Gravity dam to solve flood discharges in El-Hamamat valley

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Abstract

In Egypt, there are a lot of problems that we have to fix, one of them is climate change as it can cause destructive phenomena like tornadoes, floods, etc. Another problem is urban congestion which happens due to the unfair disruptive of materials in the country like scarcity of water in some areas in the country. With the continuous rise in the population, we found a parallel increase in the production of factories, and the process of production can cause pollution if the wastage isn't recycled in the right way. Floods are dangerous in Egypt and there are a lot of factors that affect on ratio of floods in Egypt like heavy rains or elevating of the Nile level and it has advantages and disadvantages. The disadvantage is that they can destroy a lot of things such as buildings, crops, and the lives of humans also, they can spread diseases. Through our research, we found that building a dam is the most effective solution as it doesn't just hold floods but also stores water To face those problems we decided to construct a gravity dam as the purpose of the dam is to store water and deal with flash floods and we had chosen some rules as criteria for test the dam and our dam exceed it as it contains only one manufactured material, the storage water of is 54 liter, hold the water for 2 hours without bending, the crest holds 15 kilograms without breaking down. We designed the final shape of the dam before making it as we put two gates in the dam one to discharge about 25% of the water of the reservoir and the second to discharge about 50% of the water and two spillway gates at the side of the reservoir to discharge the water of floods at height 37 cm. The test plan of the solution showed positive results and the solution achieved the specified design requirement.

Introduction

Egypt faces a lot of problem on the way to rise with its fields. From those problems we had the shortage of water as there are a lot of fields that need water like agriculture field or the needs of people of water in per day and the total ratio of the water that Egypt had less than its needs.

Another problem that faces Egypt is the urban congestion , due to the continuous increase of the number of population in Egypt and the unfair distribution of resources like water supplies in the various areas in Egypt , we also found that people concentrate in some area and some areas are completely deserted .

At any place in the world we find there is a direct relation between the ratio of production of factories and the population and through the process of production we produce a lot of wastage and that wastage can increase the pollution and that pollution can affect on various living organism like throwing plastic in the ocean .

From the factors that have high affect on Egypt economic and people lifestyle is the climate change, if we compared between the weather in the near past and the present we would found that there is a huge difference and that could be due to decrease in the water lands in Egypt .

The problem of flash floods that destroy anything in its way make the humans to find a solution to stop these destructive phenomena , If we searched we would find that there are a lot of attempts to found a solution , one of those prior solutions is the three Georges dam , these dam is a gravity dam that stores about constructed to storage water and face the floods at the area of the Yangtze River in China , these project had a lot of advantage like Hydropower Generation , Flood Control , Navigation Improvement , Tourism and Economic Development and at the other hand there are some disadvantage such as significant Displacement of people , Polluting water , Greenhouse effect.

We had chosen to build a gravity dam in Wadi EL-Hamamat for two reasons the first is because the type of soil such as sandy soil that had high bearing capacity and other types , second reason that it would reflect a lot of benefits like control the floods as the Wadi located at the zone of the floods and building a dam would decrease the economic and human life losses

If we take a look between our dam and the Three Georges dam we would find some differences such the main building material as at our dam we used cetorex grout which is faster in drying than the cement that used in building The Three Georges dam and that would decrease the time of building which would reduce the budget of wages of employers .

Before any project you should had a criteria that if your project achieved that means your project succeed, from our criteria : 1- the crest would hold 10 kilogram 2- recycled or natural material (except only one manufactured) 3-the min. of water is 50 liter and max. 60 liter without bending 4-the dam hold the water of the reservoir for two hours 5-reinforcing bar length limit is 10 cm

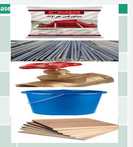
And our prototype holds 25 kilogram , the only manufactured material is cetorex grout , the volume of water is 54 liter , the dam hold the water exactly for two hours ,the reinforcing bars is 10 cm length.

After testing our prototype the flowrate was 0.2368421053 liter/sec at discharging the gate of 25% precent of the water , and it was 0.16875 liter\sec at discharging the gate of 75% precent of the water.

Materials and methods

Table 1 (shows the materials used in constructing the dam)

Item	Description	Cost	Quantity	Source of purchase
Cetorex grout	A type of cement that is waterproof and quick to dry	4 L.E per kg	64 kg	CMB
Reinforcing bars	Metallic bars	10 L.E per meter	4 meters	Painting shops
Water stopcock	Used to be gate	50 L.E	2 pieces	Plumber shop
Bucket	A small plastic bucket	Recycled	1	Plastic factory
Wooden sheets	Wood sheets that are used for the mold	150 L.E	100x50 cm	A carpenter
Total cost		546 L.E		



Methods:

First, we started by determining the way that will be used to build the prototype. and We chose to:

1.build a Mold by wooden sheets with the dimensions of the prototype, to put the building materials in it. And give them the shape of the dam.

2. we put the metal reinforced bars in the mold vertically and horizontally to give it hardness and make it more flexible.

3. We mixed the cetorex grout with water and gravel with the with ratio 1 milliliter of water for each 10 grams in the plastic bucket, and made sure that the ingredients are mixed well,

4. We put the mixture of the cetorex in the mold carefully, and waited until it gets dry.

5. After the mixture got dried, we unscrew the mold, then we put the dam in the reservoir the we have prepared to store the water in.

Figure 1 (shows the dam after constructing)

Test plan:

Every project should be tested to determine its effectiveness, efficiency, and whether it meets the requirements for which it was created.

So, **first,** we tested the dimensions and took into consideration that the concrete expands after it dries so we tested our dimensions a day after letting the dam to insure that it had dried. Using a measuring tape and determined the error.

Second, the ability of the crossroad to resist a load of 10 kg or more, by putting different masses on its center and observing any change in it.

third, we tested the ability of the dam to store the maximum amount of water without any leakage in water or effect in the dam structure, so we put 54 liters of water in the dam for 2 hour and observed the change in the quantity of water in the 2 hours.

Fourth, discharging the water from the dam from 25 % , 75 % and the whole amount of water automatically from the side spillway after filling the dam.

Fifth, the flow rate: for testing the flow rate of water in the dam gates we used a bucket to collect water getting out of the gate and we took a graduated cylinder from the chemistry lab to measure the volume of the quantity of water we collected, and a stopwatch to calculate the time by which water got out of the gates.

Results

In testing our prototype, we had to examine the efficacy and the dimensions of our prototype, and we found.

Table 2 (shows the error on the dimensions)

Measurement	Supposed to be	Measurement after error
Heigh	40 cm.	40.2 cm
width	50 cm.	48.8 cm.
Thickness at the bottom	24cm	24 cm.
Thickness at the top	11cm	11.09 cm.
The sloped part	36 cm.	35.9 cm.
The part over the sloped part	6 cm.	6.1 cm.

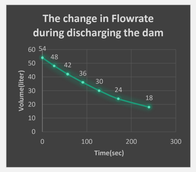
First, **in testing the dimensions** : after measuring the dimensions we found that there were an error in the dimensions of the dam **as shown in table 2.** the error in the width of the dam is -1.2 cm so we filled the space between the dam and the container by sika silicon to prevent any leak in water.

Second, **the ability of the crossroad to resist a load of 10 kg or more**: we found that the dam's crest resisted the 10 kg so we put more weight on it and it resisted up to 85 without breaking up and can be more.

Third, **the ability of the dam to store the maximum amount of water without any leakage in water for 2 hours**: in the first trial we found a leak from under the dam, so we filled the space under the dam with sika silicon and retested the dam and found no leak after that.

Fourth, the dam discharged the whole amount of water from the side spillway automatically and we could discharge the 25% and 75% of water from the dam without any malfunction in the mechanism of opening or closing of gates.

Fifth **, the flow rate :** we found that the speed of discharging of water from the lower gate is 0.2368421053 liters/sec and the upper one is 0.16875 liters/sec due to change in pressure and we calculated the flow rate of water during the discharging of the amount of water from the dam as shown in **graph 1**



Graph 1

Analysis

According to the previous results taken from the test plan, the design requirements was achieved where it was represented by the resistance of prototype on the exposure to loads causes. These results were achieved due to scientific reasons.

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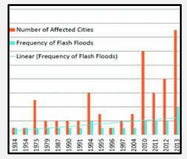
The dam should solve a lot of grand challenges which are urban congestion, flash floods , recycled wastes and garbage, pollution , increasing shortage of clean water. The dam should solve flash floods ,especially. To solve this problem in wadi El-Hamamat which suffers from flash floods. We must use materials can load and resist the water that comes from flash floods , for this reason, using cetorex grout is required form us which has chemical formula.

(Na2sio3) sodium metasilicate . the density of cetorex grout as a (powder) which is 1.95 ± 0.05 kg/ L and 2.30 ± 0.05 kg/ L.



Graph 2 (shows the rate of flash floods in Egypt)

The water has gravitational force and the gravity pulls water downwards, creating pressure on the dam's foundation and walls. Also this force needs to be counteracted by the dam's weight and the strength of its materials to prevent it from collapsing. **PH.1.02.**

And to ensure of the valid numbers of our dimensions we have tested it by two tests which are :

1.the sliding test: by which we test the force of the dam against the force of water that prevents it from sliding because if the pushing force of water by dividing the all weight of the dam by the force of water.

$$F.O.S = \frac{M.N}{T} \leq 1.5$$

so, we measure the all weight of the dam by multiplying the area of the part of the dam by the density of the material by which the dam is made of, by the gravity

and we calculate the force of the weight of water by multiplying the density of water by the area of the part of the water facing the dam and thee force of the water Is always concentrated by a triangular shape and the force of this triangle of force is concentrated at its centre by which the force is dividing the triangle into 3 parts by which the force of the lower part is equal to the two upper parts.

And the measure must be more than 1.5

2. **Turning over test**: by which we measure the ability of the dam to turn over because the force of the dam or the decrease in the weight of the dam

$$f.o.s = \frac{S.M}{O.T.M} \leq 2.0$$

We divide the stability momentum (S.M) of the dam by the overturning momentum (O.T.M) send this measure must be greater than or equal 2

(S.M) Equals the sum force of each part of the dam * the distance between the centre of the force and the toe of the dam

(O.T.M) Equals the pressure of the water on the dam equals the area of the triangle of force of water facing the dam * the distance between the centre of force of this tringle and the toe of the dam

For the efficiency of the dam, the dam produces output that is batter than it's input in many ways . *Efficiency = output / Input*: The total amount of work or energy used. Output: The amount of useful work or energy produced. For force of the dam we use Newto0n's third law which is every action has reaction equal in magnitude and opposite of direction. So, we make the force of the dam equal the force of the wate M1g1= -M2g2. **PH.1.02.**

We use the Engineering geology branch and this branch help us to build our dam. we use hydrogeology branch because this branch studies the distribution and movement of groundwater. we also use petrology branch because this branch studies the origin , composition, and structure of rocks. **Geo.1.01**

And to make our dam state, we make a dam with high mass (about 85 kg)

To make the design of the dam and determine the dimensions, we use SketchUp programme CS.1.01**. (as shown in figure 4).**

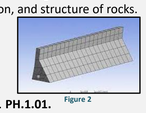


Figure 2

For estimating dimensions by applying the measurement errors concept and help us also to determine the diameter of the gate by using micrometre. **PH.1.01.**

As for estimating the dimensions, the materials of the prototype were chosen to fit with requirement and after their dimensions were measured using a tape measure, we found that they meet the design requirement as they were:

the height of the dam : 40 cm ± 1.2 cm.
the width of the dam : 50 cm ± 1.2cm.
the thickness at the base of the dam : 24 ± 0.6cm.
the thickness at the crest of the dam : 12 cm ± 0.4cm.
the length of the slope side of the dam 36 ±0.3cm.
the length of the part over the slopped side 6 ±0.2cm..
the length of the angle of the slopped part 69 ±1 degrees.
and after that we checked also the dimensions of the reservoir by which there mustn't be any mistake in them to store the certain capacity of water which is 54 litrer.

We use it to calculate the slope of the dam and the angle by using trigonometric functions. **(As shown in figure 3) Math.1.01.**

Absolute error : $\Delta x = |x_o - x|$

Figure 3 shows how to calculate the absolute error

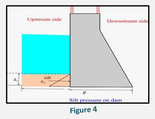


Figure 4

To make these things, we follow EDP steps (Engineering Design Process).

We can use scientific methods by following some consecutive steps which are:

1.Making observation.
2. Ask a question.
3. Making hypothesis.
4.Test the hypothesis.
5. Analysing results.
6. Drawing conclusion.
7. Communicating results. **CH.1.01.**

As shown in figure 5

Figure 5

Conclusion

The challenge which is protecting our homeland from floods was handled by constructing the prototype of our solution, which is a dam.

The test was done, and the data of the results were collected as the dam and the used materials have been tested and they achieved the design requirements, which are that the crest of the dam should resist a mass of not less than 10 kg, a stored capacity with a minimum of 50 kg and a maximum of 60 kg, and the thickness of the dam in the bottom should not be less than 10 cm while in the top it should be not less than 3 cm.

It's been concluded that the used materials succeeded to give the results that achieved the design requirements, and the prototype will be way better if it was built in real life, as it will generate hydroelectric power.

Also, the prototype can be considered to have the proper dimensions as they did not exceed the maximum determined dimension limit.

The prior solution that we got our idea from and allowed to construct in building was chosen for many reasons and it is the Three Gorges Dam.

The Three Gorges Dam is one of the best gravity dams that stores water and protects the homeland from floods in the world, as the country it was built (China) is known for water conservation and pollution control, and we also chose wadi El-Hammamat in Egypt to build the dam in it as an alternative place to build it.

It was concluded that applying such project in Egypt would be great for a safer future and a better life.

Recommendations

Recommendations for our solution:

•By decreasing the area of the gates and increasing the pressure due to putting the gates deeply in water the speed of the water getting out of it will increase so we can put a turbine in front of the flow of water and generate electricity due to the high velocity of water.

•And we can replace the motors that cutter in the fab lab to cut the dimensions of our mold accurately and prevent any error. work by batteries in our prototype by another ones that work by solar energy which is a sustainable resource, so we can solve the problem of pollution that we are facing in our grand challenges.

•We can also reduce money because the valley that we have chosen to construct our dam in is rich with materials that we can use so we can reduce the budget of transportation of the materials

•Recommendations for our prototype:

Because of our design requirements we had to use reinforcing bars with maximum height 100mm and maximum thickness 3mm so that made our prototype weaker so it 'd be better if we increase the thickness and height of the reinforcing bars to increase its strength. And I recommend also

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