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Evaluation of cement plugs in Konkan region of Maharashtra state

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Abstract : The study on 'evaluation of cement plugs in selected watersheds of Dapoli Tahshil' was undertaken in the year 2005-2006. The selected water harvesting structures were tested for hydrological, hydraulic and structural design before so as to ensure proper design of structures. Two cement plugs were situated at watershed Pisai-2 (CP_1) and Ganpatipule (CP_2), respectively in Dapoli Tahasil of Ratnagiri district were selected for the study. For design of cement plugs by using rational formula peak discharge was calculated. The height of cement nala plugs, spillway position and relative dimensions were calculated by considering hydrological and hydraulic design procedures. Existing cement plugs constructed by the Department of Agriculture, Maharashtra State was evaluated. The peak rate of runoff computed by using the rational formula for the design of cement plugsCP_1 and CP_2 was 11.38 m^3/s and 9.10 m^3/s, respectively. The total cost of construction as per the standard design procedure for CP_1 and CP_2 was Rs. 1,84,249/- and Rs. 98,452/-, respectively.

Key words : Cement plug, Cross sectional area, Stability analysis

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Soil and water are the two most important natural resources required for the survival of living things on the earth. The environment and economy is driven by these two vital resources. Therefore, for the sustainable development of environment, economy and to provide life enhancing systems for human being and animals it is inevitable to inculcate efficient management practices of land, water and vegetation.

Konkan region constitutes 10 per cent of the geographical area of Maharashtra state and receives 46 per cent of the rainfall of Maharashtra. Farmers of Konkan region are lacking in irrigation facilities and forced to take only one rainfed crop in the year. This has put the rural people in vicious cycle of 'poverty-low purchasing power-low investment-less productivity-poverty'. To overcome the problem, development of land and water resources through scientific and integrated approach on watershed basis is necessary (Mahale *et al.,* 2004). Hence, harvesting and harnessing the runoff water is very important.

Traditionally, water harvesting refers to the act of runoff water storage in ponds for off-season use. Water harvesting can be achieved by construction of structures like farm ponds, small check dams, nala bunds, gully plugging, percolation tanks etc. These structures are integral part of the soil and water conservation activity and are important components of the watershed development and management programme.

It is essential to make survey and study the geo-morphology of watershed for planning, designing and executing the works of soil and water conservation structures. Most of the time, the morphological characteristics of watershed are not taken into consideration, while designing water harvesting structures. The water harvesting structures need to be tested for hydrologic, hydraulic and structural design before their execution so as to ensure their safety as well as their functional efficiency.

The Department of Agriculture, Maharashtra state had constructed number of cement plugs in order to harvest surface runoff under watershed development programme. The Department Agriculture has their own standards and norms for the design to suit the field conditions and administrative procedures. However, such simplifications in the design may lead to improper design, which may result in more construction cost and improper functioning.

METHODOLOGY

Dapoli Taluka is confined in between Sahyadri hills at the East and Arabian Sea at the West have a geographical area of 86,400 ha, out of this 52,500 ha is cultivable area, 30, 200 ha is cultivated area, 1300 ha is culturable waste, and

3,000 ha is current fallow. Dapoli Taluka ranges from latitude17^{0}36' N to 17^{0}54' N and longitude-73^{0}05'E to 73^{0}20'E. The daily rainfall data for 25 years from 1981-2005 was obtained from the Agro-Meteorological Observatory, Department of Agronomy, College of Agriculture, Dr. B. S. K. K. V., Dapoli. The rainfall data was analyzed into weekly rainfall data to find out the Meteorological week with maximum rainfall.

Structural design of water harvesting structure ensures the stability analysis of the structure. The stability analysis of the selected structures was carried out by checking factor of safety of each structure against sliding, overturning, crushing and tension. The various forces acting on structures, moments developed and other factors were calculated in each case.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Peak flood discharge:

Hydrological design of cement plugs were checked by comparing the estimated peak flood discharge from the catchment computed by using the 'rational formula' and the existing runoff producing capacity considered by the Department of Agriculture.

From Table 1, it is clear that the existing peak flood of watersheds Pisai and Ganpatipule were more than the estimated peak flood. Hence, it can be concluded that the structure is hydrological over designed due to which the cost of structure is increased.

Table 1 : Estimated peak flood and existing peak flood

Sr. No.	Watershed	Estimated peak flood, m^3/s	Existing peak flood, m^3/s
1.	Pisai	11.38	29.75
2.	Ganpatipule	9.10	24.31

Dimensions of cement plugs:

The desired and existing dimensions of cement nala bunds are given in Table 2. From Table 2, it is seen that most of the desired and existing dimensions of cement nala bund CP_1 and CP_2 are more or less same except flow depth, total height of plug , width of water cushion, length of wing wall and length of sidewall. Department of Agriculture considered

Table 2 : Desired and existing dimensions of cement nala bunds

Sr. No.	Description	Cement plugs			
		CP_1		CP_2	
		Desired dimensions	Existing dimensions	Desired dimensions	Existing dimensions
1.	Length of main wall, m	20.00	20.00	14.00	14.00
2.	Width of spillway, m	18.00	18.00	12.00	12.00
3.	Flow depth, m	0.51	1.00	0.57	1.00
4.	Freeboard, m	0.6	0.60	0.45	0.45
5.	Height of water storage, m	2.00	2.00	1.50	1.50
6.	Foundation depth, m	1.00	0.90	1.00	0.75
7.	Total height of bund, m	2.98	3.60	2.52	3.10
8.	Top width of bund, m	0.95	0.95	0.87	0.90
9.	Bottom width of bund, m	1.98	2.00	1.68	1.75
10.	Height of water cushion, m	0.92	1.15	0.83	1.15
11.	Width of water cushion, m	1.20	2.40	1.16	1.50
12.	Length of water cushion, m	19.00	18.80	14.00	12.80
13.	Width of apron, m	5.02	-	4.14	-
14.	Thickness of apron, m	0.27	-	0.21	-
15.	Length of header wall, m	20.00	20.00	14.00	14.00
16.	Width of header wall, m	0.60	0.60	0.6	0.60
17.	Key wall length, m	0.95	0.60	0.87	0.60
18.	Key wall height, m	2.98	3.60	2.52	3.10
19.	Key wall width, m	0.60	0.60	0.60	0.60
20.	Length of wing wall, m	3.5	6.92	3.5	5.00
21.	Length of side wall, m	2.84	3.35	2.57	3.15
22.	Total length of bund, m	21.2	21.2	15.2	15.2
23.	Volume of storage, m^3	8400	8370.00	4200	3240.0

Table 3 : Estimated cost of cement plugs

Sr. No.	Item	Unit	Cement plugs				
			CP_1			CP_2	
			Qty.	Rate Rs./unit	Total cost Rs.	Qty.	Total cost Rs.
1.	Cleaning the site	Lump sum	1.0	2000.	2000.0	1.0	2000.0
2.	Excavation	m^3	220.78	-	17784	178.96	9305.66
3.	Bed concrete (1:4:8)	m^3	9.39	1290	11831.4	5.88	7585
4.	Foundation filling (1:5)	m^3	134.83	840	113,257.2.	68.81	57800.4
5.	Coping (1:2:4)	m^2	7.83	1850	14,485.5	3.72	6882
6.	Pointing (1:3)	m^3	205.14	32.0	6,564.48	140.25	4488
7.	Masonry work (1:8) for water cushion	m^3	22.08	830	18326.4	12.52	10391.6
	Total				1,84,249	Total	98,452.6

flow depth l m but desired flow depth is 0.51 m. Thus, it has resulted in increase dimensions of total height of cement plug, height of water cushion, width of water cushion, key wall height and length of wing wall by 0.62 m, 0.23 m, 1.2 m, 0.62 m and 3.42 m, respectively for cement plug CP_1 and 0.58 m, 0.32 m, 0.34 m, 0.58 m, and 1.5 m, respectively for cement plug CP_2.

The storage volume claimed by the Department of Agriculture is also less than the estimated storage volume. The desired storage volume for CP_1 is 8400 m^3 as against existing 8370 m^3. The existing storage volume for CP_2 is differed by 960m^3.

Cost analysis:

The cost of construction of cement plugs for various kinds of work was computed. The cost was estimated by considering the DSR and are presented in Table 3.

Table 3 reveals that the total cost of construction of cement plug CP_1 and CP_2 was Rs. 1,84,249 and Rs. 98,452.6, respectively. While the total cost claimed by the Department of Agriculture was Rs. 3,44,742 and Rs. 1,36,163, respectively. The increments in cost was Rs. 1,60,493 and Rs. 37,710 for the structure CP_1 and CP_2, respectively. The per cent increase in cost was 46.55 and 27.69, respectively. There is increase in cost due to over design of for both the cement plugs.

Conclusion:

Most of the design and existing dimension of cement plugs CP_1 and CP_2 was more or less same. Major difference was found in total height of bund, height of water cushion, depth of water cushion, width of water cushion, width of apron, thickness of apron, length of side wall, creep length due to more flow depth. In case of CP_1 and CP_2 the existing peak flood computed by the Department of Agriculture were more than that of estimated peak flood. Stability analysis revealed that both the cement plugs were found to be safe from stability analysis.

From the analysis of data and results obtained from comparison between existing and designed dimensions of cement plugs, it is concluded that regarding cement plug CP_1 and CP_2, total height of existing cement plugs was 0.62 m and 0.58 m higher than designed cement plugs. Department of Agriculture has not built apron for cement plugs . For cement plugs CP_1 and CP_2 the cost of construction computed by Department of Agriculture was found to be 46.55 and 27.69 per cent higher than the actual cost calculated by the standard design procedure, respectively. Therefore, it is necessary to modify the norms and procedure used by the Department of Agricultural by considering the hydrologic, hydraulic and structural design.

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