# PROJECT DELTA

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## Preface

In this assignment we will further elaborate our Delta Floods Project. Together with Chang Wei from Taiwan and her professor Gene Jiing-Yun You, we, five students from Rotterdam (Jelmer Appelo, Bodhi Demmers, Sander Pronk, Jef de Visser and Bart Wisse) investigated the current situation in Taipei. By the Delta Floods Project, the assignment was to make a solution for sealevelrise, however we have determinate that the more important problem is the heavy amount of rainfall during the rainy season and the drought in the rest of the year. So, by the Delta Floods Project we decided to focus on that, rather than focusing on the sea level rise.

## Problems

For the last couple of decades Taiwan has been hit by several typhoons and heavy rainfall in a short amount of time. Thereby landslides from up in the mountains will occur and destroy everything on its path down to the rivers. All this material will flow in the river, leaving the rivers with a mega supply of sediment combined with all the extra waterflow from the rain. This leads in overflowing banks and a peak water level and flow rate at the lowest point in Taipei.
Furthermore, over the rest of the year it barely rains in Taiwan, which leads to drought and water shortage. Also, because of the sediment the drink water basins will be too turbid for clean water supply.

## What must be done?

It is nearly impossible to present a solution that solves these problems in one go. Especially given the limited timeframe.
However, it is possible to focus on a few, and find a solution that tackles multiple problems and is (semi) viable.
The focus of this article will be orientated towards a solution that might solve the high discharge rate in the rivers that flow through Taipei, the general water shortage that is occurring in Taiwan, landslides, and the problem of sediment accumulation in the drinking water basins.
Flatten the underneath curve, is what we focus on.

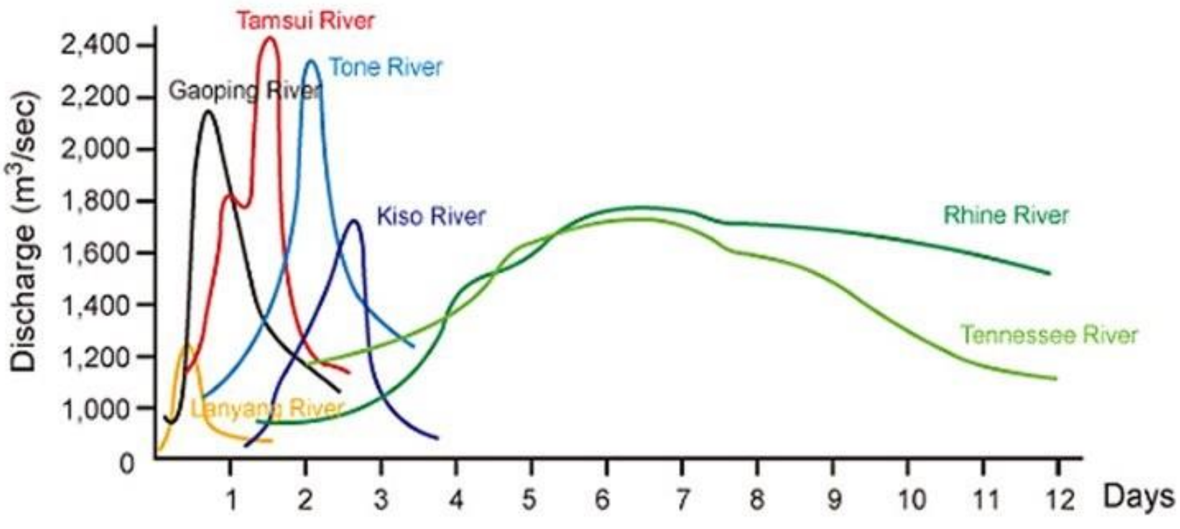



*Figure 1: Discharge flow in Taiwan's rivers*

The discharge flows from the mountain ridges down to the lowest point, Taipei. If the water is kept upstream, and discharged slowly over an extended period, the discharge curve from the river should flatten.

We want to achieve this by damming of mountain valleys. By damming off mountain valleys, multiple problems can be addressed:

- It prevents water from reaching the rivers.
- The dammed of valley can act as a water basin to a certain extend.
- It stops the landslide sediment from reaching the river. And stores it where its relatively harmless.

Thus, contributing to a lower rate of discharge in the river, stores water for when drouth arrives, and keeps the drink water basins downstream cleaner. Additionally, the sediment that has accumulated behind the dam can be cleaned out whenever the water level behind the dam is fully drained.

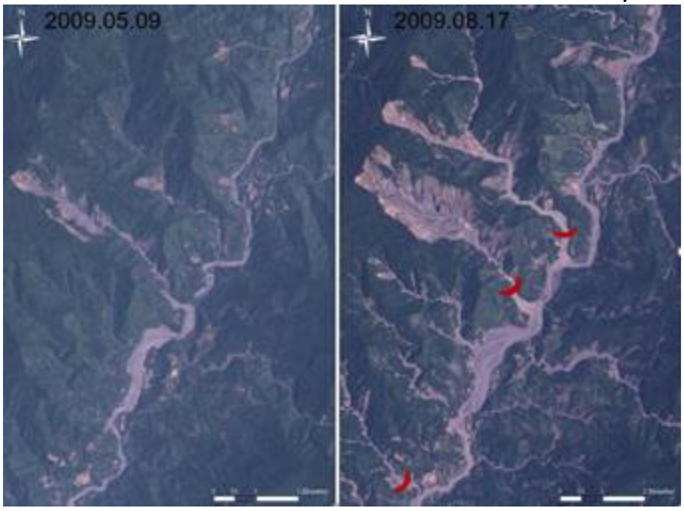



*Figure 2: Example of potential dam placements*

## Main- and sub-questions

Main question: What components are involved in the construction of a dam to protect Taipei against floods?
Sub-question 1: What is the total capacity the dam must storage?
Sub-question 2: Where are the dimensions of the dam based on?
Sub-question 3: How do other dams look like and what is their function?
Sub-question 4: How does the power generator works in a dam?

## Total capacity

However, damming of every valley is impossible and unrealistic. Therefore, we picked one bigger river where we will build the dam, and behind this dam there will form a reservoir. In the figure below, you can see the river that will been dammed of. On the black line are the highest places of the valley. This means that only the rainfall in this area of 81,38 km^2 will have an impact on the dam.

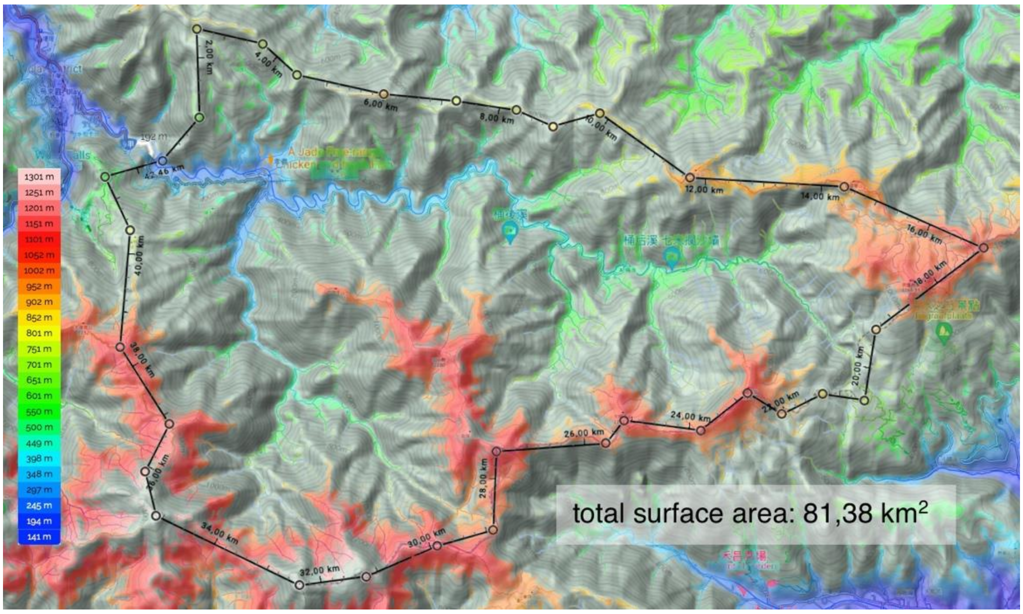


*Figure 3: Rainfall area*

The most important reason to build the dam is protecting Taipei against typhoons. Because of this reason there is used a precipitation parameter of 1750 mm. At first this water will flow from high in the mountains to the river down in the valley, when the water has reached the river, it will flow to the dam. The dam will stop the whole amount of water. But not all the rainfall will reach the river. A part of the precipitation will be infiltrated in the ground and another part will evaporate. To calculate how much water will be infiltrated in the ground, you must know the type of soil there is in that region.

The main type of the soil is inceptisol, this exist out of clay, silt and sand. The permeability of this soil is approximately 0,1 m/day. This will lead to an infiltration of around 8.138.000 m^3/day.

Because the dam must protect Taipei against the typhoons, the dam needs to be able to retain the water for 7 days. After these days the circumstances shall be less heavy than before, and the water can slowly be released by the dam into the sea. So, to calculate how much water the dam must retain we take in account a storage time of 7 days. This brings it to a total of 85.449.000 m^3.

## Comparing several dams

To get a better look on what dams are and where they are used for. We have had a look on several other dams in Taiwan. And then looked to which dams have the same goal as ours.

At first, we have had a look to the Techi Dam. This dam can you find in the middle of Taiwan. It provides hydroelectric power; irrigation water and it protect also against flood control. The building is 180 meter high, the highest dam of Taiwan and one the highest dams of the world is completed in 1974. This reservoir is also built between two mountains, like the dam we will build. The original reason why they build this dam back in the time was to protect two downstream dams against the big flows. This dam is also built in an extremely catchment area, it is very rugged and mountainous over there. Because of this, the catchment is susceptible to floods and earthflows. The river behind the dam is also good protected against this thing. The dam has a total capacity of 175.000.000 m^3 and there is an installed capacity of 234 MW.

The second dam, Ronghua Dam, is from 1984. It is in the Dahan river, also near Taipei. The main reason to build this dam was to prevent sand from flowing downstream and building up silt in the reservoir. The total height of this dam is 82 meters, the total capacity was 16,700,000 m^3 and the installed capacity of the dam 40 MW. The storage of the dam is not effective anymore since 2012, because almost the whole reservoir is filled with sediment.

And finally, we have had a look to the Shihmen Dam. This dam is another type than the two we name before. The Shihmen Dam has sloping side, and inside the dam is filled with rocks, while the other dams are both straight. The reason for this is because the dams before were built between two mountains and this one not. This dam has several functions. The first one is to provide irrigation in Taoyuan, the second one is to protect Taipei against floods, the at last the hydroelectricity and domestic water supply for more than three million people in Taiwan. The building has been completed in 1964 and has a height of 133 m. It has a storage capacity of 309.120.000 m^3. And the power station has an installed capacity of 90 MW, because of the two turbines there are.

With all these three dams in mind we will take the first one, the Techi Dam, as point of departure. This is because its function and the place where it is built. The function is to protect against floods, this is the same reason as our dam. And the place where it is built, between to mountains is also an important reason. The Shihmen Dam can we take as source of inspiration, because this dam is also in the north of Taiwan, and we can use the way of domestic water supply it uses.

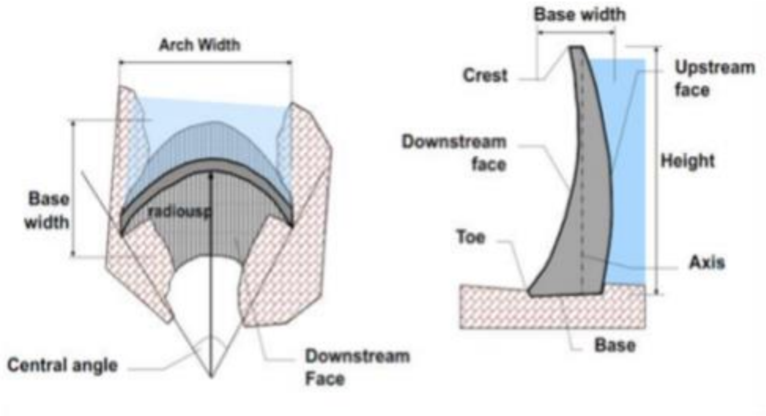
## Height

The next step is to have a look on what are the most important things that we need for a global design of a dam, and most important the height of the dam. In the paragraph above, there is made a calculation of how much water the dam should store. This parameter is needed for the calculation of the height. Also, the area around is important, the calculated 85.449.000 m^3 water must be stored on a very rough terrain. This makes it almost impossible for us to calculate how much surface area this much water will need to use. Also, the landslides will have a role in this, there more landslide, the more volume you get. Next to this all the flood lift and free board must consider for the extra safety of the dam.

Based on the analysis of various dams and the environmental relief, it was decided to design a dam 150 meters high. For example, the dam will have a reservoir of approximately 90,000,000 m3 of water. It is a requirement that a dam has a reservoir that is approximately the same size as the annual flow of the river.

## Thickness and radius

The shape of the dam is the same as on the figure below. The base of the dam is the widest point of the dam and when you go to above, the dam will be less wider. The dam will also have a round shape in both direction, this is to increase the strength.




The selection method of design an arch dam depends on the structural behaviour that will be considered such as cantilever or ring member. For ring behaviour the 'thin cylinder theory' method will be used and for cantilever behaviour the Engineering Monograph (EM) No. 36 method will be used. An arch dam will be appropriate when "Width / Height of valley" [(B/H) < 6]. Rocks at the base and hillsides should be strong enough with high bearing capacity. Reduce the volume of concrete. Stresses are allowed to be as high as allowable stress of concrete. Generally, the same forces act on an arch dam, which do act on a gravity dam.

These forces are:

i. Water pressure.

ii. Uplift pressure.

iii. Earthquake forces.

iv. Silt pressure.

v. Wave pressure.

vi. Ice pressure

By means of the Thin Cylinder Theory we determine the thickness and the central angle derivation. Before the calculations we state the following:

1. It is assumed that the sections are thin cylinders and they are free at the abutments.

2. In the thin cylinder theory, the stresses in the arch ar assumed to be approximately the same as in a thin cylinder of equal outside radius. But these dams are neither sections of thin cylinders nor are they free at the abutments.

3. This theory can only be used for rough estimation of dimensions of the arches.

4. The analysis is based on hydrostatic water pressure alone. As a result, important factors are ignored in arch dam design, such as temperature stresses and ice pressures.

5. Shrinkage in concrete and the plastic flows of concrete are not taken into account.

In the thin cylinder theory, the stresses in the arch are assumed to be approximately the same as in a thin cylinder of equal outside radius.

The final calculations of the thickness and radius can be find in the capacity building. In the end, the thickest point of the dam is also the lowest point of the dam. On a depth of 150 meters is the thickness 60 metres. The highest point of the dam is 6,3 meters. The biggest radius in the dam will be 207 degrees and the smallest radius is 146 degrees.

## Generating Power

In a hydroelectric power station, the water flows through turbines to generate hydroelectric power. Power is captured by the gravity of water falling through sluices to water turbines connected to generators. The available power depends on the combination of altitude and current. Hydropower is produced in about 150 countries. China is the largest producer of hydroelectricity, producing 721 terawatt hours in 2010. This is about 17 percent of domestic electricity consumption.

A reversible hydroelectric power station is the world's largest form of storage for excess electricity. They are a net consumer of energy, but at the same time also provide storage for any source of electricity, dips and dips in an electricity supply and demand are effectively smoothed out. The less valuable electricity comes from wind and base load power plants such as coal, nuclear and geothermal, which still output power at night, even though demand is very low. During peak daytime demand, while electricity prices are high, the storage is used for peak power, where water in the upper reservoir can be returned to a lower reservoir via a turbine and generator. In peak to coal-fired power plants, which take more than 12 hours to start up cold, a hydroelectric generator can be commissioned in minutes, meeting an ideal.

In our dam we will place two generators of 78 MW this gives us a total installed capacity of 156 MW

## Recommendations

To get a more detailed design for the dam there is more information needed. At first there must be done more research about the landslides and the sediment in the water, this is a very important thing. Beside that the height, named in this project is only an estimation. To get that clear, more research is a requirement. Another named problem is the drought in some seasons of the year, with this dam there is a opportunity to decrease this drought. But also with this thing, there is much research needed.

## Conclusion

To design a dam there are a enormous amount of things to keep in mind. All the things we named before in this report is only a small part of the hole thing. At first we had a look on the surroundings and the environment in the north of Taiwan. Based on the area and precipitation parameters, the total storage of the dam shall be almost 90.000.000 m^3. We also checked some other dams to get a feeling by the build of a dam. For this chapter we had take three different dams, who are all placed in Taiwan. The Techi Dam looks the most on our problem, because the area where it is built is compareble to our area and the problem it solves, to protect against floods, is also the same. Therefore we used this dam for making an estimation of the height of the dam, namely 150 meters. The reason why we had make an estimation for this was because there were to many missing parameters to make a calculation. On the other hand, the calculation for the thickness and radius was a bigger success. Trough to the thin cylinder theory we came out on a thickness of 60 to 150 meters and a radius of 146 to 207 degrees. And at last the research about the power generator, in our dam there are coming two generators of 78 MW, this has a total of 156 installed capacity. To make a better design in total there is much work to do.