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Design and Estimation of a Composite Earthen Dam at Gokuldham, Chikhale, Belagavi

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Abstract. To meet the water requirements of the habitants of Gokuldham vedic village, composite earthen dam is proposed across a stream flowing through the area. Surveying of the catchment area and the dam site was done to arrive at various quantities necessary to plan and design the proposed dam. The main aim of this project is to construct the Dam using naturally available materials by excluding man made materials such as cement and machineries without affecting the local ecology of the region. Soil from different sources within the property was tested for suitability to construct different parts of the dam. These test results are presented in this article. A detailed report including estimated quantities and cost of construction are submitted to the village panchayat for the approval of budget. The construction will begin after its approval. This article briefly describes the entire process of planning, designing and quantity estimation for the proposed earthen dam.

Keywords: Earthen Dam, Soil, Estimation.

1 Introduction

Gokuldham is a model Vedic village community project developed by ISKCON, Belagavi. The habitants of this community need water for agriculture and domestic use. The surface run-off needs to be stored so that it is available for use in non-monsoon seasons. The earthen dam project was taken up with this objective in mind. Being a part of MoU between the institute KLS GIT and ISKCON, Belagavi. This project has adopted the principles of Gokuldham society, the exclusion of man-made material like cement and machineries used for compaction and using natural materials available in the area without affecting the local ecology of the region.

1.1 Site Overview

Gokuldham is located in the Sahyadri Mountain ranges, 40 kms, from Belagavi city. The dam site is situated in a location with elevated abutments on both sides. The substrate is a rocky and provides a firm foundation for the dam. In case of breach there will be no harm to life or property as there are no places of dwelling immediately on the downstream of the dam. The latitude and longitude of proposed dam site is **15°40'11" N** and **74°17'16"E**.

1.2 Need

This area receives abundant rainfall but does not have a structure in order to store this water. A few years ago, the old earthen Dam was breached due to heavy rainfall and improper methods of construction. Thus, construction of a composite earthen dam is proposed across one of the streams running in this area to meet the water requirements of the habitants of Gokuldham vedic village.

1.3 Objective

To prepare a detailed project report to submit to the village panchayat in order to get approval and funds sanctioned for the construction of proposed composite earthen dam at Gokuldham. The report consists of surveying, results of various tests conducted on soil samples collected from the vicinity of the dam site and the material estimation for the dam.

2 Preliminary Stage

In the preliminary stage of the project surveying of dam site, its catchment area and reservoir was carried out. Soil from different sources in the area was also tested for suitability as a construction material for the dam. Methodology of the work is shown in Fig.1.

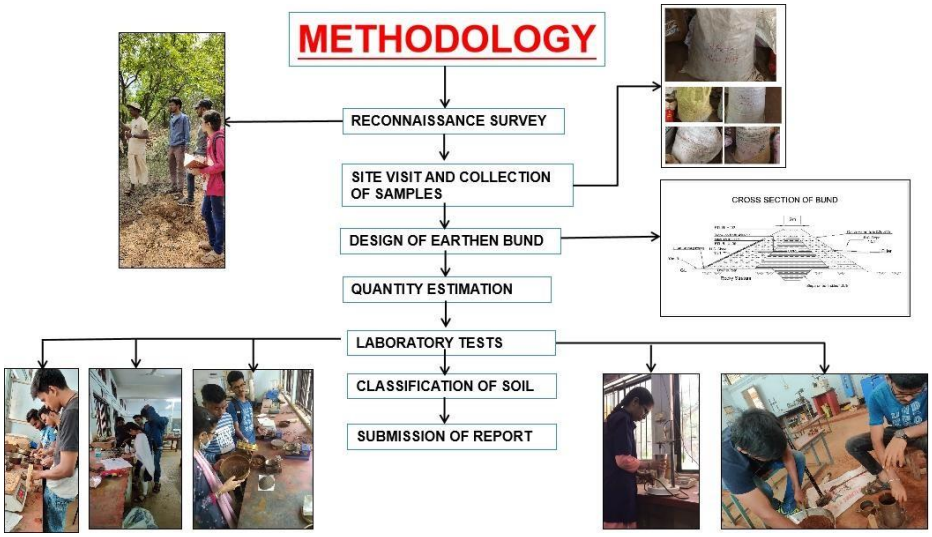

Fig.1 Flowchart showing the methodology

2.1 Survey and Selection of Site

Based on the requirement of a dam site, a suitable location was chosen across the natural stream flowing through the area to construct the dam. The important feature of the site includes a strong substrata and natural elevated apartments on either sides of

the reservoir with sufficient capacity and no danger to life and property on the downstream side in case of breach. A contour map was developed after surveying the site to establish different elevations to be used in the design and determine the reservoir capacity. Google map of the catchment area was provided the run off volume into the reservoir. Fig.2 shows the topographical map of the project site on Google map. Fig.3 shows the project boundary on Google map. Dam site as shown in Fig.4.

Location map

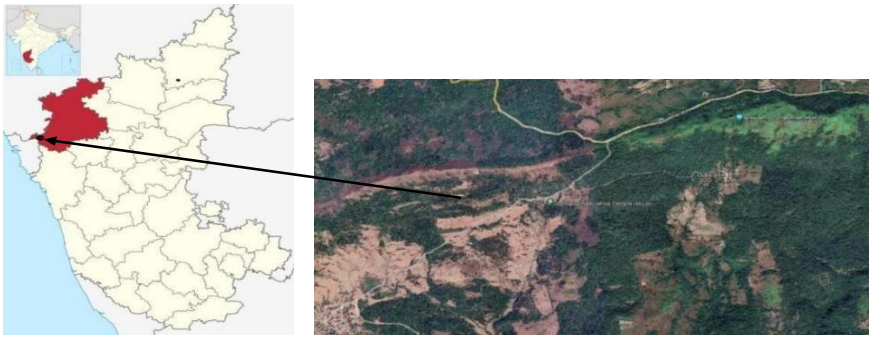

Fig.2 Location of Gokuldham, Chikhale Village, Belagavi

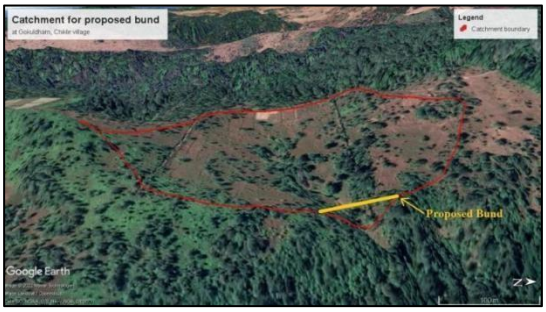

Fig.3 Catchment area under consideration

Fig.4 Dam Site

2.2 Runoff Estimation

The maximum flood discharge was calculated using Ryves Coefficient. Ryves Coefficient: It was originally developed for the Tamil Nadu region, is in use in Tamil Nadu and parts of Karnataka and Andhra Pradesh. It is represented as $\mathbf{Q_p = CR*A^{2/3}}$ or Peak Discharge = Ryves Coefficient X Catchment Area$^{2/3}$.

The catchment area of the dam site is 0.1 km^2 and maximum flood discharge has been calculated by considering 31.2 inches of average annual rainfall. The maximum flood discharge calculated using Ryves Coefficient is 2.15 m^3/sec. The capacity of the reservoir up to MWL is 20 lakh liters.

2.3 Material Selection

One of the requirements of this project, as stipulated by Gokuldham authority was to use the soil which was within the area and from a source as close as possible to the dam site in order to avoid additional transportation expenses. Five different soil samples were collected from different sources at Gokuldham. These soil samples were tested in laboratory in order to classify them. The classification chart was then used to decide the suitability of soil for the core and shell of the dam based on IS:12169-1987(R2006) Appendix A. Table 1. shows the basic test results carried out on the soil samples.

The soil samples collected were named based on their location as:

1. Near Electrical Pole (N EP)
2. Near Tree (N T)
3. Near Pond (N P)
4. Near Dam (N D)
5. Near New Plot (N PL

Based on Indian Standard Soil classification system (ISSCS), Classified the soil samples like silty gravel (GM) for Electrical pole, high compressibility clayey soil (CH) for tree, high silty soil (MH) for pond, Intermediate silty soil (MI) for dam, Intermediate clayey soil (CI) for new plot. Among these soil samples Near Electrical pole (GM) soil is used for pervious casing and Near Tree (CH) soil is used for Impervious core.

Where G showing specific gravity, LL represents liquid limit in %, PL represents plastic limit in %, MDD represents maximum dry density in kN/m^3 and OMC represents optimum moisture content in %.

Table 1. Soil Tests Results

Soil location	G [1]	Particle Size distribution % [2]				LL % [3]	PL % [3]	MDD kN/m^{3}[4]	OMC % [4]	Classification	Suitability [IS:12169-1987(R 2006) Appendix A] [5]
		G	S	M	C						
Near Electrical Pole	2.65	45	27	21	8	46	30	38	14.7	GM	Suitable for pervious casing
Near Tree	2.65	4	16	32	48	58	20	28	14.5	CH	Fairly suitable for impervious core
Near Pond	2.60	4	40	29	27	57	27	52	14.9	MH	Poorly suitable for both core and casing
Near Dam	2.70	1	9	53	37	40	20	35	16.7	MI	Poorly suitable for both core and casing
Near New Plot	2.66	5	12	41	42	45	26	24	14.3	CI	Fairly suitable for impervious core

3 Design and Estimation

3.1 Geometry of Dam

IS: **12169-1987** Criteria for Design of small embankment dams is referred for the designing of the earthen Dam. Since the Dam is less than 15m in height, it is considered as a small dam, for which stability analysis is not required [5,6]. Cross section of the dam is shown in Fig.5. Dimensions of the Dam is shown in Table 2. The components of the Dam are:

1. Cut-off
2. Core
3. Casing
4. Internal drainage system
5. Slope protection
6. Surface drainage

Table 2. Dimensions of Dam

Sl.No	Description	Dimensions	Clauses
1	The total length of the Dam	37.2m	
2	Upstream slope	2H:1V	5.1.2.3
3	Downstream slope	1.5H:1V	5.1.2.3
4	Top width	2m	5.1.2.3
5	Top Dam level	RL - 102m	
6	Full tank level	RL - 100m	
7	Height of the Dam	5m	
8	Height of key trench	1.50m	
9	Slope of Core	1:01	4.2.3
10	Top width of core	1m	4.2.3

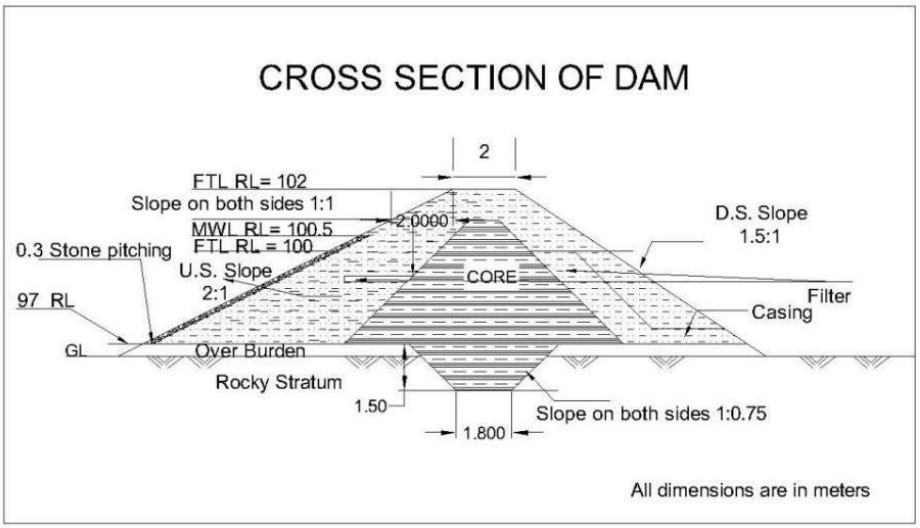

Fig.5 Cross Section of Dam

3.2 Weir Design

For surplus water, Design of weir is done and Table 2. shows the dimensions of the weir.

Table 3. Dimensions of Weir

Sl.No	Description	Dimensions
1	Total length of the weir	5m
2	Upstream slope	2H:1V
3	Downstream slope	1.5H:1V
4	Top width	2m
5	Height of the weir	3m

3.3 Estimation and Rate Analysis

Quantity Estimation

Quantities of Dam stripping, Excavation for key trench, Key trench filling, Hearting Embankment for core, Casing Embankment, Upstream stone pitching and downstream grass turfing have been calculated. Estimated quantities is shown in Table 4.

Table 4. Quantity Estimation

Sl.No	Description of Quantities	Quantity	Units
1	Stripping Quantity for Earthen Dam	149.79	m^3
2	Excavation for Dam Key Trench	158.64	m^3
3	Hearting Key Trench Filling	158.64	m^3
4	Quantity of Hearting Embankment	339.09	m^3
5	Quantity of Casing Embankment	748.82	m^3
6	Stone Pitching	249.55	m^2
7	Grass turfing	201.22	m^2

The quantity of soil required to be excavated from the borrow pit is 810m^3 , 1876.1m^3 and 375.6m^3 for core , casing and trench filling respectively.

Rate Analysis

The Rates adopted in the estimate are as per the SR Minor Irrigation Belagavi Circle for the year of 2018-19. The estimate is framed by adopting economic way of execution. Rate analysis has been done for the above quantities calculated.
The final estimated cost of Earthen Dam is Rs.14,00,000. Table 5 showing the results of rate analysis.

Table 5. Rate Analysis

Item no.	Description/ Item of work	Unit	Quantity	Rate in Rs.	Amount
1	Clearing jungle growth	m^2	3500	3.15	11025
2	Excavation for foundation	m^3	322.14	250.6	80728.284
3	Providing hearting embankment	m^3	179.34	218.4	39167.856
4	Providing Cutoff trench filling	m^3	158.64	218.4	34646.976
5	Providing casing embankment	m^3	908.57	219.45	199385.686
6	Providing and constructing vertical / inclined graded filter	m^3	252.93	1873.2	473788.476
7	Providing and constructing 300mm thick hand packed rough stone	m^2	249.55	437.85	109265.467
8	Providing and laying in-situ vibrated lime mortar	m^3	2.74	5501.78	15074.877
9	Providing and constructing granite / trap / basalt rubble stone masonry	m^3	15.6	3627	56581.2
10	Providing 12mm thick lime plaster	m^2	26.63	210	5592.3
11	Maintenance of lawns with fine grassing	m^2	201.22	23	4628.06
12	Planting and maintenance permanent hedges	m^2	120.23	92	11061.16
13	Renovation lawns	m^2	20	1050	21000
	Total estimated cost				1061945.343
Including technical assistance, consultancies 6%, Miscellaneous Lump sum 15%					Rs.1400000

4 Discussion

Detailed design, drawings, estimation report has been submitted to Gokuldham ISKCON, Chikhale Village, Belagavi for Panchayat approval.

All test results are within the range and hence the soil samples can be used for the construction of different components of Earthen dam.

5 Conclusion

In this case it was possible to locate borrow pits for the soil required to construct the earthen dam in the vicinity of the site. This makes the project environment-friendly as the transportation effort to carry soil from borrow pits to the dam site is considerably reduced. The cost of borrowing soil is also considerably reduced because of this. For small dams (like the one in this project) simple guidelines given in codes of practice may be used to proportion the geometry of the dam. These guidelines provide a conservative geometry of the dam in simple steps.

6 References

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