Model, Working and Benefits of Sponge Dam over Other Dam
Balraj B. More

Abstract - The main aim of this project is to introduce a new concept of Sponge Dam which is constructed by using Sponges. This dam will increase the storage capacity within specific area and which will reduce the evaporation and percolation losses of water as happens in Earthen dams, Rockfill dams, Concrete-face rock-fill dams, Asphalt-concrete core. This is most beneficial in the area which are facing critical water deficiency. It is also useful for decreasing the effect of flood as we can maintain the water in main dam by storing water in Sponge Dam. The cost of construction is also comparable to other types of dam. Hence all limitations of these dams can be filled by constructing Sponge Dam.

Keywords Water deficiency, Flood, Sponge Dam, Area, Gravity dam, Earthen dam Evaporation, Storage Capacity.

I. INTRODUCTION

Though we store water in reservoirs we have to face the problems of water every year. The careless use, limited water resources, shortage of rain will lead to critical condition for human beings. The irregularity of rain can not be governed by human beings. Storage at such condition is also very difficult even in dams when natural disaster like flood conditions arises we can not store that excess amount of water and we have to flush it out. We have too many problems regarding flood and storing water till today though we spend too much money, time for constructing such large dams, reservoirs, and tanks. Deliberating all such problems I have introduced a new approach of Sponge Dams which is totally different and which is much beneficial than normal reservoirs and normal dams. “Sponge Dams” Sponge dams are nothing but use of sponges for storing water rather than using direct storage method like dams, reservoirs. The Sponge Dam concludes the storage of water in large sponges. As we know sponges have capacity to adhere water for longer time and without affecting water. In the Sponge Dam the height, quality can be used as per requirements the water capacity may get increased. The machineries like Sponge Filling Machine (SFM) for filling sponges and Sponge Lifting Machine (SLM) is necessary to carry sponges are required. This type of dam can only be constructed where problem of water is very serious and inevitable than other. The large areael reservoirs having less capacity of storage and having particular site for Sponge Dam can be replaced with it. The replacement of Jayakwadi Dam is elaborated below as case study.

II. MATERIAL AND METHODS

Experiments
1. Determination of loss of water due to evaporation from sponge and normal cylindrical container.

2. Determination of storage capacity of Sponge.

Apparatus - Sponges of known size, Water vessel, Sponge vessel, a large vessel for sponge filling, Measurement scale.

Various formulae - 1. Evaporation formula (Initial water – final water) / Time
2. Area of circle $A = \pi r^2$ or $Pd^2 / 4$ (Where, $r=$Radius of circle, $d=$Diameter of circle) (1) 3. Volume of cylinder $A \times h = A \times h$ (2)

Taking the sponge of size 14 cm$\times$8 cm$\times$5 cm the following evaporation results are obtained.

EXPERIMENT 1

Aim - To determines the loss of water due to evaporation in sponge and normal container.

Apparatus - 2 sponges of size 14 cm$\times$8 cm$\times$5 cm, a cylindrical water container, a large container for filling sponge, Rubber cover for sponge.

Procedure -
1. Take all sponges of size mentioned above. Take water in the in the large vessel so that sponges can be dropped completely inside the vessel and get filled with water.
2. Keep the sponges in sponge filling vessel and by compressing fill it one by one with water. Then take same amount of water in the water vessel. And take initial readings (volume of water).
3. Keep sponge covering it by rubber cover so that it should be closed properly over five surfaces and keep another water container in open space.
4. After 84 hours take readings that is water remained after 84 hours in sponge and water container. The following observations occurred.

Observation

a. Specimen - Sponge 1 (14 cm$\times$8 cm$\times$5 cm)

<table>
<thead>
<tr>
<th>Observation of Sponge 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial no.</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

b. Specimen - Cylindrical Water container (D=11.2 cm, h=11 cm)
(D-Diameter of cylindrical container, h-Height of cylindrical water container)
Table 2: Observation of Cylindrical Water Container

<table>
<thead>
<tr>
<th>Serial no.</th>
<th>Time (hours)</th>
<th>Water level(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>5.52(approx.)</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>5.1(approx.)</td>
</tr>
<tr>
<td>3</td>
<td>84</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Table 3: Overall Observation of specimens

<table>
<thead>
<tr>
<th>Container</th>
<th>Total time t (hour)</th>
<th>Initial water level(cm)</th>
<th>Final water level(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sponge1(14x8x5)</td>
<td>84</td>
<td>6</td>
<td>5.6</td>
</tr>
<tr>
<td>Sponge2(15x9x5)</td>
<td>84</td>
<td>6.2</td>
<td>5.8</td>
</tr>
<tr>
<td>Water vessel(D=11.2,H=4.6)</td>
<td>84</td>
<td>6</td>
<td>4.6</td>
</tr>
</tbody>
</table>

(Here the Observation of Sponge 2 is not mentioned. Directly the average of readings is taken.)

**Calculations**

Total loss of water due to evaporation in time $t= (\text{Initial water level}− \text{Final water level}) ÷ t$

For Sponge 1.

Total loss of water per hour = $(6−5.6) ÷ 84$

=0.004762 cm/hr.

For Sponge 2.

Total loss of water per hour = $(6.2−5.8) ÷ 84$=0.004762 cm/hr.

For Normal Cylinder Water Vessel

Total loss of water per hour = $(6−4.6) ÷ 84$=0.004762 cm/hr.

**Result** - The observation shows the 0.017 is 4 times 0.004762. Hence water loss due to evaporation is more in Normal Cylindrical Water Vessel. It is approximately “4” times more than loss in Sponge. The following graph elaborates more about result of this experiment.

Fig.1: Variation of Water Level With Respect To Time in Sponge 1.

Fig.2: Variation of Water Level With Respect To Time in Normal Cylindrical Water Container

The above graphs (Fig. 1and Fig. 2) elucidate that the rate of decrease of water level in Normal cylindrical container is greater than sponge. Hence it can be said that the evaporation in normal water container is more than sponge.

**Conclusion** - Storage of water in sponge is much more beneficial and conservative than direct storage in dams and reservoir which causes enormous loss due to evaporation. This experiment states that the water we can store up to one year in the normal dams. However in Sponge made reservoir can be stored up to 4 years as losses are minor. Hence water can be used up to 4 years.

**EXPERIMENT 2**

As we know the area required for construction of normal dam is much more and construction of dam is causing the problems like re-establishment of the people and the villages surrounded by it. It also consumes large amount of useful and cultivated land. But in case of Sponge Dams; the dams requires very small area and decreases rehabilitation of people in large amount this can be proved as below. Areal distribution can be described by comparing two dams that is Sponge Dam and Normal Dam. Consider an example of Jayakwadi dam. ( Case Study- Jayakwadi Dam is situated near Aurangabad in Maharashtra state)

**Procedure**

Drain out water from sponge when it is full of water in a vessel which is having scale to measure water content. Measure the water content by experiment.

**Observation and Calculation**

Observation-Total water storage capacity of Sponge 1 of size 14 cmx8 cmx5 cm can be calculated as follows.

Water capacity of a Sponge 1 (14x8x5) =0.59101056 litres.

(The dimensions of Cylindrical Normal Water Container are Diameter “D”= 11.2 cm, Height “h” (for this calculation) = Level of water from bottom when remaining sponge water is drained out into container mentioned in the Table:3)

Area of cylindrical container (A) = \( \pi \times D^2/4 = \pi \times 11.2^2/4 \) (From equation (1) )

= 3.141x11.2^2/4=98.5017 cm²

Water content in the Sponge
=Height of water (h) × Area of cylinder (A)  
(Shape of sponge is similar as cube)  
= 6x98.901 (h=6 cm From Table:3)  
= 591.01056 cm$^3$  
= 0.59101056 litres.

If we are using large sponges in practical; consider the sponge of size 70 mx40 mx25 m.
The storage capacity of this sponge is calculated as  
= Capacity of sponge 1× (25×70×40) ÷ (Volume of Sponge 1)  
= (0.591010×25×70×40) ÷ (0.05×0.14×0.08)  
= 73876250 litres.

**Comparison with Jayakwadi dam**
The total area of Jayakwadi dam is about 350 km$^2$ which stores the amount of water 2.909×10$^{12}$ litres.

Hence total sponges or total area required of the size 70 mx40 mx25 m to store the water 2.909×10$^{12}$ litres is calculated as follows;

As the water storage capacity of given sponge is 73876250 litres of surface area 70 mx40 m and hence total sponge area required to store 2.909×10$^{12}$ litres of water is;

If 70×40 = 73876250  
Then  x = 2.909×10$^{12}$  
\[ x = 110.2546 \text{ km}^2 \] (cross multiplication)

If a standard sized sponge is used like 65 mx28 mx42 m (Whose height is more than width) the area required for storing 2.909 km$^3$ water is calculated as follows.
The storage capacity of this sponge is calculated as;  
= Capacity of sponge 1×(65×28×42) ÷ (Volume of Sponge 1)  
= 0.591010 × (65×28×42) ÷ (14×8×5)×10$^{-6}$  
= 80672865 litres.

Hence surface area of 65×28 can store water of 80672865 litres hence 2.909×10$^{12}$ litres can be stored by;

\[ = (65×28×2.909×10^{12}) ÷ (80672865) \]
\[ = 65.6277 \text{ km}^2 \]

Equal to about 65.6277 km$^2$ (Theoretically). But practically we require spacing between two sponges and hence it is equal to approx.70 km$^2$.

**Result**
The area acquired by Sponge Dams for storing water 2.909 km$^3$ is equal to 65.6277 km$^2$ and that of the area of Earthen Dam (Jayakwadi) for storing same amount of water is equal to 350 km$^2$. This is about 5.33 (Theoretically) times more than the area required for Sponge Dam at same site.

If double storied storage house is constructed then this value gets halved that is this amount of water can be stored in 35.81385 km$^2$ area which is very small as compared to 350 km$^2$.

**Note:** In this experiment the sponge used is normal the high quality sponge may have more storage capacity than this.

Hence this states the second advantage of sponge dams.

**III. STRUCTURAL COMPARISON WITH AN EARTHEN DAM JAYAKWADI DAM**

- This figure shows top view design of Sponge Dam constructed instead of Jaykwadi Dam.
- Constructing Sponge Dam of same water storage capacity as of Jayakwadi Dam is elaborated below with dam construction.
- There are three electricity power generation plants can be installed as shown in Fig. 3 of the Sponge Dam.
- The Fig.1 introduces new concept of power generation that as shown in Fig.3 the installed three power plants at one dam.

The plant contains three Sections those are
1. Sponge filling with water is done in initial part of the river.
2. The filled sponges are stored at storage house.
3. Removing of water from the sponges is done at third section.

![Fig. 3: Design for Top View of Sponge Dam](image-url)

**Section 1**

This section includes the purified water coming directly from purification plant constructed on the river before main wall of dam. The base of this section is constructed by concrete or can be kept as it is. This section contains (SCM) Sponge Compression Machinery and Sponge Lifting Machinery (SLM) without loss of water as the sponges filled with water can be sledded over slider or can be carried on wheel transporters this section provided with transporting Slider or transporting Wheeler which can transfer water filled sponges to second section that sponge storing section without loss of water.

**Section 2**

This section contains the water filled sponge storage plant. The basement and flouring of this plant should be constructed by smooth material so that while transporting the water filled sponges should not get any hindrance in the way. The rubber covers are provided sponge so that it could not get exposed to air and heat. The humidity of air also affects the evaporation of water which is avoided by rubber covers. Hence the rubber cover of good quality material should be made up.

**Section 3**

This section is constructed by analysing the water supply to the catchment area of dam. This section also contains (SCM) and (SLM) to remove the water from sponge. And to supply water to the citizens and other...
farmers through water tunnel poured in it directed towards out of dam. This section doesn’t require too much as it is like temporary storage tank. Other constructions carried out for this type of dam are as follows

a. Section
The first red coloured section also plays an important role in this dam. This part contains two sub parts and those are.
1. Water purification plant
2. Hydraulic power generation plant

1. Water purification plant-this plant is constructed to take out the impurities in water. The sand and silt which comes along with running water in river as this sand and silt can affect the storage capacity of sponges by blocking the pours in it and may decrease the storage capacity and life of the sponge. In this plant the water is purified and then carried forward.

2. Hydraulic power generation-the objective of this plant is to produce electricity by using hydraulic turbines. This is the general hydraulic power plant which can produce the same electricity as it produces at any other dam.

b. Section
Another blue section after sponge filling tank is the main wall of the dam. Which aimed to fade the flood attack and work as a supporting wall for sponge filling tank? This wall also act as the main dam wall of the reservoir provided with gates to excrete the water if sponge filling tank gets over filled. The hydraulic power generation plant can be provided here which can provide electricity production.

c. Section
This section is marked with blue colour in front of temporary water storage tank in the tunnel area or channel area. A small hydraulic generation plant is installed here to give a hand to produce electricity.

I. COST PREDICTION
The general dam requires space that is government has to purchase the land from farmers or the surrounding residential humans which increases the cost of dam to incredible amount. Even the small dams like Jayakwadi require about 350 km² of area for storing 2,909 km³ of water. But in case of sponge dams it will be less as the area requirement will be small and can store water of large amount. As above it is expounded how the area get decreased for Sponge Dam in comparison with Jayakwadi dam. It gets reduced to 1/5th the area of Jayakwadi dam for storing same amount of water. The cost required for the Sponge Dams may be less than normal dam as well as rubber dam.

IV. REHABILITATION
Migation of people during construction of Earthen dam, Concrete Dam etc. is in extensive amount due to requirement of large land for construction of such dams. But Sponge Dams requires very small land as compared to others hence it will decrease the rehabilitation of the people and can decrease the problems caused due to rehabilitation.

A. BENEFITS (Sponge Dams over other types of dams)
- Storage capacity gets increased to enormous amount within very small area.
- Evaporation of water gets diminished considerably so that water can be stored for more years.
- Water provision to the catchment area all time.
- As the total area of reservoir get decreased the land beside river edge can be utilized for farms can be used for cultivation.
- Demolition due to flood reduced to considerable amount as the water storage capacity of main dam can be raised by keeping the water in the sponges in the storage houses.
- The total cultivation area gets increased around dam. This is because of requirement of small area for construction of Sponge dam.
- This type can be constructed in the countries where water acquires more value than other things.
- The Pi-Shi-hang Irrigation districts in China serves 680 000 hectares which stores about 420 million m³ of water but if it is stored in the form of Sponge Dam it will require approximately 5 times smaller area.
- As the overflow never occurs due to water storage into sponges the Sponge Dam is more beneficial than Rubber and other types of dams.

B. DISADVANTAGES
- It is costly to construct such dam.
- Sponges and Sponge covers.
- Occupations like fishery get decreased in large amount, hence such dams can be provided at the places where water requirement for other areas is more important than fishery.
- Generally this type of dams can be provided at the desert and at the places where water is critically insufficient for irrigation.
- Water percolation gets decreased.

C. DISCUSSION
Whole world is aware of irregular rain fall, increase in pollution, global warming, natural calamities like flood etc., enormous rain fall but we do not have solution. Even the construction of Dams, Reservoirs does not help us to resist such conditions. Which in turn severely affects industrial development ultimately development of country. Such excess use of water may create problems to our next generation. If such use and problems continued further it will diminish the existence of human beings on the earth. Hence these problems must be considered. This introduction of Sponge dams may help the human beings to prolong our existence on earth. This will help us to store the water up to four years which can be stored only for one year in any other type of dam. The water requirement of the urban areas surrounding the sponge will be continuous. The water to the industries can be provided without any disruptions. If the rain fall is insufficient in one year its consequences will not be severe on the human life if such dams are constructed. The water storage capacity can be extended if sponges of
large storage capacity that is of good quality used. This will be the best storage method of water. The second benefit of it is its area that is it requires very small area as compared to earthen dam. The equivalent amount of water in the earthen dam of area (A) can be stored in Sponge dam of area “A/5” which is most considerable use of it.(A=Area under water of dam). This value can be decreased if the storage capacity of sponge is used. This will decrease the value of such dams to significant amount. The remaining area can be used for various other purposes like industries, for cultivation and also for residence. The river coastal soil is suitable and yielding for farming hence can be used. The small area requirement will also preclude large rehabilitation of people. Hence this will be more advantageous than other dams. The affects of natural catastrophe like flood can be shrunk to certain amount with this Sponge Dams. As the water can be stored in any amount in the sponges the water level in the main reservoir can be maintained and overflowing water get controlled. But the total cost of such dam is more because of the new equipments like Sponge Filling Machine (SFM) and Sponge Lifting Machine (SLM), sponges of good quality material, sponge covers. But in practical the total cost of earthen dam is much more because of the cost of ground area required. Such types of dams causes large amount of rehabilitation. Hence the Sponge Dams are more beneficial than other dams. Other sections like electricity providence etc. is also considerable factor but the electricity to the dam can be provided by hydraulic power stations. The purification plants provided at beginning of the first section can increase the efficiency of the electricity production. The electricity production at main wall and at temporary storage tank also increases the production of electricity. The irregular rain fall in South Africa can be controlled with such type of dams. The failure for flood control problems in South Africa and other flood affected areas can also be avoided with the help of such dams.

V. CONCLUSION

The use of sponge dams must be constructed in the areas where water deficiency is major problem. If the future is considered the Sponge dam is the dam which can serve water up to so many years as compared to other dams. If we want to serve water for long period on earth for our future generations then such dams are very useful. Irregular fall of rain does not affect on this dam. Flood problems can be solved. The water deficiency get diminishes. Cost of such dams is also comparable to earthen dams.

ACKNOWLEDGEMENT

I appreciate Pooja Nitturkar for her incredible support and help while experimental analysis. Special thanks to Shyam More for clarifying doubts. I am highly grateful to Professor Dilip.G.Patil for notifying me about this journal.

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