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Case Study: Efficient Design of Drainage and Rainwater Harvesting System of COER Campus

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Abstract- **A proper drainage system is one of the most important aspects of any civil construction for the proper disposal of sewage as well as storm water in order to prevent the structure and to minimize the problems related to accumulation of water. Similarly rainwater harvesting system finds an important place in today's scenario of increasing water demand and scarcity of water. Effective use and conservation of water becomes very much necessary. The present drainage system of COER is not designed properly and is insufficient to drain off the large amount of rainwater which can also be stored by making water harvesting tanks to use for various different purposes. An attempt has been made by us to suggest the way to design an effective drainage and water harvesting system by thoroughly studying and surveying the drainage and**
Topographical conditions of the college as well as the meteorological data of the area. We would be highlighting the important steps and precautions to be taken regarding the implementation of the suggested solution.
Keywords- Drainage System, Rainwater Harvesting System, Survey, Topography, Meteorological Data.

1: INTRODUCTION

There has been growing interest in the use of rainwater harvesting systems in recent years. Rainwater can be collected and stored to supply a range of non-potable domestic uses. Until recently, rainwater tanks were primarily considered as a solution to reduce potable water consumption. The impact of rainwater harvesting practices on drainage systems, mainly during extreme rainfall events, has been a secondary consideration, one reason being that these two functions, namely supplying water and managing storm water runoff, appear to be contradictory. This study uses a meteorological data and rainfall data. Considering the assumptions of the model, the results show that substantial reductions can be achieved in areas where, on average, the rainfall supply is smaller than the non-potable domestic demand in the households.

The College of Engineering Roorkee also known as COER is an engineering college located on the outskirts of Roorkee city on NH -58. Water logging conditions prevail in our college during rainy seasons because of poor drainage conditions and due to high water table, rain water doesn't fully percolate into the earth surface. So there is need for rectification of drainage system of campus.

So to rectify this problem the drainage system of college has to be redesigned. For this we have proposed a new drainage plan with rainwater harvesting. For this firstly we conduct survey of the whole college. Surveying was done in order to calculate area of the whole college (which include paved area, unpaved area, roof top area of all buildings), elevation and prepare contour map for the same. The whole surveying process is done by using Total Station and AUTO CAD software.

In second step we draw a suitable drainage path line which is based on contour map (i.e. based on elevation of college), existing roads and also based on economic design. As the roads in campus has got uneven elevation, so before constructing drains we must redesigned our roads. So we proposed that for economical design super-elevation should be provided in the existing roads so that water can be easily drained in the open channel drains which are provided along sides of the roads.

For rain water harvesting total amount of water will be collected from roof top of every building and will be directly dumped into the open channels.

Now in last step we proposed two rectangle tanks for storing water which will be collected through open channel. These tanks have capacities according to the peak discharges during rains. The water stored in these tanks will then be utilized for gardening and other purpose in COER campus. So for drawing water from tanks suitable pumping system is provided.

2. MATERIAL AND METHOD

Study area: The COER campus is located at NH-58, 7th km from Roorkee (Uttarakhand), offers an enchanting site with 150548 m^2 total area of lush green pollution free environment. This area consist of 36376.69m^2 paved area (which includes administrative buildings, academic buildings, hostels buildings cafeteria etc.) 114171.68m^2 unpaved area (which includes beautiful gardens, orchards and playfields). This area of Uttarakhand receives an annual rainfall of around 1165mm with maximum

rainfall of around 371mm to 400mm in month of July and August.

College Of Engineering Roorkee, Roorkee (U.K.) is situated on the bank of river Ratmau. Due to a wide range of Shivalik Hills and by virtue of rivers in the Uttarakhand region, here the water table is very high (around 10m) and annual precipitation is high.

For the development (planning and the design) of the RWH system in the campus of the COER (total campus area 38 acres) a series of projects were undertaken.

3. SURVEYING THE WHOLE COLLEGE AREA

Surveying has to do with the determination of the relative spatial location of points on or near the surface of the earth. It involves following:-

• It is the art of measuring horizontal and vertical distances between objects, of measuring angles between lines, of determining the direction of lines, and of establishing points by predetermined angular and linear measurements.

• Along with the actual survey measurements are the mathematical calculations.

• Distances, angles, directions, locations, elevations, areas, and volumes are thus determined from the data of the survey.

• Survey data is portrayed graphically by the construction of maps, profiles, cross sections, and diagrams.

This survey helps in forming the contour map and the college map and then to ultimately draw the path of drainage.

4. RAINWATER QUANTITY AND QUALITY ANALYSIS

This project was related to the assessment of the economic and technical feasibilities of RWH as an alternative for some uses. The main aspects were developed in this project: (i) Assessment of the available rainwater volumes and the possible collection points rainwater; and (ii) To propose size of tanks to be constructed for the collection of water.

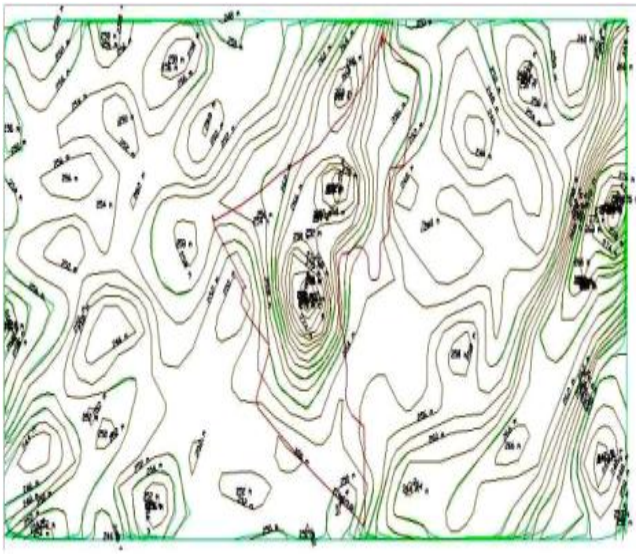

Fig.1 Contour map of COER campus.

5. CALCULATING THE AMOUNT OF WATER THE CATCHMENT AREA WILL PRODUCE

The amount of storm water the catchment will produce can be determined with the following formula.

Q = 2.8 x C x I x A

Q : the design peak runoff rate, or the maximum flow of storm water the system will be designed for (in liters per second)

C: the runoff coefficient.

I: the rainfall intensity at the time of concentration read from the chosen IDF curve;

A: the surface area of the catchment area (in ha (10,000 m^2)

6.SIZING A DRAIN TO COPE WITH THE DESIGN PEAK RUNOFF RATE

With the design peak runoff rate known, we will have to plan where the drains will be installed. A drainage system must be planned together with other structures like roads and buildings to assure they are all adapted to one another. Unlined drains are at risk of erosion, and should therefore have a relatively low gradient to control the velocity of the storm water. Gradients in unlined drains should probably not exceed 0.005 (1 meter drops in 200 meters horizontal distance). In less stable soil unlined drains should be made with a slope less steep than 1/2), in more cohesive material a steeper slope could be used.

The size of the drain can be calculated with the formula:-

Q = 1000 x A x R2/3 xS0.5 / N

Where,

Q : the capacity of discharge of the drain (in l/s)

A : the cross section of the flow (in m^2)
R : the hydraulic radius of the drain (in m)
S : the gradient of the drain
N : Manning's roughness coefficient the hydraulic radius is the surface area of the cross section of the flow/the total length of the contact between water and drain;

Hydraulic radius, **R = (a x b) / (a + 2b).**

Areas calculated:
•Total area of campus = 150548.37 m^2.
•Paved area= 36376.69 m^2.
•Unpaved area= 114171.68 m^2.
•Building area (outside the hostel campus) = 12697.35 m^2
•Building area (inside the hostel campus) = 12157.04 m^2.
•Road area (outside the hostel campus) = 7984.56 m^2
•Road area (inside the hostel campus) = 3537.74 m^2

.1 Calculation of discharge:-

- Intensity of rainfall in the area, I = 0.3mm/hr.
- Constant, C=1 (for paved area).
- All areas are taken in hectares.

(a) Discharge through roads in college campus (outside hostels):-

- Q_{OR}=2.8CIA
- =2.8*1*0.3*0.798456
- =0.67 Lt/sec

(b) Discharge through roads inside the hostel campus:-

- $Q_{IR=}$2.8CIA
- =2.8*1*0.3*0.353774
- =0.297 Lt/sec

(c) Discharge from buildings outside the hostel campus:-

- $Q_{OB=}$2.8CIA
- =2.8*1*0.3*1.2697
- =1.066 Lt/sec

(d) Discharge from buildings inside the hostel campus:-

- $Q_{IB=}$2.8CIA
- =2.8*1*0.3*1.2157
- =1.021 Lt/sec

7 RESULTS AND DISCUSSIONS

Whole the COER campus was categorized in to different zones based on the area in square meter; Table 1 shows the different zones of COER campus in area wise and perimeter wise whereas Table 2 shows the total discharge of rainwater from the different areas.

(e)Total discharge outside the hostel campus:-

- $Q_{O=}Q_{OR+}Q_{OB}$
- =0.67+1.066
- =1.736 Lt/sec

(f)Total discharge inside the hostel campus:-

- $Q_I=Q_{IR}+Q_{IB}$
- =0.297+1.021
- =1.318 Lt/sec.

7.2 DESIGN OF STORAGE TANK:-

- Detention Period = 3 days.
- a= length of tank
- b=breadth of tank
- c=depth of tank
- All dimensions are in meter.

(a) Dimensions of Tank 1 (outside the hostel):-

- Q=1.736 Lt/sec
- = 1.736*3*24*3600 Lt/3 days
- =450 m^3/3 days
- So Design discharge= 450m^3/3 days
- We take depth of tank =3 m.
- Volume of tank= Discharge
- a*b*c=450
- a*b*3=450
- a*b=150
- Providing dimensions of tank as **15*10*3.**
- a=15 m
- b=10 m
- c=3 m, **This tank will be located near the guard house.**

Table 1. Area and perimeter of Buildings of COER campus

Name of buildings	Area (m^2)	Perimeter (m)
Auditorium	1305.58	137.39
cafeteria	1646.35	184.16
Academic block	815.68	109.74
Mechanical block	794.005	117.24
Lab block	932.39	156.75
Civil block	1092.16	144.48
Library	1073.69	152.04
ADM block	365.23	88.54
Parking	891.26	113.8
MBA block	1240.53	143.32
Sant niwas	184.55	45.4
Residence campus	1783.24	168.28
Medical center	122.92	44.47
Tarawati bhawan	878.02	210.9
Ahilya bhawan	693.19	173.36
Saraswati bhawan	879.74	212.95
Sarswati bhawan extension	382.5	84.9
Senior mess	1006.87	127.42
Arihant bhawan	973.00	214.49
GS bhawan	837.97	195.83
BCJ bhawan	837.97	195.83
Aklank bhawan	751.83	189.86
Kunkund bhawan	751.83	189.86
Ashok bhawan	2701.42	263.28
Junior mess	771.54	146.34
Boys hostel cafe	50.6	26.48
Papa point	41.57	24
Overhead Tank	13.46	13
Basketball court(s)	517.66	94.67

Table 2 App. Discharge from COER campus

Name of buildings	Approx. discharge(Lt/s)
Academic block	0.0684
Mechanical block	0.0666
Lab block	0.0783
Civil block	0.0918
Library	0.0900
ADM block	0.0306
MBA block	0.1041
Residence	0.1497
Medical center	0.0102
Tarawati bhawan	0.0738
Ahilya bhawan	0.0582
Saraswati bhawan	0.0738
Saraswati bhawan extension	0.0327
Senior mess	0.0846
Arihant bhawan	0.0816
Ashok bhawan	0.2268
GS Bhawan	0.0705
BCJ bhawan	0.0705
Aklank bhawan	0.0630
Kunkund bhawan	0.0630
Junior mess	0.0648

(b)Dimensions of Tank 2 (inside the hostel):-

- Q=1.318 Lt/sec
- =1.318*3*24*3600 Lt/3 days
- =341.6 m^3/3 days
- So considering Design discharge with overboard= 360 m^3/3days.
- We take depth of tank=3 m.
- Volume of tank= Discharge
- a*b*c=360
- a*b*3=360
- a*b=120
- Providing dimensions of tank as **12*10*3.**
- a=12 m
- b=10 m
- c=3 m, **This tank will be located near Dhobi Ghat.**
- **<u>Design of main drains:</u>**
- Dimensions of c/s of drain=b*d
- b=breadth of drain
- d=depth of drain
- Using Manning's Formula,
- Q= $A*r^{2/3}*s^{1/2}*1000/n$ Lt/sec
- A= catchment area
- r=A/P
- s=bed slope = 0.005
- n=manning's coefficient = 0.015
- P=wetted perimeter

(c) Design of main drain (outside) Drain 1:-

- $Q=1000*A*r^{2/3}*(0.005)^{0.5}/ 0.015$
- $1.736=1000*b*d*(b*d/b+2d)^{2/3}*.005^{0.5}/0.015$
- putting d=2b,
- on solving we get,
- b=0.078 m=7.8 cm
- d=0.156 m=15.6 cm
- But to avoid clogging and easy flow of water in the drain, the dimensions we provide are:
- b=20 cm
- d=30 cm

- Dimension of c/s of **main drain 1**= 20 cm*30 cm.
- Main drain will be located along Rajpath.
- Dimension of c/s of **sub drains** = 15 cm*25 cm

8: RECOMMENDATIONS

Following recommendations were must be fulfilled to overcome the drainage problem of COER campus. These recommendations were given on the basis of design provided in whole project.

- Firstly the conditions of the road must be improved.
- Concrete or bitumen roads are more preferred over C.C. tile roads.
- Suitable super-elevation in existing roads should be provided.
- Provision of different chamber in roads to drain off the rainwater.
- Proper drains along roadside should be provided.
- Rainwater harvesting system should be implemented.
- Storage tanks of sufficient capacity as suggested should be constructed.

9: CONCLUSION

In this project we aim to solve the problem of accumulation of water in COER campus, for that proper drainage system with rain water harvesting has been proposed. But before we suggest that the conditions of the roads should be improved and proper super elevation must be provided so that the water can be properly drained off. Suitable design of drains have been suggested along with the map were provided. Also, rain water harvesting should be done. The store water of rain can further be used as storage

(d)Design of main drain (inside) Drain 2:-

- $Q=1000*b*d*(b*d/b+2d)^{2/3}*.005^{0.5}/0.015$
- $1.318=1000*b*d*(b*d/b+2d)^{2/3}*.005^{0.5}/0.015$
- putting d=2b
- we get,
- b=0.072 m= 7.2 cm
- d=0.144 m= 14.4 cm
- But to avoid clogging and easy flow of water in the drain, the dimensions we provide are:
- b=15 cm
- d= 25 cm

- Dimension of c/s of **main drain 2**= 15cm*25cm.
- Main drain will be located along main hostel road.
- Dimension of c/s of **sub drains** = 10 cm*15 cm.

tanks of suitable capacity are proposed to be constructed for recharging ground water table or gardening or for other purposes as proper pumping system have been implemented in it.

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10. College master plan drawing for reference.

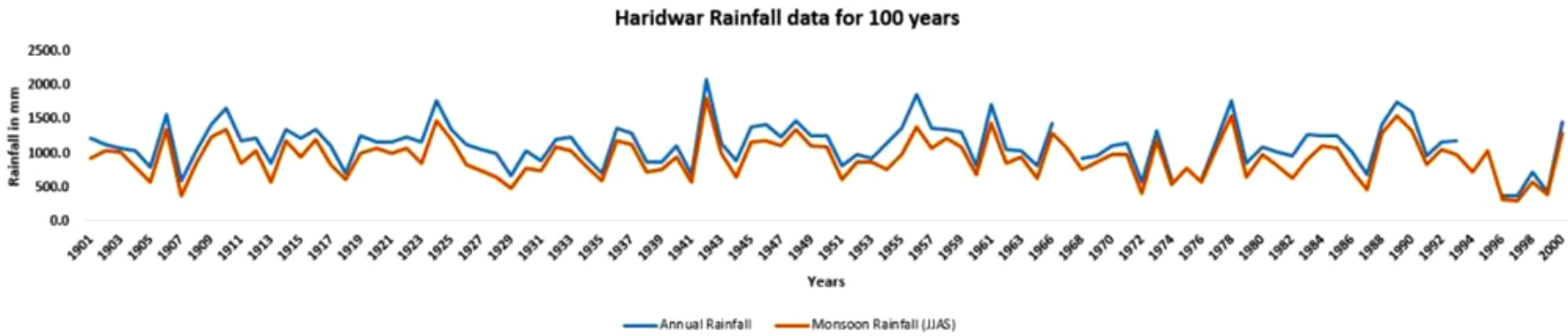

Fig 2. Rainfall data of Haridwar region (taken from NIH, Roorkee)