RUBBERIZED DAM AT KUMBIDI (KOOTTAKKADAV)

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Abstract - *Water is diverted from the streams for hydro power generation using suitable diversion structures. The experience of inflatable dams in India is very limited even though worldwide over 4,000 installations exist and more than 10 manufacturers offer this type of weir. For selecting a suitable diversion structure, economic and technical aspects are to be carefully considered. This study is an attempt to study the rubber dam technology for the irrigation of water at "Koottakkadavu". Koottakkadavu is the place near Velliyankallu at Pattambi. The main problem at Koottakkadavu village is the water scarcity during the summer season and the flood during the rainy season.*

1. INTRODUCTION

Water is important and its storage is also important aspect that should be considered for sustainable life. Rubber Dam is a different type of hydraulic structure compared to a conventional water retaining structure with gated or un-gated spillways and weirs to release the surplus water, such as dams and barrages. Strictly speaking these are not dams, but structures made of high strength fabric adhering with rubber, which forms a ballooned rubber bag when filled with water or air and anchored to the basement concrete floor, and are used for water retention. Inflatable dams are flexible cylindrical inflatable and deflectable structures made of rubberized material attached to a rigid base and inflated by air, water, or a combination of air/water. This is a project of design and analysis of rubber dam at Koottakkadavu. This is the first project in South India. The dam is constructed across the river Bharathapuzha at the downstream side of Koottakkadavu. The main problem in that locality is scarcity during summer and flood during rainy season. Through the study conducted by the irrigation department they arrived at the conclusion that a dam can minimize the scarcity on there. But the possibility of flood during monsoon is unavoidable. It was found that the property of inflation and deflation of rubber bag can control these problems.

1.1 Scope and Objectives of the study

The purpose of the study are

- To maximize irrigation at Koottakkadavu.
- To study and design rubber damfeatures.
- To draw the 2D and 3D model structure designed in softwares
- Reduce water scarcity on that locality.
- Study and implementation of Inflation -deflation mechanism to control water level.

2. METHODOLOGY

2.1 Consult an Engineering Geologist And Hydrologist

The technical details of the site and required specification dependent on the amount of water involved. Mechanical engineers will be constructed to design necessary pipe work, valves and floodgates. Geotechnical engineers will check whether the rock or soil below the proposed dam is strong enough to accommodate the weight of the dam and determining possible permeability.

2.2 Selection Of Dam Site

In the selection of a suitable dam site, geological, geomorphic, hydrological, meteorological, and hydraulic factors as well as construction methods should be taken into consideration. Although the body of a rubber dam is light and the load is uniform, the dam site should always be on a solid ground and a concrete foundation should be placed.

2.3 Preliminary Survey, Reconnaissance Survey And Detailed Survey

Site selection, type of river, nature of slope, past records and details, determination of depth, suitable alignments, permanent benchmarks, contour mapping, soil characteristics, estimate sheets preparation, selection of most economical alignment, centerline of final alignment and required markings.

2.4 Analysis Of Rubber Dam

Analyses rubber dam velocity, duration and other factors that influence maximum discharge and loads over it, soil parameters etc.

2.5 Hydraulic Design

The design data/parameters required for hydraulic design of a rubber dam data/parameters are design discharge (20 years discharge record of river), design water level, water retention level of the project, average lowest bed level of the river, soil information, embankment crests level, cross section of the river up to 5-7 Km U/S and up to 2 Km D/S, long section of the river , internal pressure of rubber dam. The main parts of rubber dam such as foundation, concrete slab, weir/dam material, embankment and partition walls are to be design.

2.6 Computation of Components Of Rubber Dam

Compute the various parameters like dam height, depth of dam foundation, length of rubber dam, strength of rubber dam and shape and size of rubber bag. Compared with steel gates, the rubber dam becomes more cost-effective with the increase in the length of its span(s). Steel gates are expensive and require intermediate structures (such as concrete piers) that collect debris during floods. Water can spill over the top automatically without additional support or adjustment.

3 DETAILS COLLECTED

3.3 Location Of The Proposed Dam

Fig 3.1 - Koottakkadav location by google map

Fig 3.1 - Site view from the bank

3.2 Details From Irrigation Office, Koottakkadav

Table 3.2.1 - High Flood Level details

Sl. NO	YEAR	HFL	DATE
1	2018	7.60	23-Aug
2	2019	7.63	18-Sep

Table 3.2.2 - The necessary Details from the irrigation office, Koottakkadavu

DETAILS COLLECTED FROM IRRIGATION OFFICE	
Name of river	Bharathappuzha
Name of basin	Bharathappuzha
Location of confluence point	Ponnani
Site code	KR000C9KUMBIDI
Catchment area upto site catchment area ofbasin	5755 Sq.Km 6186 Sq.Km
Length of stream upto site from start	184 Km
Lenth of stream from site to confluence point	25 Km
Average height of bank: left and right	5m and 6m
Nature of river bed	sandy
Nature of river banks	hard rock
HFL in 2019(max) HFL in 2003(min)	7.270 6.110
Max observed discharge	3022 cu.m.
Max point velocity	3.97m/s

When the length of the dam become more we have to provide partition walls to avoid over deflation rate and the vibration of dam bag on the slab. The high flood level details of the river is given below. The specified properties of rubber layers were obtained from the rubber sheet manufacturing company at Ooty. And the details are as follows.

3.3 Details From Manufacturing Company, Ooty

TABLE 3.3.1 - Properties of various diameter air filled spoiler rubber dam

Code	Height (m)	Inner pressure / outer pressure	Perimeter (m)	Bottom gaskets width (m)	Coefficient (k)
Air inflatable spoiler rubber dam					
SDMS-20	4.0	1.25	14.62	8.25	6-8

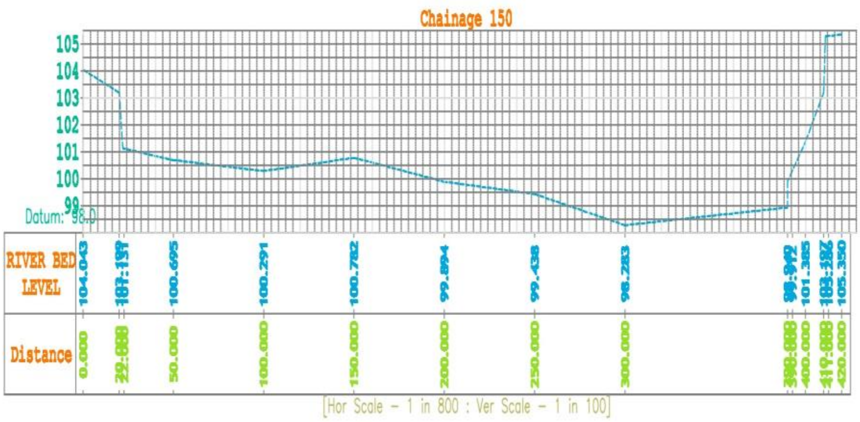
TABLE.3.3.2 - Properties of rubber layers

Item	Unit	Outer layer	Middle layer, inner layer	Cover rubber sheet
Tensile strength at break	Mpa	14	12	6
Elongation at break	%	400	400	250
Hardness		55-65	50-60	55-65
flexibility,no cracking	10000 times	20	20	20
Brittleness temperature	°C	-30	-30	-30
Wear loss	Cu.cm/1.61Km	1.0	1.0	1.2

3.4 Survey Details

Then the surveys were conducted on the site to get the reduced levels.

Fig 3.4.1 – River cross section at the reference point



4 DESIGN OF RUBBER DAM

4.1 Foundation Design

As per Bligh's theory,Total maximum head loss, H_L= 4m, Soil gradient C = 12

Total length of creep required including creep along cut off = L_c= C H_L= 12 x 4 = 48 m

The length of down stream flow is given by

$$L_2 = 2.21C\sqrt{\frac{H_L}{10}} = 2.21 \times 12 \times \sqrt{\frac{4}{10}} = 16.77m \approx 17m$$

The bottom width of dam = B = 4m. Provisions of cut offs are given.

The head over the check dam when high flood discharge is passing is given by, q = 1.7 $H^{3/2}$

Where q = Q/L = 3032/420 = 7.22 m^3 · Then, 7.22 = 1.7 $H^{3/2}$ $\therefore$H = $\left(\frac{7.22}{1.7}\right)^{2/3}$ = 2.62m

Head over the dam crest = 2.62m, ∴u/s HFL (bed level=98.00 and crest level=102.00) = 98+4+2.62 = 104.62m.

Now R = Lacey's regime scoured depth = 1.35 $\left(\frac{q^2}{f}\right)^{1/3}$ Assuming f = 1, R = 1.35 $\left(\frac{7.22^2}{1}\right)^{1/3}$ = 5.04m

Depth of u/s sheet pile from below u/s HFL = 2R = 2 X 5.04= 10.08m. ∴Level of bottom of u/s sheet pile = 10.08 - 7.63 = 2.45m Provide a depth of 2.5m for u/s cut off. Use a similar d/s cut off of 2.5m depth below the check dam floor. Now total creep length provided except u/s floor = (2 x 2.5) + bottom width of floor +L_2+(2x2.5)= 5+4+5+17 = 31m.

The balance length , i.e. 48-31 = 17m

$$L_2+L_3 = 18C\sqrt{\frac{H_L X q}{10X75}} = 18 \times 12x\sqrt{\frac{4\,X7.22}{750}} = 42.38m, \quad L_3 = 42.38-17 = 25.38m \approx 26m$$

Hence provide (say 1m thick) d/s loose talus of 26m in length.

The length of u/s talus L_4 may be kept as equal to 1/2 the length of d/s talus, i.e. 13m.

D/s Floor Thickness :

The H.G line is now plotted . The maximum Ordinate of the H.G. line above the bottom of the floor for the d/s portion at the junction of dam wall, h=(4/48) x 18 =1.5m. The thickness of d/s floor at this point is then obtained by Eq.

$$t = 1.33\left(\frac{h}{G-1}\right) = 1.33 X\left(\frac{1.5}{2.65-1}\right) = 1.21m \approx 1.3m.$$

4.2 Rubber Bag Design

Table below shows the appropriate measures of the rubber bag according to the environment conditions on there.

The length of the rubber bag = 30m

Diameter of the rubber bag = 4m (to protect the irrigation projects already exist in there)

Table 4.2.1- Spoiler air filled rubber bag details

Code	Height (m)	Innerpressure (N/sq.m)	Perimeter (m)	Coefficient (K)
SDMS-20	4.0	1.25	14.62	6-8

4.3 Abutment Design

Top bank level = 105.58 Good , soil level = 95.5 Provide top with of 0.5m, ∴ Height of the abutment = 105.58-95.50 =10.08m, Bottom width of abutment = 0.4 x height = 0.4 x 10.08 = 4.032m

4.4 Design Of Wing Walls

Top level of wing wall= top level of abutment = upstream bank level= 105.58 Bottom level of wing wall= good soil foundation level= 95.00, top thickness of wing wall= top thickness of abutment = 0.5m Bottom thickness of wing wall = 0.4x height of wing wall =0.4x (top level- bottom level) =4.032m

Wing wall is splayed one to one and has enough length such that it gets keyed in to the bank (splay= horizontal slope).Use similar downstream wingwalls.

4.5 Design of Anchorage System

We are using anchorage of dam bag with concrete base. Steel clamps are provided with high strength anchorage bolt for fixing the rubber bag on the dam. And from this two bolt system was using here.

And its parts are as below:

1) Plastic washers : Inner diameter: 21mm , Outer diameter: 42mm, Thickness: 2.8mm

2) Steel tube : Material: #45 steel, Inner diameter: 36mm Outer diameter: 50mm, Length: 210mm

3) Anchor bolt : Model: MSGLW-335/20X250, Material: MnSi

4) Bottom rigid cylinder : Diameter: 35mm, Height:50mm, Material: Steel

5) Nut : Thread specification: M20 Height: 16mm

6) Square pallet: Length: 50mm Width: 50mm, Thickness: 22mm

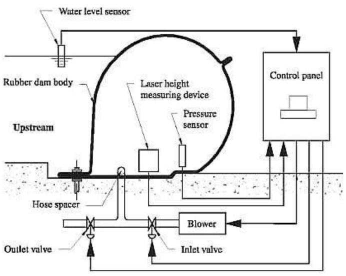
7) Resign anchoring agent : Model: MSM2360, Uniaxial compressive strength: 45.1 Mpa , Tensile strength: 3.12 Mpa

8) Concrete matrix : Ratio of water, ash and sand: 0.5:1:3 , Uniaxial compressive strength: 35.3 Mpa ,Tensile strength: 2.75 Mp

4.6 Automatic Air Control System

There will be an automatic air control system for the air filling and removing. Pumping system will be used for this.

Fig 4.6.1- Air Controlling systems of rubber bag



5. RESULTS AND DISCUSSION

- By the construction of this rubber dam there can maximize irrigation and control the flood.
- The site for this project is of good soil at the banks and sandy soil at the river bed from the bore logged details we found that the hard soil is at 2.5m depth and river bank is at105.00RL.
- By using rubber dam we can avoid mass construction and its time period for construction.

Table 5.1 - Foundation details

Length of u/s concrete floor	17 m
Length of d/s concrete floor	17 m
Length of u/s stone aprons / talus	13 m
Length of d/s stone aprons / talus	26 m
Width of dam below rubber bag	4 m
Thickness of d/s floor at the junction	1.3 m

Table 5.2 - Rubber bag details

Diameter	4 m
Code	SDMS 20
Inner pressure	1.25 N/sq.m
Perimeter	14.62 m
Length	3 m

Depth of brick foundation at the ends	0.5 m

Table 5.3- Abutment details

Top thickness	0.5 m
Height of abutment	10.08 m
Bottom width	4.032 m

Table 5.4 - Wing wall details

Top width	0.5 m
Bottom width	4.032 m
Height	10.58 m

Table 5.5 - Anchorage system details

Plastic washers	Inner diameter – 21 mm, Outer diameter – 42 mm, Thickness– 2.8 mm
Steel tube	Inner diameter – 36 mm, Outer diameter – 50 mm, Length– 210mm
Anchor bolt	Model- MSGLW-335/20X250, Material- Mnsi
Bottom rigid cylinder	Diameter– 35mm, Height– 50mm, Material– Steel
Nut	Thread specification - M2, Height- 16mm
Square pallet	Length- 50mm, Width - 50 mm, Thickness- 22mm
Resign anchoring agent	Model- MSM2360, Uniaxial compressive strength - 45.1Mpa Tensile strength- 3.12 Mpa
Concrete matrix	Ratio of water, ash and sand- 0.5:1:3 Uniaxial compressive strength - 35.3 Mpa, Tensile strength- 2.75 Mpa

6. CONCLUSION

As per our studies conducted at Koottakkadav we understood that there is a need for storage of water and to control flood. We identified that the check dam can minimize the problems. This can reduce the scarcity on there but the possibility of f load increases. If we choose a concrete dam the flood intensity increases. We found that the property of inflation and deflation mechanism of rubber dam can solve these two problems simultaneous. From the detailed survey a suitable location for this dam was found out. Then the soil characteristics, river characteristics and other details required for this design purpose are collected from irrigation office and rubber manufacturing company. Hydraulic design was thus completed with the help of information from reference. With these design values we drawn 2D and 3D drawings of the dam. After the designing we achieve the goals specified.

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