAL	RAINFALL	WEIGHTED RAINFALL	WEIGHTED RAINFALL OF CATCHMENT
1991	52.06	9.83934	91.7	12.2878	21.32	7.05692	16	5.536	34.72
1992	137.08	25.90812	100	13.4	205.3	67.9543	36	12.456	119.72
1993	89.14	16.84746	87.7	11.7518	83	27.473	8.22	2.84412	58.92
1994	167.5	31.6575	130.6	17.5004	225	74.475	42.3	14.6358	138.27
1995	207.2	39.1608	230.1	30.8334	245.3	81.1943	69.3	23.9778	175.17
1996	123	23.247	150	20.1	86	28.466	144	49.824	121.64
1997	98.6	18.6354	166	22.244	58	19.198	143	49.478	109.56
1998	54.1	10.2249	154	20.636	90.2	29.8562	75.8	26.2268	86.94
1999	149	28.161	259	34.706	137	45.347	86.1	29.7906	138.00
2000	303.3	57.3237	318	42.612	285	94.335	152.3	52.6958	246.97
2001	172.9	32.6781	499.4	66.9196	593.2	196.3492	860	297.56	593.51
2002	81.98	15.49422	269.2	36.0728	129.12	42.73872	13	4.498	98.80
2003	150.3	28.4067	241.3	32.3342	239	79.109	317	109.682	249.53
2004	74.3	14.0427	193.6	25.9424	74	24.494	24	8.304	72.78
2005	140.5	26.5545	150.5	20.167	119.5	39.5545	126	43.596	129.87

Table 8.



JULY

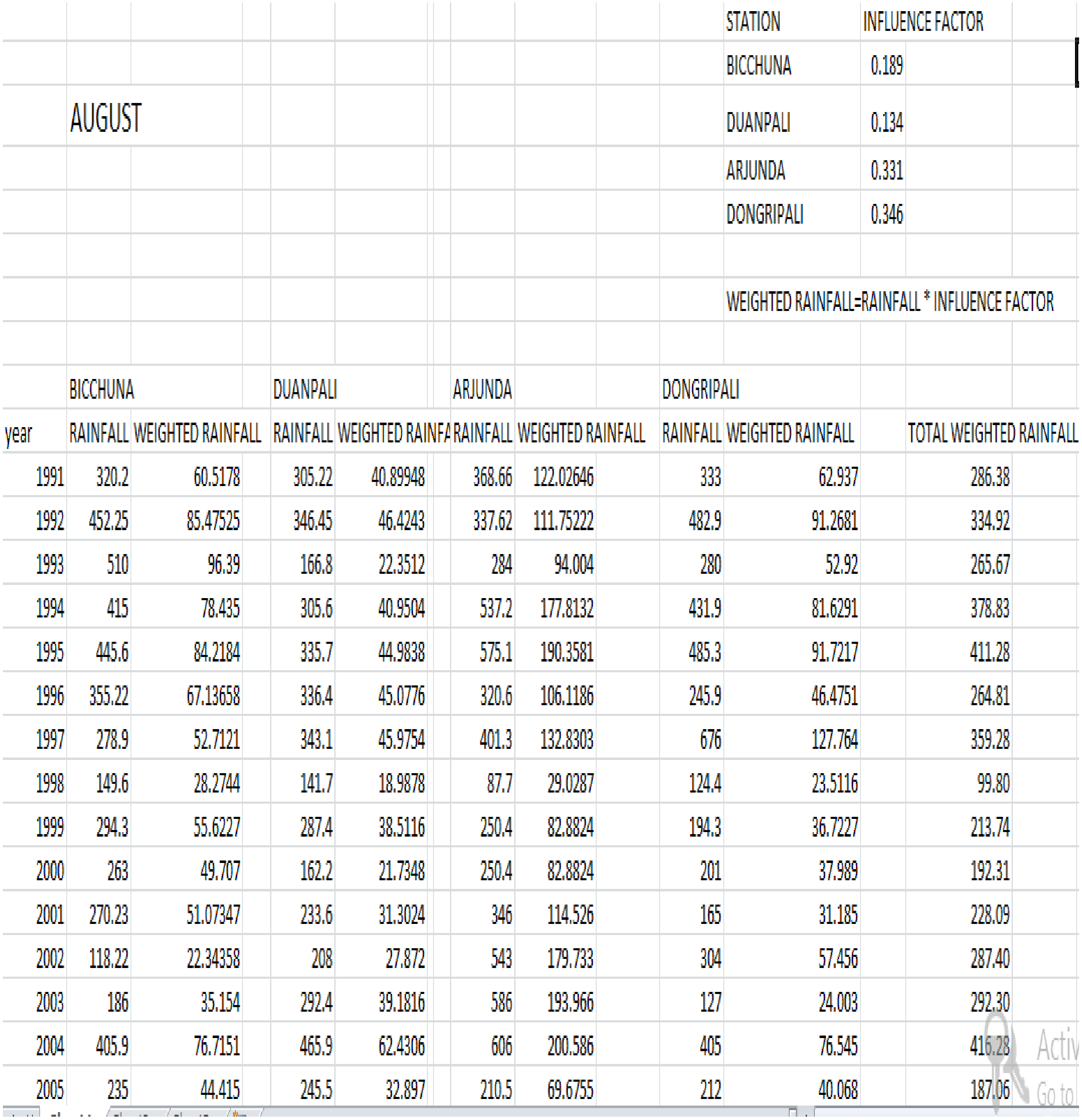
STATION	INFLUENCE FACTOR
BICCHUNA	0.189
DUANPALI	0.134
ARJUNDA	0.331
DONGRIPAL	0.346

RAINFALL IN mm

WEIGHTED LL=RAINFALL*INFLUENCE FACTOR

	BICCHUNA		DUANPALI		ARJUNDA		DONGRIPALI		
YEAR	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	TOTAL WEIGHTED RAINFALL
1991	262.11	49.53879	339	45.426	338.28	111.9707	258.1	89.3026	296.23807
1992	400.2	75.6378	394.95	52.9233	500.32	165.6059	215	74.39	368.55702
1993	256.29	48.43881	255.7	34.2638	318	105.258	142.34	49.24964	237.21025
1994	420.8	79.5312	398.5	53.399	529	175.099	245.6	84.9776	393.0068
1995	455.9	86.1651	418.5	56.079	565	187.015	257.8	89.1988	418.4579
1996	274.5	51.8805	236.45	31.6843	277.9	91.9849	246.4	85.2544	260.8041
1997	224	42.336	368.2	49.3388	303	100.293	185	64.01	255.9778
1998	196.5	37.1385	386.9	51.8446	234	77.454	320.6	110.9276	277.3647
1999	196.7	37.1763	208.5	27.939	267.3	88.4763	351.3	121.5498	275.1414
2000	280.2	52.9578	227.4	30.4716	266	88.046	358.1	123.9026	295.378
2001	307.8	58.1742	493.5	66.129	481	159.211	423	146.358	429.8722
2002	124.14	23.46246	177.3	23.7582	219.04	72.50224	452	156.392	276.1149
2003	237.6	44.9064	192.4	25.7816	579	191.649	402	139.092	401.429
2004	149.7	28.2933	269.3	36.0862	200	66.2	193	66.778	197.3575
2005	460.5	87.0345	375	50.25	545	180.395	431	149.126	466.8055

Table 9



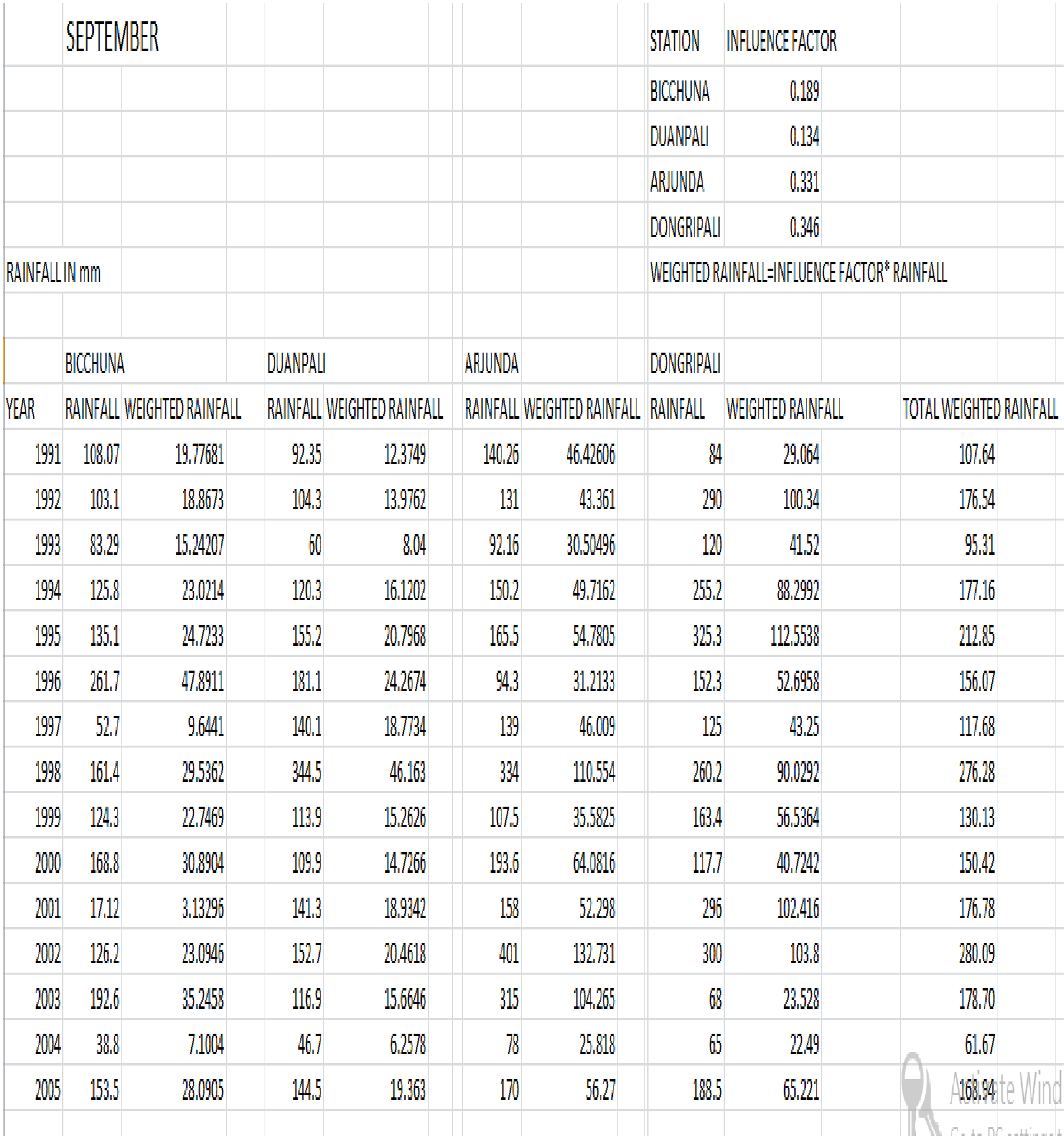
AUGUST

STATION	INFLUENCE FACTOR
BICCHUNA	0.189
DUANPALI	0.134
ARJUNDA	0.331
DONGRIPALI	0.346

WEIGHTED RAINFALL=RAINFALL * INFLUENCE FACTOR

	BICCHUNA		DUANPALI		ARJUNDA		DONGRIPALI		
year	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFA	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	TOTAL WEIGHTED RAINFALL
1991	320.2	60.5178	305.22	40.89948	368.66	122.02646	333	62.937	286.38
1992	452.25	85.47525	346.45	46.4243	337.62	111.75222	482.9	91.2681	334.92
1993	510	96.39	166.8	22.3512	284	94.004	280	52.92	265.67
1994	415	78.435	305.6	40.9504	537.2	177.8132	431.9	81.6291	378.83
1995	445.6	84.2184	335.7	44.9838	575.1	190.3581	485.3	91.7217	411.28
1996	355.22	67.13658	336.4	45.0776	320.6	106.1186	245.9	46.4751	264.81
1997	278.9	52.7121	343.1	45.9754	401.3	132.8303	676	127.764	359.28
1998	149.6	28.2744	141.7	18.9878	87.7	29.0287	124.4	23.5116	99.80
1999	294.3	55.6227	287.4	38.5116	250.4	82.8824	194.3	36.7227	213.74
2000	263	49.707	162.2	21.7348	250.4	82.8824	201	37.989	192.31
2001	270.23	51.07347	233.6	31.3024	346	114.526	165	31.185	228.09
2002	118.22	22.34358	208	27.872	543	179.733	304	57.456	287.40
2003	186	35.154	292.4	39.1816	586	193.966	127	24.003	292.30
2004	405.9	76.7151	465.9	62.4306	606	200.586	405	76.545	416.28
2005	235	44.415	245.5	32.897	210.5	69.6755	212	40.068	187.06

Table 10.



SEPTEMBER

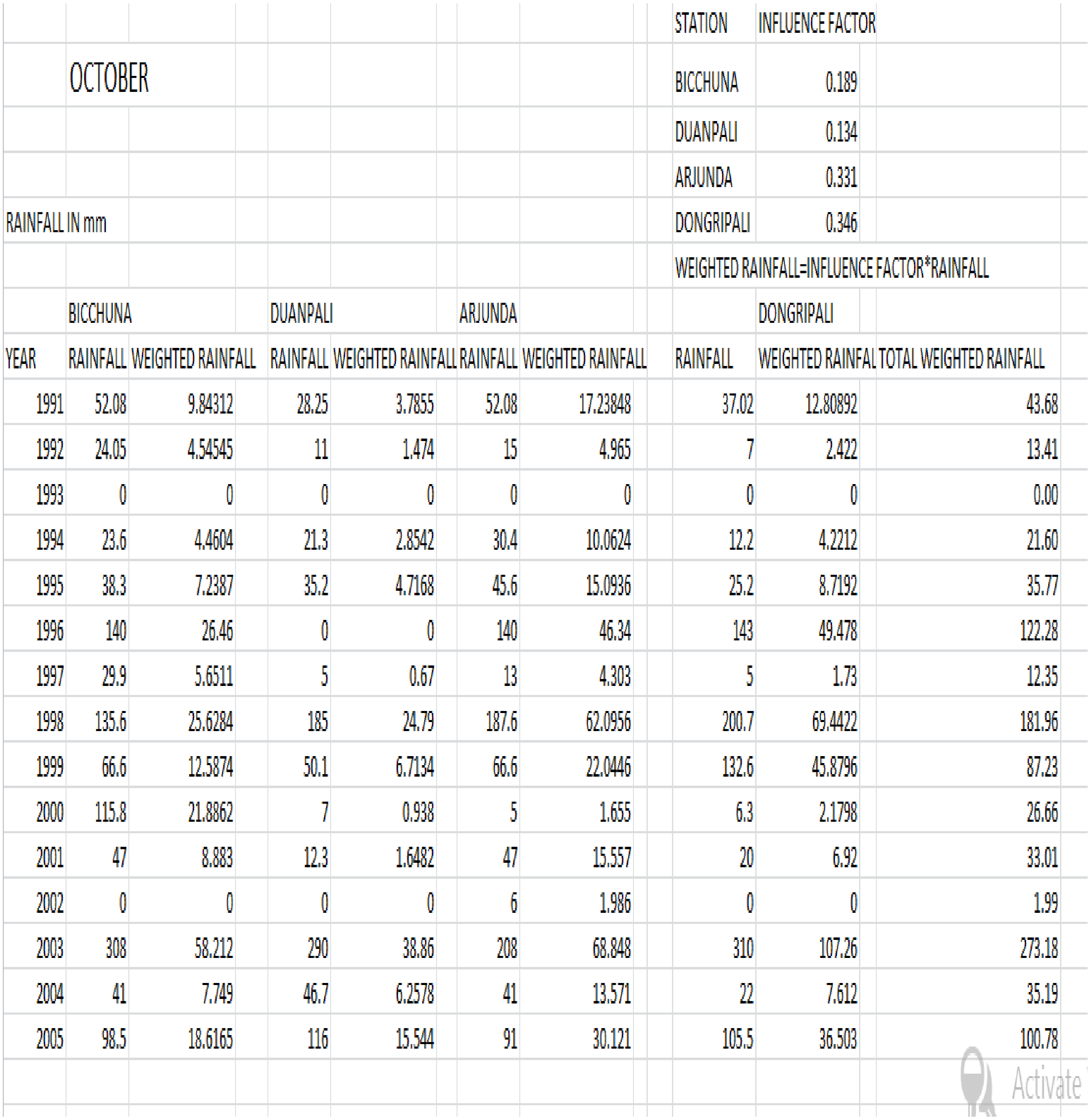
STATION	INFLUENCE FACTOR
BICCHUNA	0.189
DUANPALI	0.134
ARJUNDA	0.331
DONGRIPALI	0.346

RAINFALL IN mm

WEIGHTED RAINFALL=INFLUENCE FACTOR* RAINFALL

	BICCHUNA		DUANPALI		ARJUNDA		DONGRIPALI		
YEAR	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	TOTAL WEIGHTED RAINFALL
1991	108.07	19.77681	92.35	12.3749	140.26	46.42606	84	29.064	107.64
1992	103.1	18.8673	104.3	13.9762	131	43.361	290	100.34	176.54
1993	83.29	15.24207	60	8.04	92.16	30.50496	120	41.52	95.31
1994	125.8	23.0214	120.3	16.1202	150.2	49.7162	255.2	88.2992	177.16
1995	135.1	24.7233	155.2	20.7968	165.5	54.7805	325.3	112.5538	212.85
1996	261.7	47.8911	181.1	24.2674	94.3	31.2133	152.3	52.6958	156.07
1997	52.7	9.6441	140.1	18.7734	139	46.009	125	43.25	117.68
1998	161.4	29.5362	344.5	46.163	334	110.554	260.2	90.0292	276.28
1999	124.3	22.7469	113.9	15.2626	107.5	35.5825	163.4	56.5364	130.13
2000	168.8	30.8904	109.9	14.7266	193.6	64.0816	117.7	40.7242	150.42
2001	17.12	3.13296	141.3	18.9342	158	52.298	296	102.416	176.78
2002	126.2	23.0946	152.7	20.4618	401	132.731	300	103.8	280.09
2003	192.6	35.2458	116.9	15.6646	315	104.265	68	23.528	178.70
2004	38.8	7.1004	46.7	6.2578	78	25.818	65	22.49	61.67
2005	153.5	28.0905	144.5	19.363	170	56.27	188.5	65.221	168.94

Table 11.



OCTOBER

RAINFALL IN mm

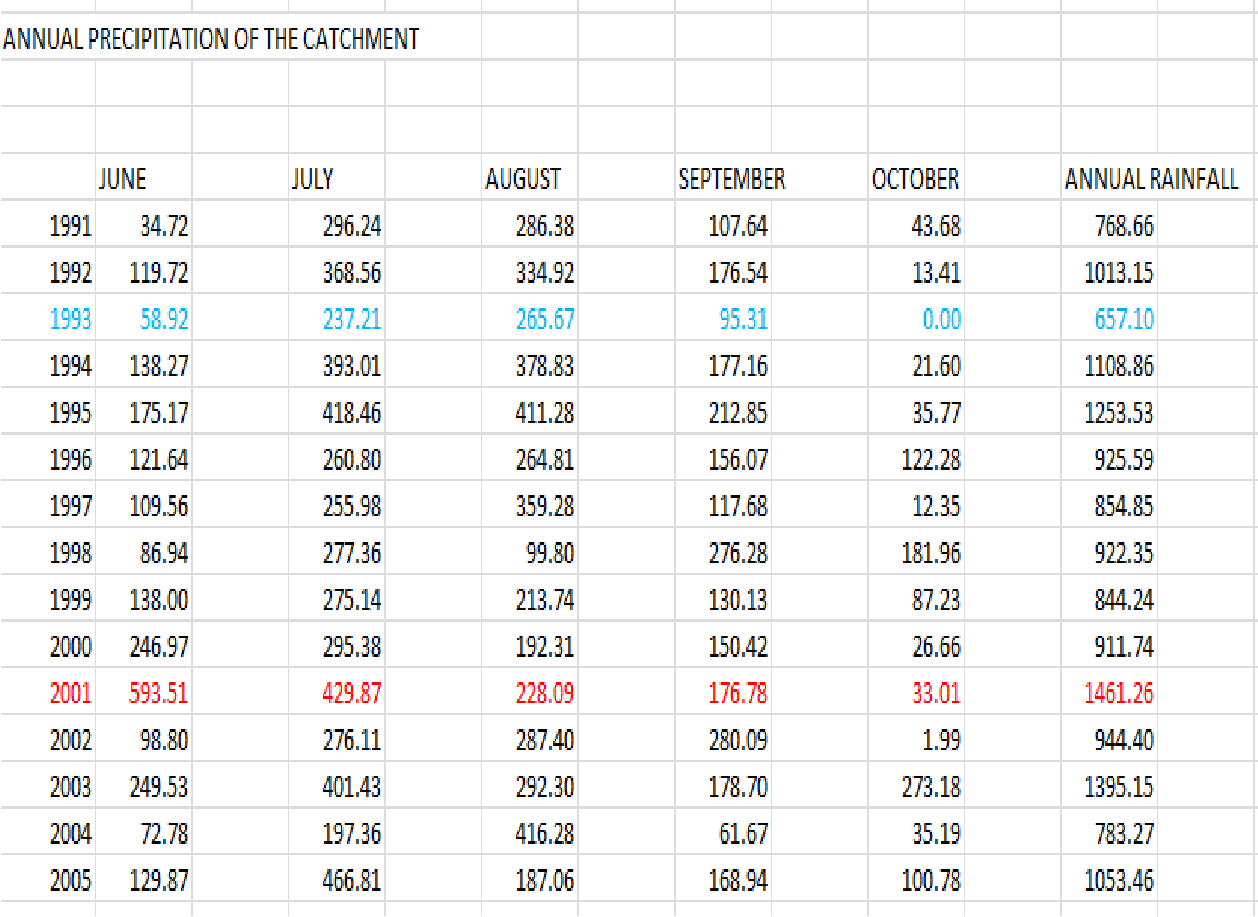
STATION	INFLUENCE FACTOR
BICCHUNA	0.189
DUANPALI	0.134
ARJUNDA	0.331
DONGRIPALI	0.346

WEIGHTED RAINFALL=INFLUENCE FACTOR*RAINFALL

	BICCHUNA		DUANPALI		ARJUNDA			DONGRIPALI	
YEAR	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFALL	RAINFALL	WEIGHTED RAINFAL	TOTAL WEIGHTED RAINFALL
1991	52.08	9.84312	28.25	3.7855	52.08	17.23848	37.02	12.80892	43.68
1992	24.05	4.54545	11	1.474	15	4.965	7	2.422	13.41
1993	0	0	0	0	0	0	0	0	0.00
1994	23.6	4.4604	21.3	2.8542	30.4	10.0624	12.2	4.2212	21.60
1995	38.3	7.2387	35.2	4.7168	45.6	15.0936	25.2	8.7192	35.77
1996	140	26.46	0	0	140	46.34	143	49.478	122.28
1997	29.9	5.6511	5	0.67	13	4.303	5	1.73	12.35
1998	135.6	25.6284	185	24.79	187.6	62.0956	200.7	69.4422	181.96
1999	66.6	12.5874	50.1	6.7134	66.6	22.0446	132.6	45.8796	87.23
2000	115.8	21.8862	7	0.938	5	1.655	6.3	2.1798	26.66
2001	47	8.883	12.3	1.6482	47	15.557	20	6.92	33.01
2002	0	0	0	0	6	1.986	0	0	1.99
2003	308	58.212	290	38.86	208	68.848	310	107.26	273.18
2004	41	7.749	46.7	6.2578	41	13.571	22	7.612	35.19
2005	98.5	18.6165	116	15.544	91	30.121	105.5	36.503	100.78

Rainfall in mm

Table



ANNUAL PRECIPITATION OF THE CATCHMENT

	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	ANNUAL RAINFALL
1991	34.72	296.24	286.38	107.64	43.68	768.66
1992	119.72	368.56	334.92	176.54	13.41	1013.15
1993	58.92	237.21	265.67	95.31	0.00	657.10
1994	138.27	393.01	378.83	177.16	21.60	1108.86
1995	175.17	418.46	411.28	212.85	35.77	1253.53
1996	121.64	260.80	264.81	156.07	122.28	925.59
1997	109.56	255.98	359.28	117.68	12.35	854.85
1998	86.94	277.36	99.80	276.28	181.96	922.35
1999	138.00	275.14	213.74	130.13	87.23	844.24
2000	246.97	295.38	192.31	150.42	26.66	911.74
2001	593.51	429.87	228.09	176.78	33.01	1461.26
2002	98.80	276.11	287.40	280.09	1.99	944.40
2003	249.53	401.43	292.30	178.70	273.18	1395.15
2004	72.78	197.36	416.28	61.67	35.19	783.27
2005	129.87	466.81	187.06	168.94	100.78	1053.46

12

From the table summing up the rainfall for five months the annual monsoonal rainfall was calculated.

Therefore from table

Max annual rainfall= 1461.26mm

Min annual rainfall=657.10mm

Average annual rainfall=931.10mm

Thus a comparative result was obtained between artithmatic mean and thiessen polygon method.

For AM method average rainfall=958.51mm and for thiessen polygon 931.10 mm

3.2 Determination of Flood discharge

Hydrograph

A **hydrograph** is a graph showing the rate of flow i.e. discharge with time in a river, or other channel or conduit carrying flow.It is the total response or the output of a watershed beginning with precipitation as the hydrological exciting agent or input.A hydrograph is a result three phases namely base flow, subsurfaceand surface flow The rate of flow is usually expressed in cubic meters or cubic feet per second.

UNIT HYDROGRAPH

An Unit Hydrograph (UH) or unit graph of a watershed is defined as the hydrograph of direct runoff hydrograph resulting from a unit depth of 1 cm of excess rainfall of constant intensity generated uniformly over the basin or drainage area occurring for a specified duration of D hour.The term unit depth of rainfall excess means excess rainfall above and over all the losses (like evaporation, transpiration,interception,depression storage and depression storage) in the basin for which hydrograph is to be obtained.

SNYDER'S SYNTHETIC UNIT HYDROGRAPH

When a catchment is ungauged, the established empiracle formula or relation between the catchment characteristics and unit hydrograph parameters may be used to synthesize a unit hydrograph for a basin. A synthetic unit hydrograph has all the features of the unit hydrograph, but it does not require rainfall-runoff data for a particular flood. A synthetic unit hydrograph is derived from the theory and experience, and its main purpose is to simulate basin diffusion by estimating the basin lag or lag time based on a certain formula or procedure. The first synthetic unit hydrograph model was developed by Snyder in 1938 and is accepted as a standard practice for the derivation of a unit hydrograph for a basin where rainfall and runoff datas are not available. (ref Patra sir).

Parameters of Synder's Approach:-

1. <u>Lag time</u> (t_p): It is the time from the center of rainfall – excess to the Unit Hydrograph (UH) peak and is given by

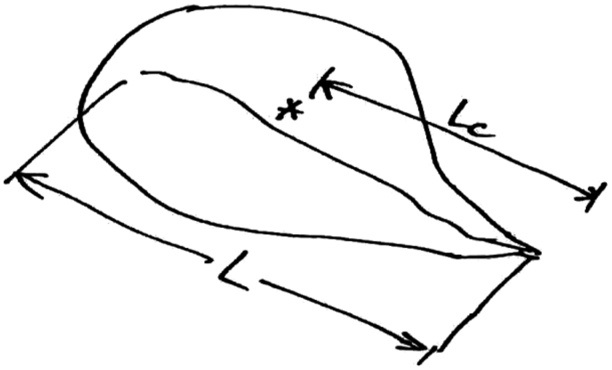
$$t_p = C_t (L.L_c)^{0.3}$$

where t_p = Time [in hrs];

C_t = Coefficient,a function of watershed slope,shape and ranges between 1.35~1.6 (for steeper slope, C_t is smaller);

L = length of the longest main channel [in km];

L_c = length along the main channel from the gauging site to the point nearest to the watershed area centroid.



2. UH Duration (t_r):

It is the duration of rainfall excess for a standard storm and is given by

$$t_{re} = \frac{t_p}{5.5}$$

where t_r and t_L are in hours. If the duration of UH is other than t_{re}, then the lag time needs to be adjusted as

$$t_{np} = t_p + 0.25\ (t_r - t_{re})$$

where t_{np} = adjusted lag time;

t_r = desired UH duration.

3. UH Peak Discharge (q_p):

It is the maximum discharge in the basin and is given by

$$Q_{pr} = \frac{2.78 C_p A}{tp}$$

Where, C_p = coefficient of the area for flood wave and storage condition, varying between 0.56 ~ 0.69;

A= area of the basin in km^2

Q_{pr} = Peak discharge in $m^3/s/km^2$

4. Time Base (T b):

It is the time period between the starting of the direct runoff hydrograph to the end of the runoff hydrograph due to storm and is given by,

$$T_b = 72 + 3tp$$

This equation holds good for small catchment however in case of small catchment follwing equation propsed byTaylor and Schwartz(1952) may be followed as in case of our catchment,

$$T_b = 5(t_{np} + .5t_r)$$

where Tb is in [hrs]

5. UH Widths:

The tentative unit hydrograph is ploted by considering the following two equations proposed by US Army Corps of Engineers,

$$W_{50} = \frac{5.87}{q_{pru}^{1.08}}$$

$$W_{75} = \frac{3.354}{q_{pru}^{1.08}}$$

Where $q_{pru} = \frac{Q_{pr}}{A}$ is the peak discharge per unit drainage area in $m^3/s/km^2$

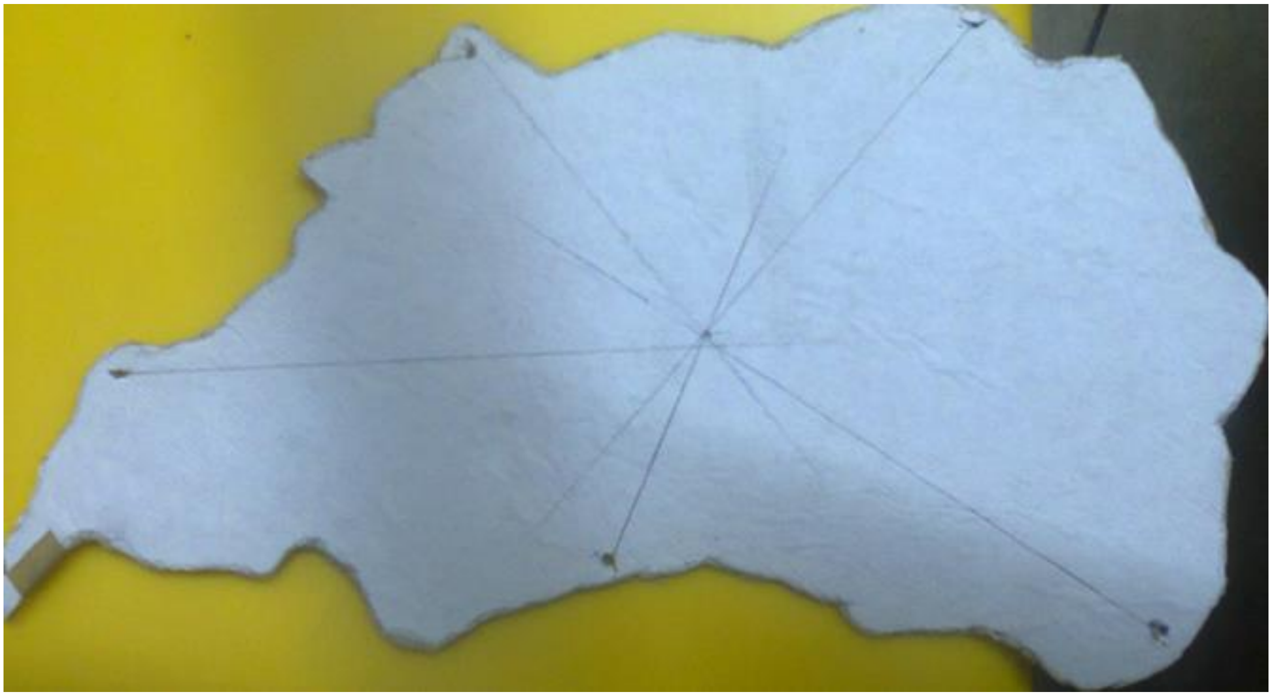
W_{50} and W_{75} are in hours; Usually, 1/3 of the width of W_{50} and W_{75} is distributed before UH peak and 2/3 after the peak

The volume of UH was checked to be close to 1 cm x area of the catchment in km^2.The coordinate of the UH was adjusted to make 1 cm x area of the catchment in km^2.

Determination of the geometric centroid of the basin for determining (Lc)

A crude method was done to determine the centroid. The procedure is described as follows:

1. First of all a cardboard was carefully cut into the shape of the basin as shown in fiq.
2. The cardboard should be of uniform shape, otherwise there may be error.
3. The basin size is the same as that of the scale of the map.
4. Then at the four sides of the cardboard four small holes are made.
5. Then the cardboard is suspended from one of the holes with a thread one at a time.
6. The straight vertical line of the thread is extended above the cardboard.
7. In the same way the steps are repeated.
8. Finally all the lines intersect at a particular point which is the centroid.
9. From the centroid a nearest point of one of the streams is located. From this point to the basin outlet will give the length Lc.



Fiq. 4 Determination of Centoid of the basin

Scale of the catchment is 1:50000

So for 1cm length in the map actual distanece will be 1x50000 cm = 0.5 km

The parameters obtained are:

Catchment Area= 187 sq. km

L=12.75 km

Lc= 6.25 km

C_t for the catchment =1.5

Lag Time, t_p :-

$t_p = C_t (L.L_c)^{0.3}$ =5.57 hours

Duration of Rainfall excess, t_{re} :-

$t_{re} = t_p / 5.5 = 1.01 < 2$ hours.

Modified lag time taking duration of rainfall excess, t_r = 4 hours

$$t_{np} = t_p + 0.25\,(t_r - t_{re}) = 5.82 \text{ hours}$$

Peak Discharge:-

$$Q_{pr} = \frac{2.78 C_p A}{tp}$$

= (2.78 x .56 x 1176)/5.82

=52.8 cumecs.

Time base:-

$T_b = 5(t_{np} + .5t_r)$ = 34.1 hours

UH Widths:-

$W_{50} = \frac{5.87}{q_{pru}^{1.08}}$ = 23.211 hours ; ($q_{pru} = \frac{Q_{pr}}{A}$ = .28m3/sq. km)

$W_{75} = \frac{3.354}{q_{pru}^{1.08}}$= 13.26 hours

With these parameters a 2-h unit hydrograph was drawn which is the Synthetic unit hydrograph.

From the synthetic unit hydrograph a 2=h unit hydrograph was drawn by contracting the ordinates such

that $\frac{\text{(total area of the graph)}}{\text{Catchment area}} = 1$

The two graphs are shown below. One the original synthetic unit graph and the other obtained graph.

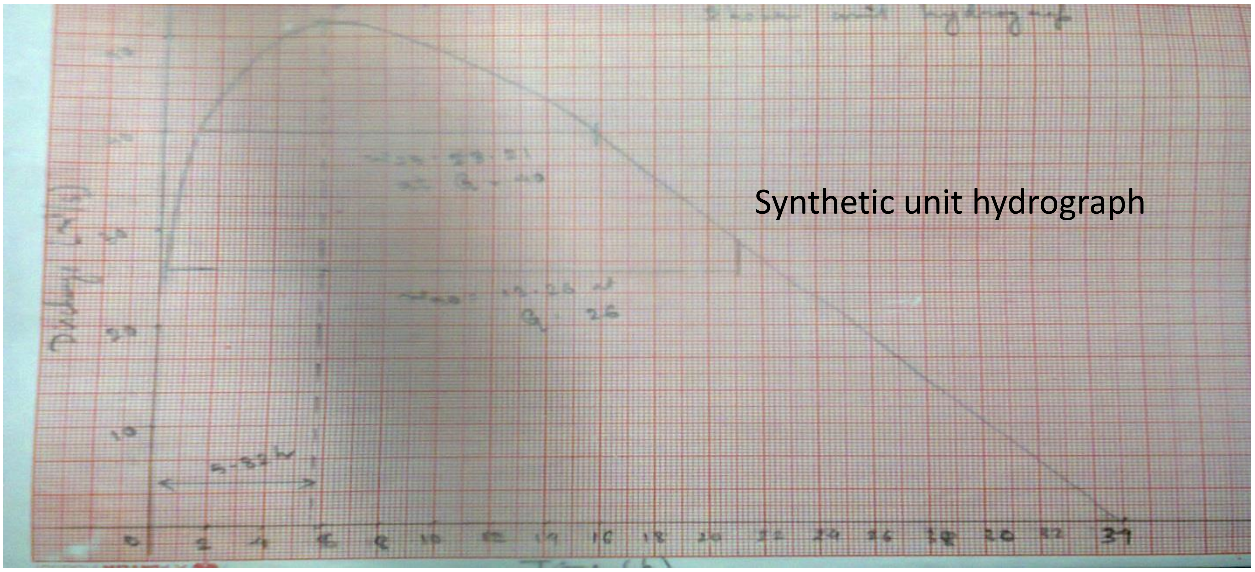
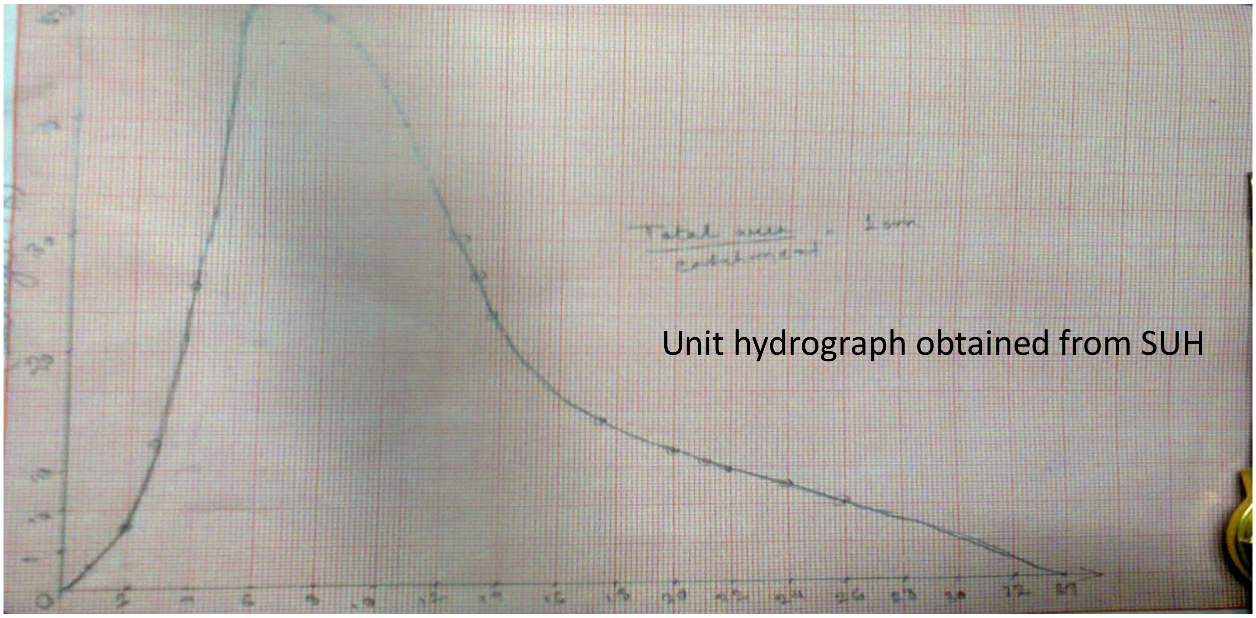


Fig. 5 Synthetic unit hydrograph



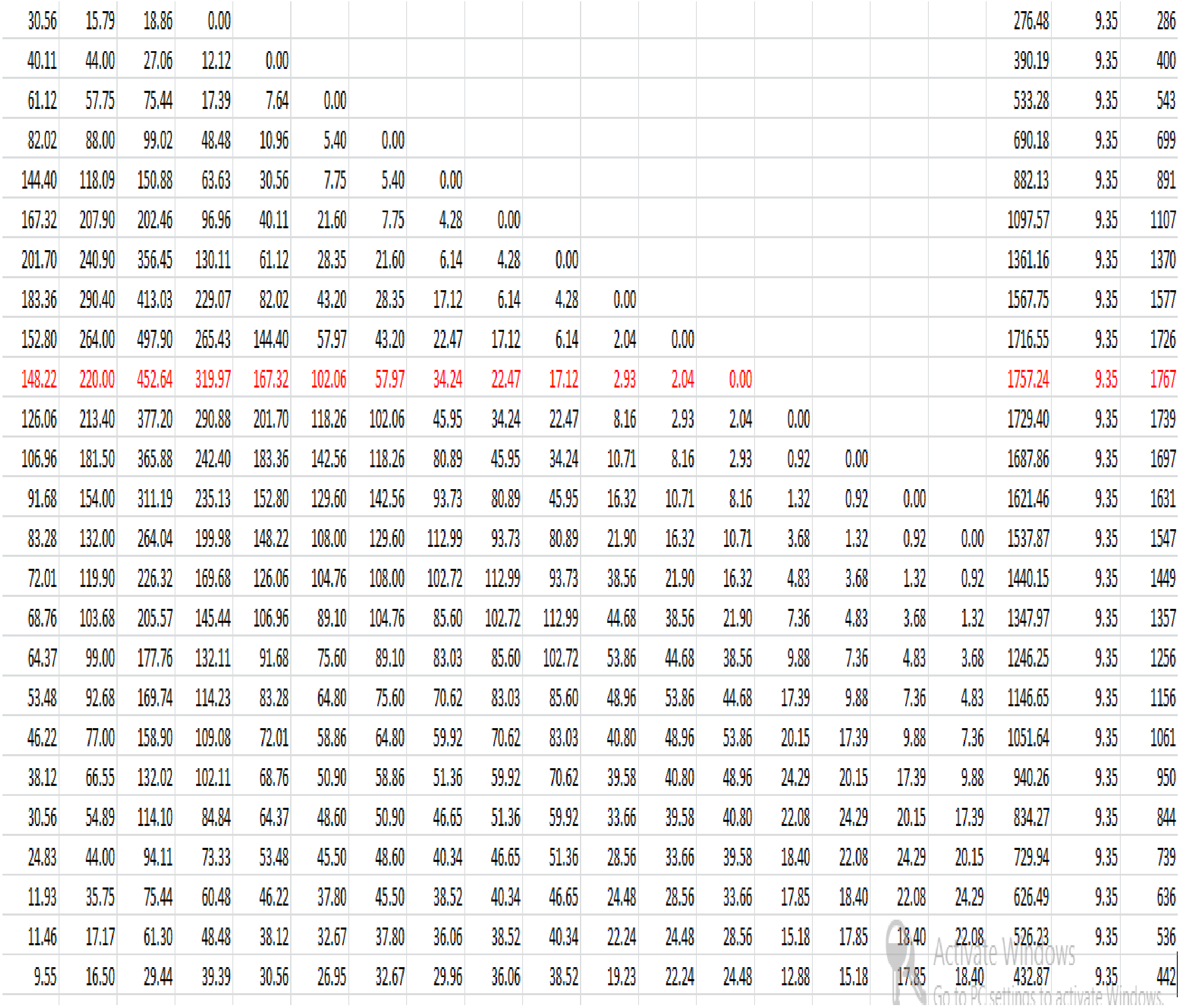
Fiq. 6 Unit hydrograph obtained from SUH

Now we obtained the unit hydrograph. By knowing the excess rainfall, we multiply it with the ordinates of hydrograph for every hour and superpose it to obtain the flood hydrograph.

The table obtained is given below.

Table 13.

	RAINFALL EXCESS(mms/cms)				C.A.(Sq.km)=187										
4.6	4.6	10.2	10.2	15.8	15.8	21.4	38.2	55	94.3	60.6	38.2	27	27	21.4	21.4
0.46	0.46	1.02	1.02	1.58	1.58	2.14	3.82	5.5	9.43	6.06	3.82	2.7	2.7	2.14	2.14
0															
0.92	0														
1.32	0.92	0													
3.68	1.32	2.04	0												
4.83	3.68	2.93	2.04	0											
7.36	4.83	8.16	2.93	3.16	0										
9.88	7.36	10.71	8.16	4.53	3.16	0									
17.39	9.88	16.32	10.71	12.64	4.53	4.28	0.00								
20.15	17.39	21.90	16.32	16.59	12.64	6.14	7.64	0.00							
24.29	20.15	38.56	21.90	25.28	16.59	17.12	10.96	11.00	0.00						
22.08	24.29	44.68	38.56	33.92	25.28	22.47	30.56	15.79	18.86	0.00					
18.40	22.08	53.86	44.68	59.72	33.92	34.24	40.11	44.00	27.06	12.12	0.00				
17.85	18.40	48.96	53.86	69.20	59.72	45.95	61.12	57.75	75.44	17.39	7.64	0.00			
15.18	17.85	40.80	48.96	83.42	69.20	80.89	82.02	88.00	99.02	48.48	10.96	5.40	0.00		
12.88	15.18	39.58	40.80	75.84	83.42	93.73	144.40	118.09	150.88	63.63	30.56	7.75	5.40	0.00	
11.04	12.88	33.66	39.58	63.20	75.84	112.99	167.32	207.90	202.46	96.96	40.11	21.60	7.75	4.28	0.00
10.03	11.04	28.56	33.66	61.30	63.20	102.72	201.70	240.90	356.45	130.11	61.12	28.35	21.60	6.14	4.28
8.67	10.03	24.48	28.56	52.14	61.30	85.60	183.36	290.40	413.03	229.07	82.02	43.20	28.35	17.12	6.14



30.56	15.79	18.86	0.00														276.48	9.35	286
40.11	44.00	27.06	12.12	0.00													390.19	9.35	400
61.12	57.75	75.44	17.39	7.64	0.00												533.28	9.35	543
82.02	88.00	99.02	48.48	10.96	5.40	0.00											690.18	9.35	699
144.40	118.09	150.88	63.63	30.56	7.75	5.40	0.00										882.13	9.35	891
167.32	207.90	202.46	96.96	40.11	21.60	7.75	4.28	0.00									1097.57	9.35	1107
201.70	240.90	356.45	130.11	61.12	28.35	21.60	6.14	4.28	0.00								1361.16	9.35	1370
183.36	290.40	413.03	229.07	82.02	43.20	28.35	17.12	6.14	4.28	0.00							1567.75	9.35	1577
152.80	264.00	497.90	265.43	144.40	57.97	43.20	22.47	17.12	6.14	2.04	0.00						1716.55	9.35	1726
148.22	220.00	452.64	319.97	167.32	102.06	57.97	34.24	22.47	17.12	2.93	2.04	0.00					1757.24	9.35	1767
126.06	213.40	377.20	290.88	201.70	118.26	102.06	45.95	34.24	22.47	8.16	2.93	2.04	0.00				1729.40	9.35	1739
106.96	181.50	365.88	242.40	183.36	142.56	118.26	80.89	45.95	34.24	10.71	8.16	2.93	0.92	0.00			1687.86	9.35	1697
91.68	154.00	311.19	235.13	152.80	129.60	142.56	93.73	80.89	45.95	16.32	10.71	8.16	1.32	0.92	0.00		1621.46	9.35	1631
83.28	132.00	264.04	199.98	148.22	108.00	129.60	112.99	93.73	80.89	21.90	16.32	10.71	3.68	1.32	0.92	0.00	1537.87	9.35	1547
72.01	119.90	226.32	169.68	126.06	104.76	108.00	102.72	112.99	93.73	38.56	21.90	16.32	4.83	3.68	1.32	0.92	1440.15	9.35	1449
68.76	103.68	205.57	145.44	106.96	89.10	104.76	85.60	102.72	112.99	44.68	38.56	21.90	7.36	4.83	3.68	1.32	1347.97	9.35	1357
64.37	99.00	177.76	132.11	91.68	75.60	89.10	83.03	85.60	102.72	53.86	44.68	38.56	9.88	7.36	4.83	3.68	1246.25	9.35	1256
53.48	92.68	169.74	114.23	83.28	64.80	75.60	70.62	83.03	85.60	48.96	53.86	44.68	17.39	9.88	7.36	4.83	1146.65	9.35	1156
46.22	77.00	158.90	109.08	72.01	58.86	64.80	59.92	70.62	83.03	40.80	48.96	53.86	20.15	17.39	9.88	7.36	1051.64	9.35	1061
38.12	66.55	132.02	102.11	68.76	50.90	58.86	51.36	59.92	70.62	39.58	40.80	48.96	24.29	20.15	17.39	9.88	940.26	9.35	950
30.56	54.89	114.10	84.84	64.37	48.60	50.90	46.65	51.36	59.92	33.66	39.58	40.80	22.08	24.29	20.15	17.39	834.27	9.35	844
24.83	44.00	94.11	73.33	53.48	45.50	48.60	40.34	46.65	51.36	28.56	33.66	39.58	18.40	22.08	24.29	20.15	729.94	9.35	739
11.93	35.75	75.44	60.48	46.22	37.80	45.50	38.52	40.34	46.65	24.48	28.56	33.66	17.85	18.40	22.08	24.29	626.49	9.35	636
11.46	17.17	61.30	48.48	38.12	32.67	37.80	36.06	38.52	40.34	22.24	24.48	28.56	15.18	17.85	18.40	22.08	526.23	9.35	536
9.55	16.50	29.44	39.39	30.56	26.95	32.67	29.96	36.06	38.52	19.23	22.24	24.48	12.88	15.18	17.85	18.40	432.87	9.35	442

The ordinates of the flood hydrograph are thus obtained.

Of which the max peak flood discharge is of our importance. The red part in the table gives us the peak flood discharge which is 1767 qumecs.

CHAPTER 4

DESIGN AND STABILITY OF DAM

4.1 EARTHEN DAM

Any hydraulic structure that supplies water to the off-taking cannel is called a headwork.Headworks my be divided into follwing two types :

1. Storage headwork.
2. Diversion headwork.

A diversion headwork is a hydraulic structure constructed to divert the required supply into the canal from the river.

A storage headwork comprises the construction of a dam across a river valley so that water can be stored during the period of excess water level in the river and release it when demand increases above the available supplies.According to the most common type of classification a dam can be classified into two types namely

1.Rigid Dams.
2.Non-Rigid Dams.

Rigid dams are those which are constructed using rigid materials like masonary,concrete,steel or timber.They are further classified as follows:

1.Solid masonary or concrete gravity dam.
2.Arched masonary or concrete dam.
3Concrete butress dam.
4.Steel dam.
5.Timber dam.

Non-rigid dams are those which are constructed using non-rigid materials like earth and/or rockfill available near or away the site.They can be of following types:

1.Earth dam.
2.Rockfill dam.
3.Combined earth and rockfill dam.

Earthen dams are the type of dam which are constructed using earth material available economically or locally.These are the cheapest type of dam as they utilizes the locally available materials, less skilled labour and primitive equipment.It is further divided into following three types:

1. Homogeneous Embankment type
2. Zoned Embankment type
3. Diaphragm type.

We had opted for Homogeneous Embankment or Homogeneous earth dam during the construction of which soil material is placed in thin layers(15 cm to 30 cm) and then compacted by using rollers.It is the simplest type of an earthen dam which consists of single material and is homogeneous throughout so it is called homogeneous type. A purely homogeneous type of dam is composed of a single kind of material. Such purely homogeneous section, has now been replaced by a modified homogeneous section in which considerable amount of pervious material is used to control the action of seepage so as to allow much steeper slopes as compared to pure homogenous dam. This type of dam is used when only one type of material is economically or locally available around the site of construction. It is also used as it is economic due to requirement of less skilled labour and primitive type of equipment during the construction.However larger dams are rarely designed as homogeneous type because of the dam being more prone to failure due to seepage and unstability. To overcome this problem, internal drainage system in the form of horizontal blanket,rock toe and/or sand chimney is constructed inside the dam.

The main components of Homogeneous Earthen dams,their brief function and basic design requrements are mentioned below;

.

Internal drainage system and foundations: The water seeping through the body of earthen dam and/or through the foundation is very harmfull as it weakens the stability of the dam causing the softening of slopes due to the development of pore water pressure.Inorder to control this seepage to a large extent,Internal drainge filters plays very important role.Such drainage filters are generally provided in the form (i) rock toe (ii) horizontal blanket and (ii) vertical or slanted sand chimney.

Drainage filter is one of the important part in the dam construction and it should be such designe that neither embankment nor the foundation material can penetrate and clog the filter.Terzaghi has given a rational approach to design the drainage filters which is given as,

$$\frac{D_{15}\ of\ filter}{D_{85}\ of\ base\ material} < 4\ to\ 5 < \frac{D_{15}\ of\ filter}{D_{15}\ of\ base\ material}$$

Base material here denotes the embankment soil or the foundation soil surrounding the filter.

Slope protection: Due to the precipitation and water level in the reserviour,scouring of the external slope surface can take place.In order to ensure this slope protection riprap is placed at the outer slope in the upstream. A minimum of 300 mm thick riprap over 150 mm thick filter layer may be generally provided upto the top of dam. In case of the downstream,slope protection is ensured by turfing or riprap turfing on the entire downstream slope from top of the dam to the toe.In addition, horizontal berms at suitable interval may be provided in case of large dam to protect from the erosion action of rain and its run-off. The details on downstream and upstream slope protection is clearly mentioned in IS 8237-1985.

STABILITY OF THE EARTHEN SLOPES

This is the most important part of this project. Designing a dam is not only of the prior importance,designing it safe against failure criterion is the main deal. The constructed dam should be safe against adverse materological condition and the geological feature of the location and the dam itself. The following stability condition were taken into consideration for analysis as mentioned below:

1. Stability of the downstream slope during steady seepage
2. Stability of the downstream slope under steady seepage from the consideration of horizontal shear at base under downstream slope of the dam.
3. Stability of the foundation against shear.

Overall stability of the dam section

4.2 **DAM DESIGN**

Dam designing is the most important for any irrigation project.Surveying result as mentioned on the project report “Project report of jeera Irrigation Project”, by Prof. K.C. Patra were taken as the main source for the designing. The report says to be a dam of max height of 17.5 m with total length of 1958m.

As per Strange’s preliminary dimensions of low earth design the cross section of the dam was designed:

The dam is designed as:

Maximum height= 17.5m, Highest flood level=15m (w.r.t.) bed slope.

Top width= 6m, upstream slope= 3:1, downstream slope 2:1

Horizontal sand blanket of 25m from toe to reduce the phreatic line.

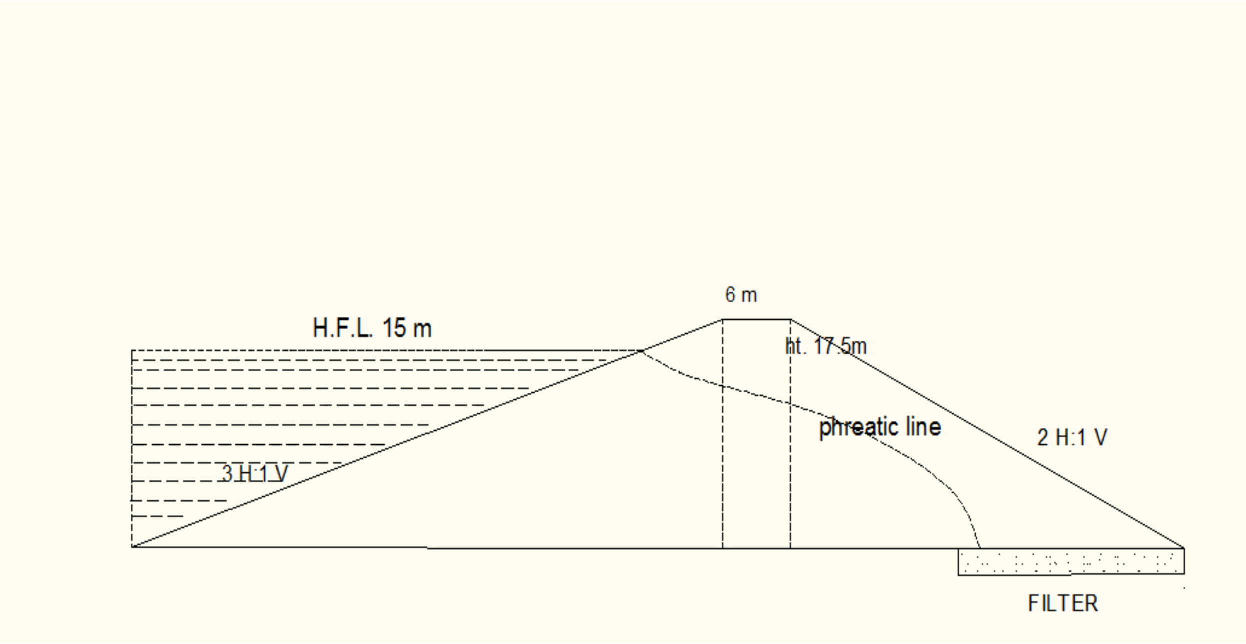


Fig. 7 Cross section of the Dam

After designing the cross section of the dam its stability check is very important.

So first and foremost we have to determine the phreatic line of the dam.

Phreatic line.

The passage within the body of dam through which the seepage occurs is the phreatic line.About 30% of dams that failed is due to the seepage failure, viz piping and sloughing. Recent comprehensive reviews by Foster et al. (2000) and Fell et al. (2003) show that internal erosion and piping are the main causes of failure and accidents affecting embankment dams; and the proportion of their failures by piping increased from 43% before 1950 to 54% after 1950. The sloughing of the downstream face of a homogeneous earth dam occurs under the steady-state seepage condition due to the softening and weakening of the soil mass when the top flow line or phreatic line intersects . Regardless of the flatness of the downstream slope and impermeability of soil, the phreatic line intersects the downstream face to a height of roughly one-third the depth of water . It is usual practice to use a modified homogeneous section in which an internal drainage system in the form of a horizontal blanket drain or a rock toe or a combination of the two is provided. The drainage system thus provided keeps the phreatic line well within the body of the dam. Horizontal filtered drainage blankets are widely used for dams of moderate height.

The minimum length of the horizontal blanket filter required to keep the phreatic line within the body of the dam by a specified depth and also equations for maximum downstream slope cover and minimum and maximum effective lengths of the downstream filtered drainage system.

Detemination of phreatic line of the embankment when provided with filter. In this case a horizontal blanket filter is used at a distance of 25 m from the toe of the dam.

Determination of the phreatic line.

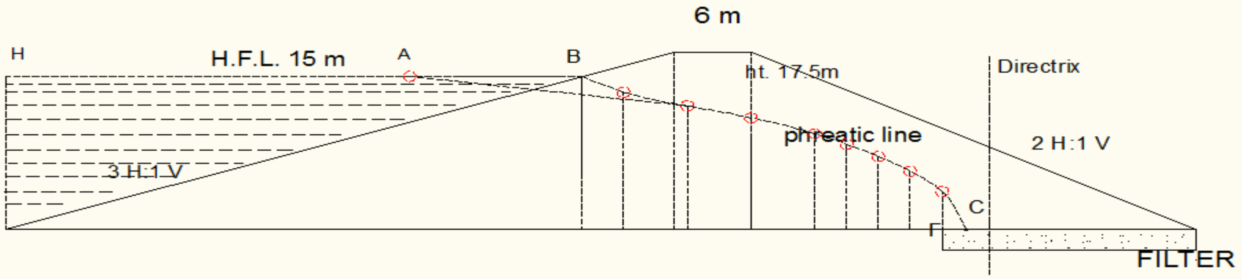


Fig. 8 Determination of phreatic line

Taking the focus F at the d/s toe of the dam as the origin the equation of the base parabola is given by sq root of (x 2 + y 2)= x +S

Where S is the distance of the point (x,y) from the directrix, called focal distance.

Point A is such selected that AB = .3 HB

Or AB= .3 x 45.2= 13.5

So A is plotted at a distance of 13.5 m from B.

This is the start point of parabola. Now the coordinates of A is determined with respect to F as origin.

A(41.3, 15.0)

Therefore root(41.3x41.3 +15.0x 15.0) = 41.3 +S

S=2.66 m

So the vertex C of the parabola shall be situated at S/2 =1.33 m beyond the point F.

Now by knowing the value of S an equation of unknown x and y is derived.

y 2 =2xS + S 2.

Putting values of x we get the corresponding values of y which is plotted as seen in the figure.

This curve gives us the phreatic line of the embankment.

After determining the phreatic line a series of hand calculation was done to determine the stability analysis.

The parameters taken for the dam and the foundation body are given below.

Parameters of soils of dam and foundation are:

Dam:

c =38 kN/m2 Φ=20 °

Yd =17.20 kN/m3 Ysub =10.69kN/m3

K =0.1m/sec

Foundation:

c=54 kN/m2 Φ=12 °

Yd= 18.3 kN/m3

8m thick layer of clay with negligible permeability.

1. Overall stability of the dam section as a whole

F.O.S = 4.036 >1.3 safe

2. Stability of the upstream slope portion of dam (due to sudden drawdown)

F.O.S =2.32 > 2 safe

3. Stability of the d/s portion of dam

F.O.S= 1.45 > 1 safe

4.Stability of the foundation

F.O.S= 1.1> 1 safe

Hence the slope and the parameters of dam and foundation are safe for construction

Analysis of dam by using software:

4.3 ANALYSIS DAM BY PLAXIS

Analysis of the designed dam was done by using PLAXIS. A two-stage dam constructed is taken.

Analysis for steady seepage was done.

PROCEDURE:

INPUT STAGE

a. Section of the dam was designed by using coordinate.

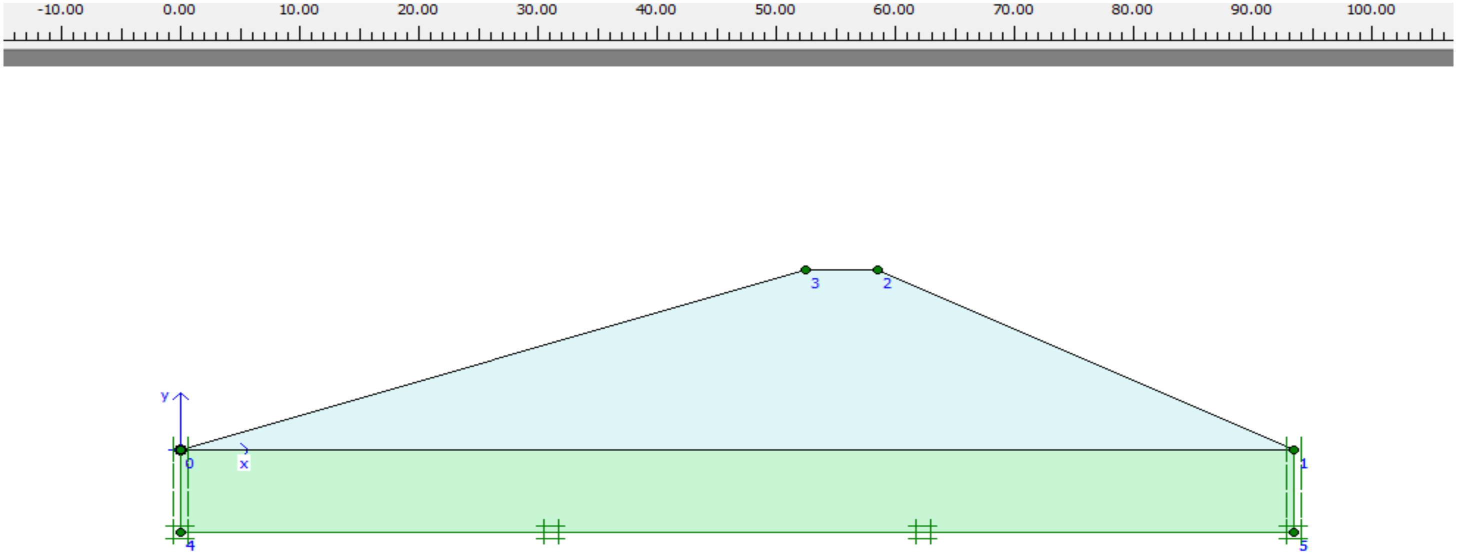
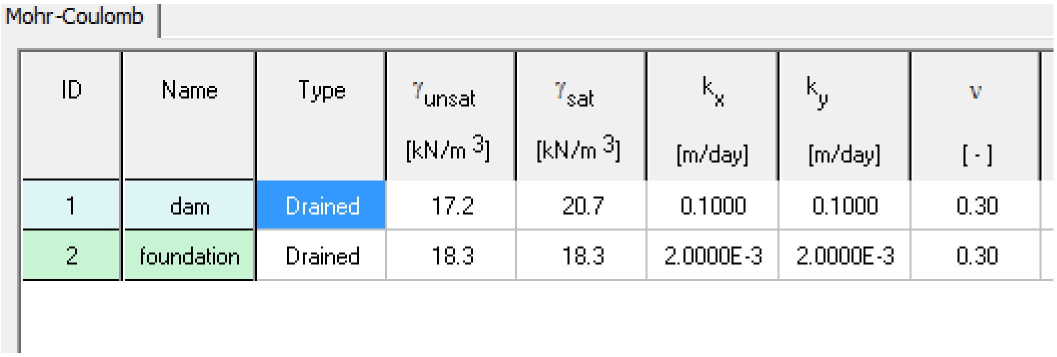
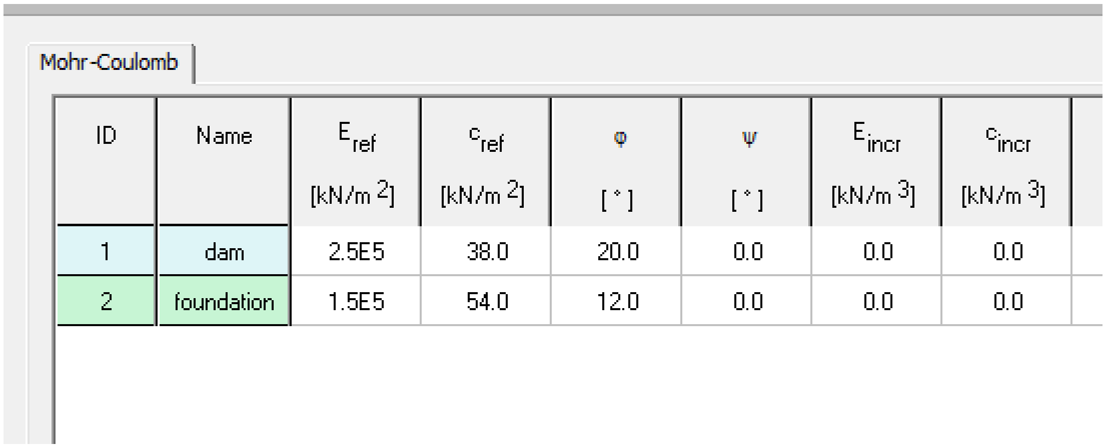


Fig. 9

b. Material Property was assigned to the different components.



ID	Name	Type	γ_{unsat} [kN/m ^{3}]	γ_{sat} [kN/m ^{3}]	k_x [m/day]	k_y [m/day]	ν [-]
1	dam	Drained	17.2	20.7	0.1000	0.1000	0.30
2	foundation	Drained	18.3	18.3	2.0000E-3	2.0000E-3	0.30



ID	Name	E_{ref} [kN/m ^{2}]	c_{ref} [kN/m ^{2}]	φ [°]	ψ [°]	E_{incr} [kN/m ^{3}]	c_{incr} [kN/m ^{3}]
1	dam	2.5E5	38.0	20.0	0.0	0.0	0.0
2	foundation	1.5E5	54.0	12.0	0.0	0.0	0.0

c. Mess Generation.

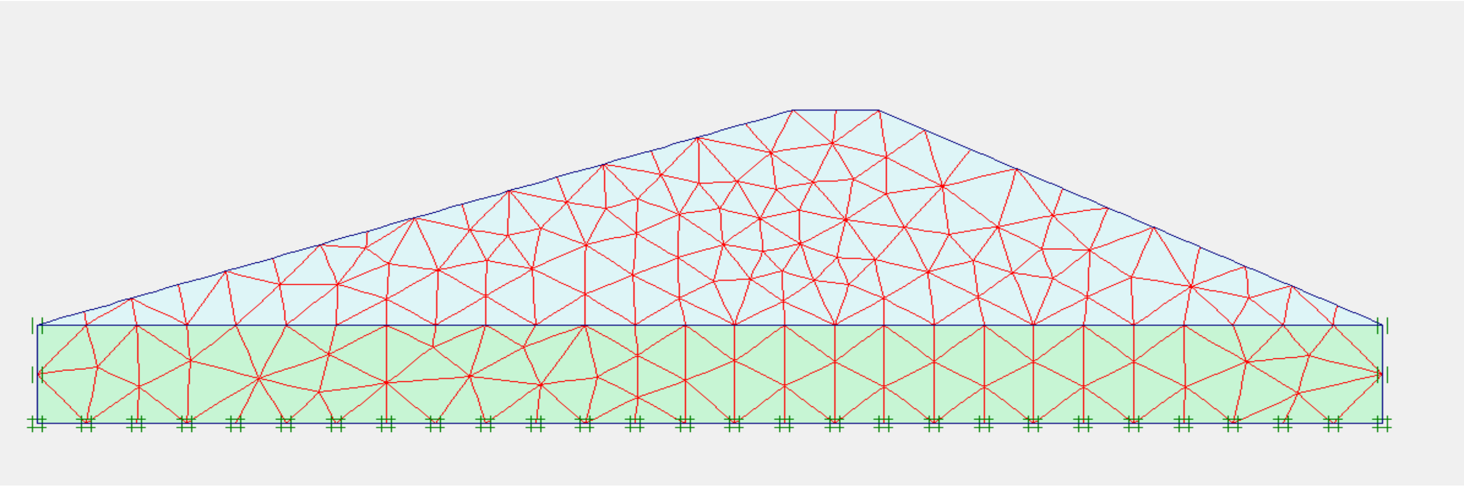


Fig. 10

d. Phreatic line was drawn on the dam section.

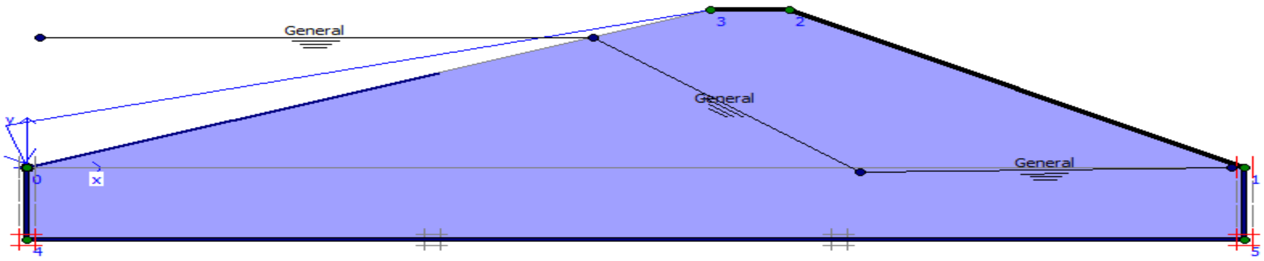
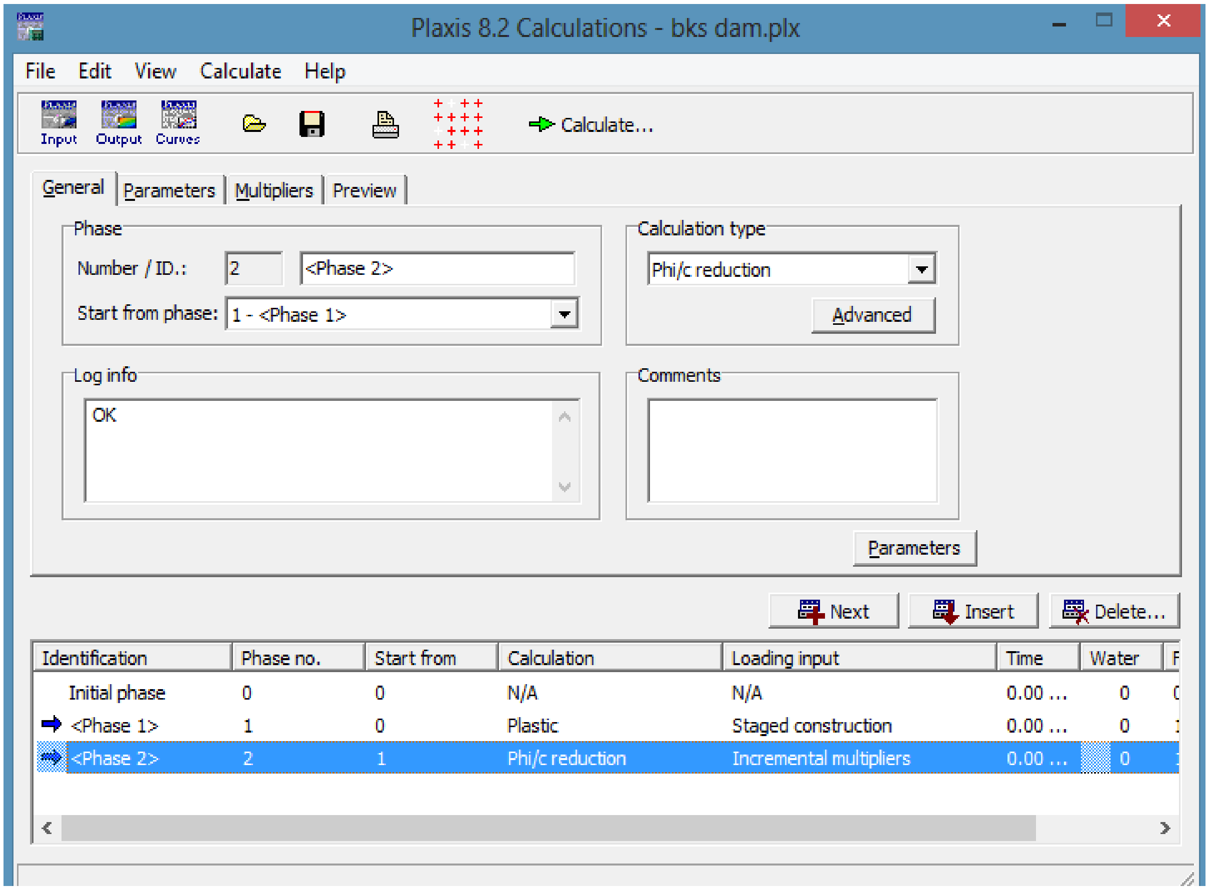


Fig. 11

CALCULATION STAGE

1. First stage of calculation was done as Plastic.
2. Second and Final stage of calculation as phi-c reduction.



Phase

Number / ID.: 2 <Phase 2>

Start from phase: 1 - <Phase 1>

Calculation type: Phi/c reduction

Log info: OK

Comments

Identification	Phase no.	Start from	Calculation	Loading input	Time	Water
Initial phase	0	0	N/A	N/A	0.00 ...	0
<Phase 1>	1	0	Plastic	Staged construction	0.00 ...	0
<Phase 2>	2	1	Phi/c reduction	Incremental multipliers	0.00 ...	0

POST PROCESSING

In the post processing stage, plotting of curves between various calculated parameters such as vertical strain,shear stress,active pore water pressure,etc were obtained.It is the output of the analysis.

4.4 DESIGN OF SPILLWAY:

A spillway is a structure which is used to provide the controlled release of water flows from a dam or levee into a downstream area, typically being the river that was dammed.

There are two main types of spillways namely controlled and uncontrolled.

A controlled spillway has mechanical structures or gates to regulate the rate and amount of flow. This design allows nearly the full height of the dam to be used for water storage year-round, and flood waters can be released as required by opening one or more gates.

An uncontrolled spillway, in contrast, does not have gates; when the water rises above the lip or crest of the spillway it begins to be released from the reservoir. The rate of discharge is controlled only by the depth of water within the body of reservoir. All of the storage volume in the reservoir above the spillway crest can be used only for the temporary storage of floodwater, and cannot be utilized as water supply storage because it is normally empty.

The spillway to be designed is the ogee crested spillway. This type of spillway does not scour the downstream side as the water is released in its followed path.

The specifications of spillway are:

1.	Type	Ogee Crested
2.	Effective Length	72m
3.	Crest Level	202m
4.	Spillway Capacity	1767 qumecs
5.	No. of Bays	6

Calculation:

The spillway is designed using the equation $Q= C\ Le\ (He)^{\wedge 3/2}$

Where Q=Discharge,

Le= Effective length of spillway crest.

C=Coefficient of discharge.

Here Q= 1767 cumecs, Taking C= 2.2 for Odisha catchment ,

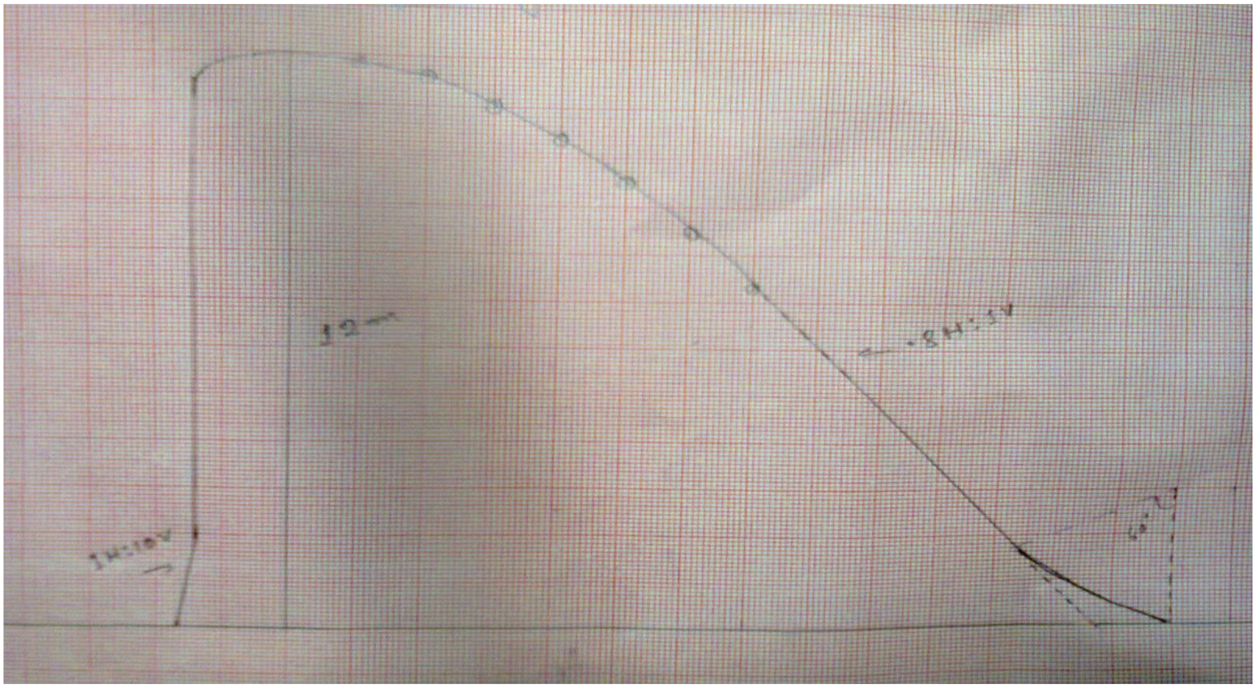
He calculated was, He=5.017m

By using the Equation X^1.85 =2 x Hd^(.35) x Y

A graph is plotted for various values of X upto the point where dy/dx =0

After that a slope of .8 H: 1V is provided and continued till toe.

The profile of the ogee crested spillway is given below



Fiq. 12 Cross section of spillway

CHAPTER 4

RESULTS AND DISCUSSIONS

5.1 RESULTS AND CONCLUSION

1. GENERAL

a. State	Odisha
b. District	Bargarh
c. Block	Bhatli
d. Village	Duanpali
e. River	Jeera

2. LOCATION

a. Latitude	21_0 – 23’ – 11”N
b. Longitude	83_0 – 26’ – 13”E
c. Near Rail Head	Bargarh
d. Nearest Airport	Bhubaneswar
e. Distance from State Capital to Project Site	About 350 Km

3. HYDROLOGY

a. Catchment area	187 sq. km
b. Max. annual monsoon rainfall	**1461.26mm**
c. Min. annual monsoon rainfall	**657.10mm**
d. Design Flood Discharge	1767 qumecs
e. Average Normal rainfall	**931.10mm**

4. DAM

a.Type of Dam	Homogeneous Rolled Earth Fill
b. Total length	1958m
c. Max. Height	17.5 m
d. Top Width	6m

5.DAM MATERIAL

a.Dry unit weight	17.20 kN/m3

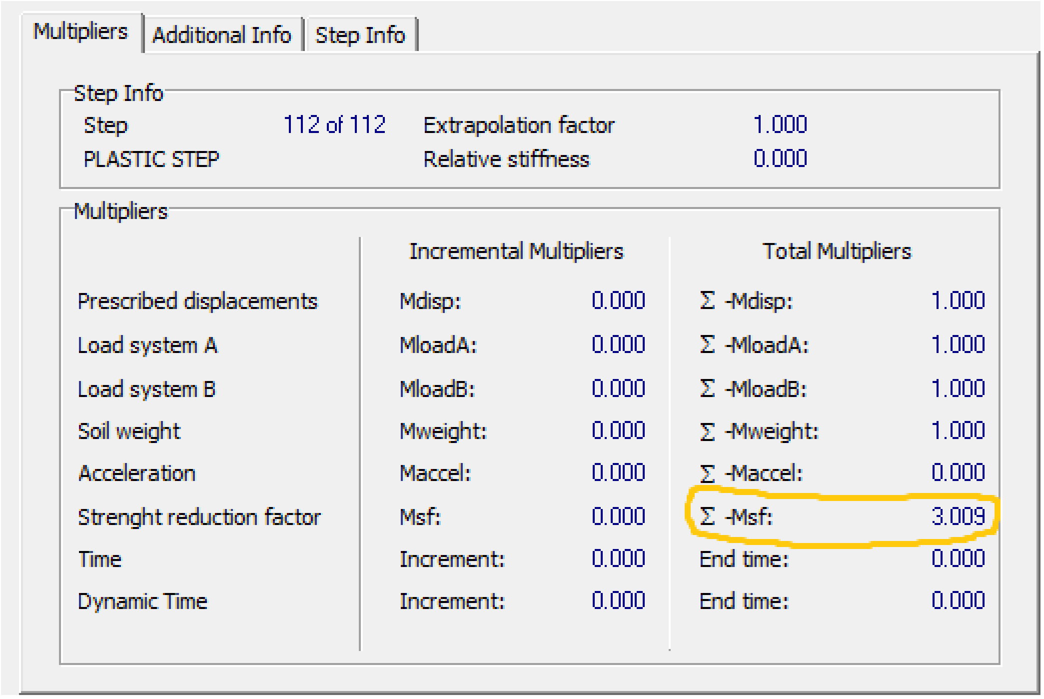
b. Submerged unit weight	10.69kN/m3
c. Cohesion	38 kN/m2
d. Angle of internal friction	20 °
e. Coefficient of permeability	0.1 m/sec

6. SPILLWAY

a. Type	Ogee crested
b. Effective Length	72m
c. Crest Level	202.00 M
d. Spillway Capacity 1	767 Cumec
e. No. of Bays	6
f. Size of Gate	12.0M x 7.0 M

5.2 RESULTS OF THE MODEL IN PLAXIS

Following results were obtained as the result of postprocessing.



Step Info

Step	112 of 112	Extrapolation factor	1.000
PLASTIC STEP		Relative stiffness	0.000

Multipliers

	Incremental Multipliers		Total Multipliers	
Prescribed displacements	Mdisp:	0.000	Σ -Mdisp:	1.000
Load system A	MloadA:	0.000	Σ -MloadA:	1.000
Load system B	MloadB:	0.000	Σ -MloadB:	1.000
Soil weight	Mweight:	0.000	Σ -Mweight:	1.000
Acceleration	Maccel:	0.000	Σ -Maccel:	0.000
Strenght reduction factor	Msf:	0.000	Σ -Msf:	3.009
Time	Increment:	0.000	End time:	0.000
Dynamic Time	Increment:	0.000	End time:	0.000

Fig 13. Safety factor of the design

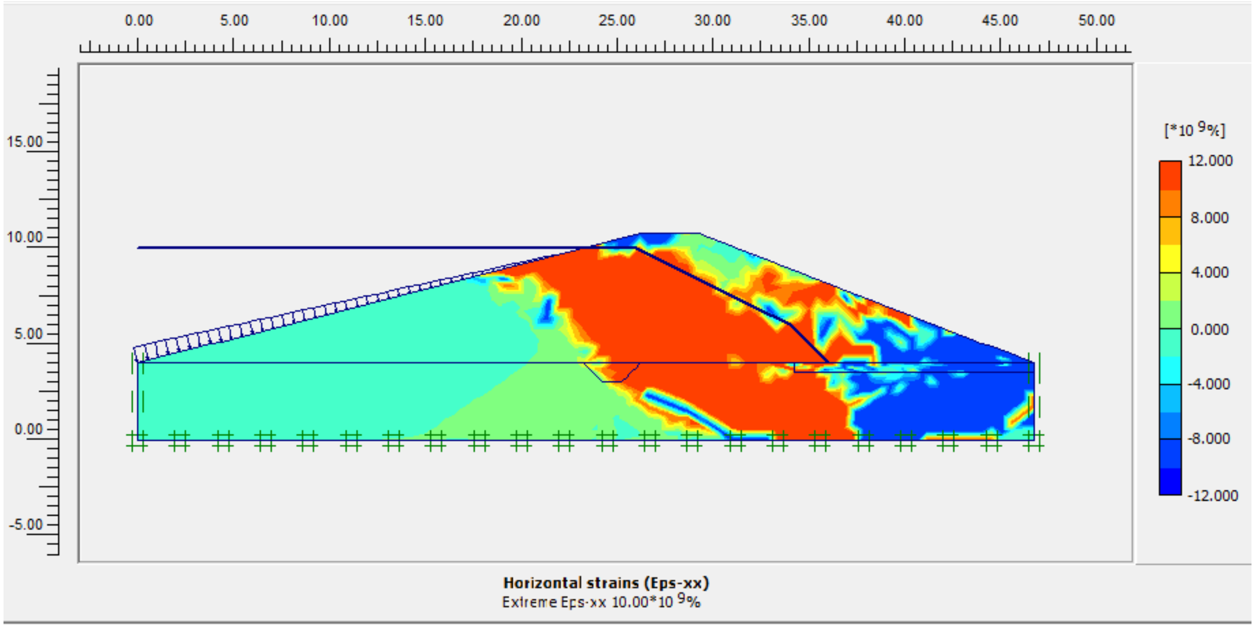


Fig.14 Horizontal strain

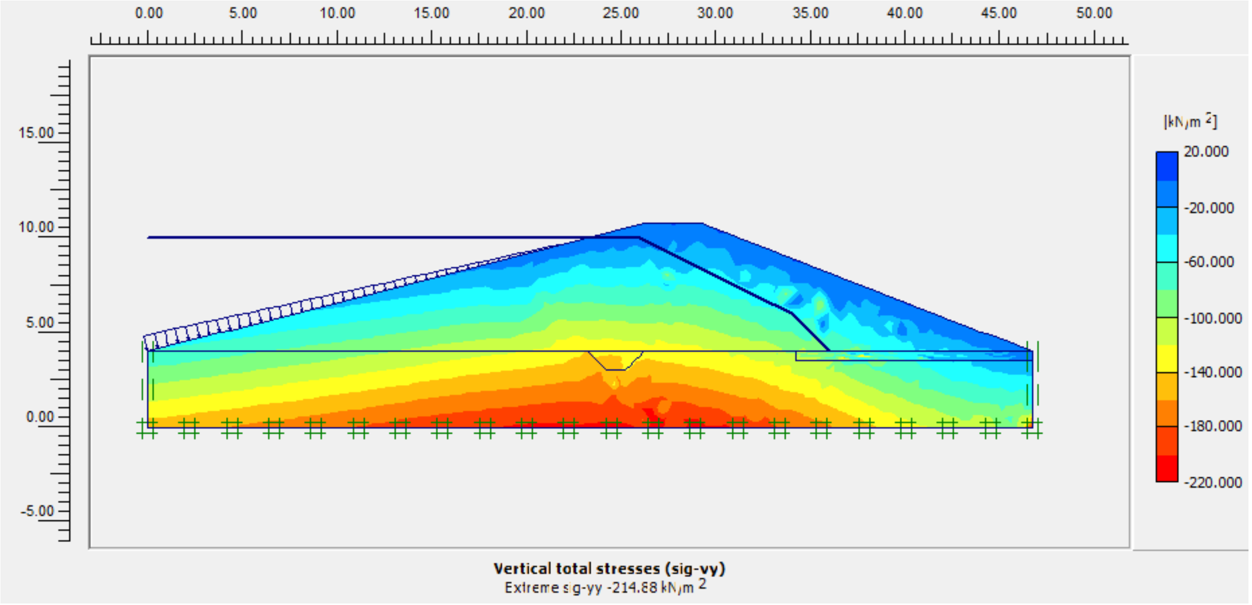


Fig.15 Vertical Total Stress

5.3 DISCUSSIONS:

The primary function of an engineer is to design a structure economically without compromising on its strength. So one should never compromise with the strength even though the cost is high.The fury of nature should never be underestimated. A thorough knowledge on the hydrological analysis is therefore relevant for designing such structures safely and economically. While determining the average precipitation of basin, two methods were used. There is not much variance between the two results, but still we choose the Thiessen polygon method because here the distribution is much spatial as compared to average mean method and so give much better results.

While determining the centroid of the basin cardboard and thread method was used which is always not accurate. Because the cardboard may not be uniform at every point. But still it the easiest and can be calculated easily by anyone as compared to modern softwares.

In case of design of slopes of dam, steep slopes require less earth work hence, lesser cost. But, the factor of safety is compromised.. Another, option is to provide reinforced slopes or retaining walls. These slopes have greater factor of safety than corresponding non-reinforced or unsupported slopes. Although, they decrease the amount of earth work involved the cost is significantly increased due to the addition of these structures. But, the cost of construction of slopes also depends upon the cost of land. Therefore, in urban areas where the cost of land is high steeper slopes may be provided with adequate reinforcement or retaining walls in order to minimize cost.

In case of small earthen dam horizontal filter can be used. But while designing bigger dams vertical chimney as well as rock toe should be provided to considerably reduce the seepage.

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