PROJECT DELTA

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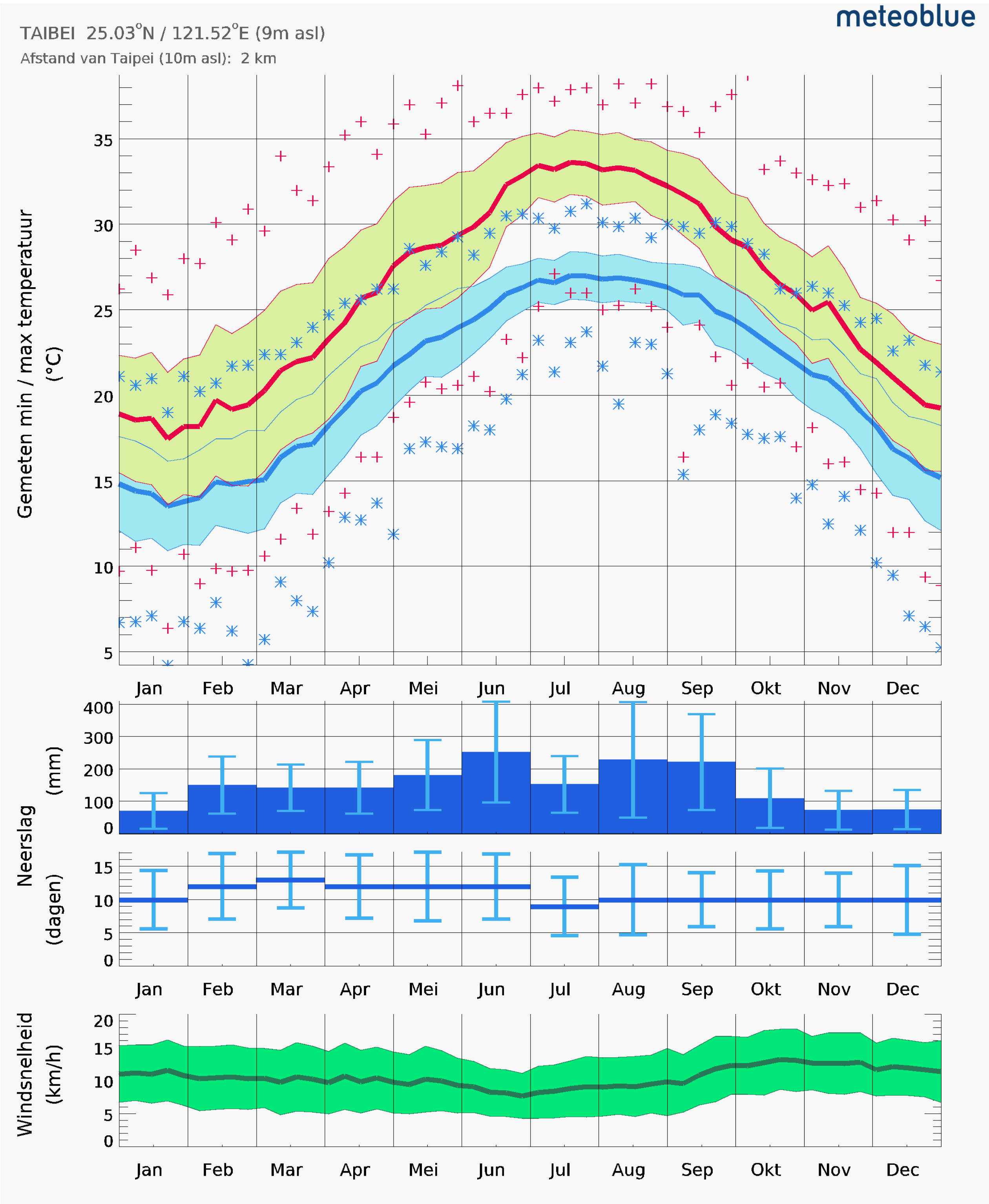
Inhoud

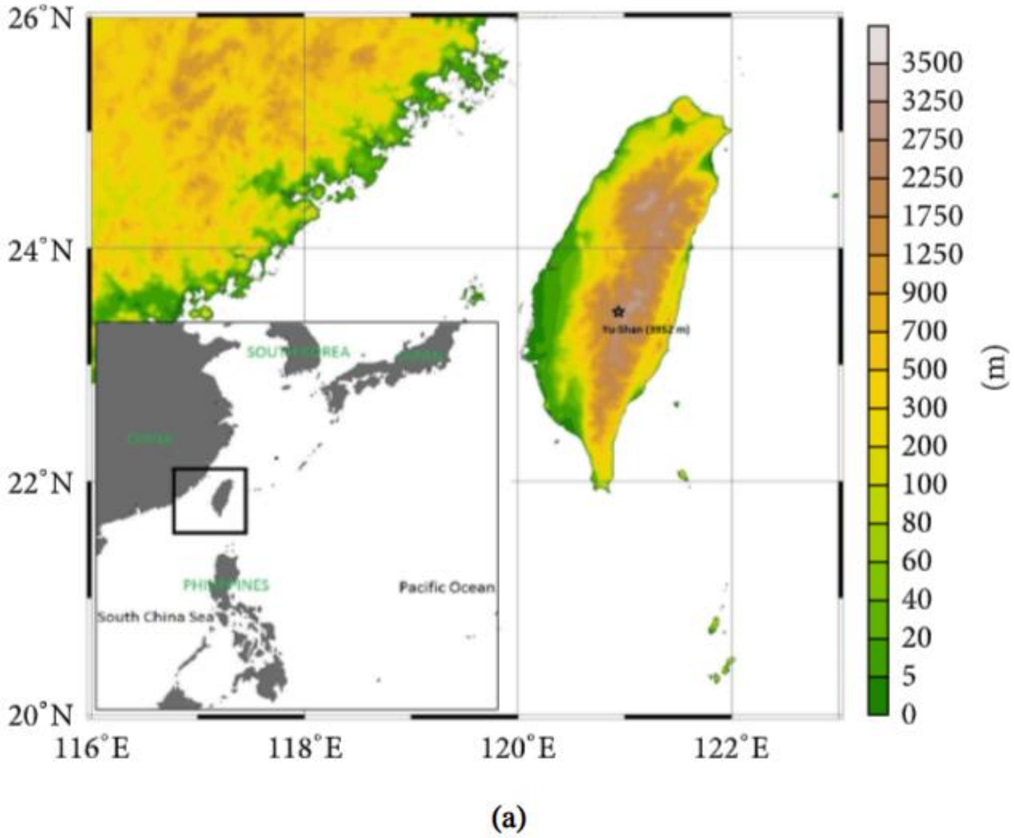
Capacity building

Research Precipitation

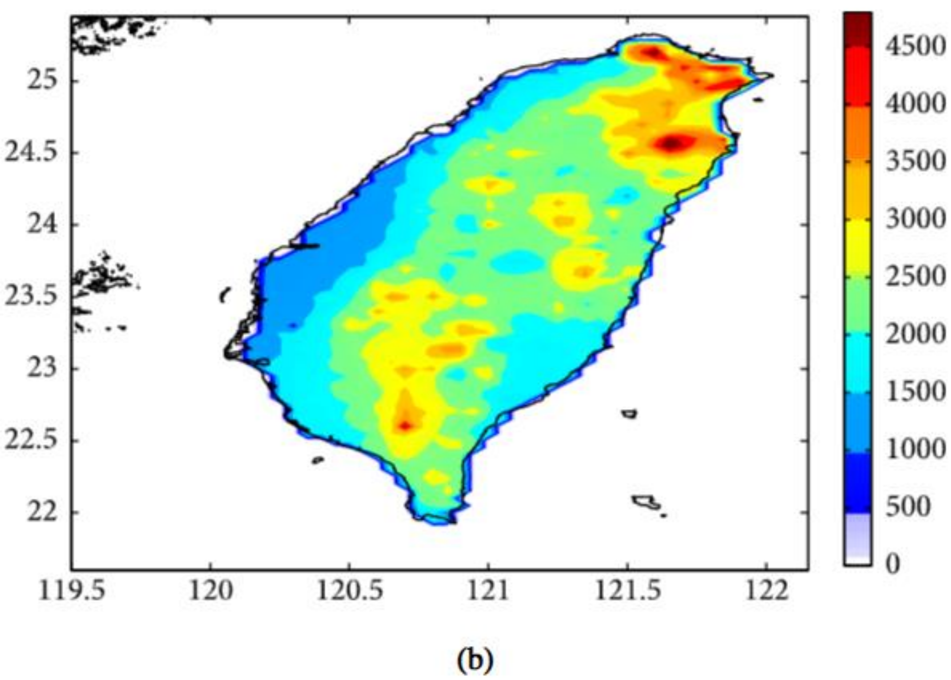
First of all we started doing research about the annual rainfall in and around Taipei. We came across the following diagrams and illustrations.



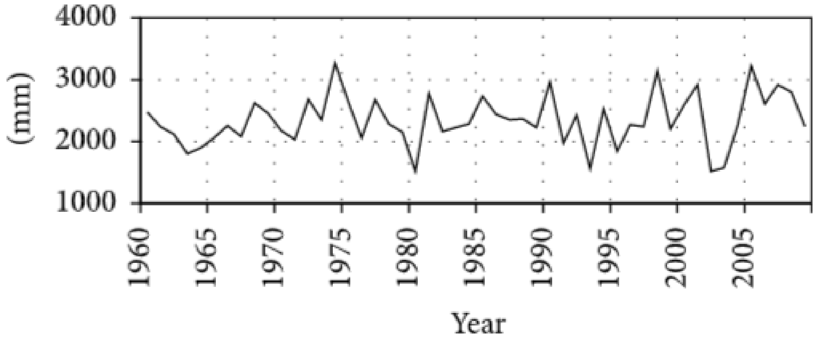
Figuur 1 Neerslag is te laag



Figuur 2 precipitation taiwan

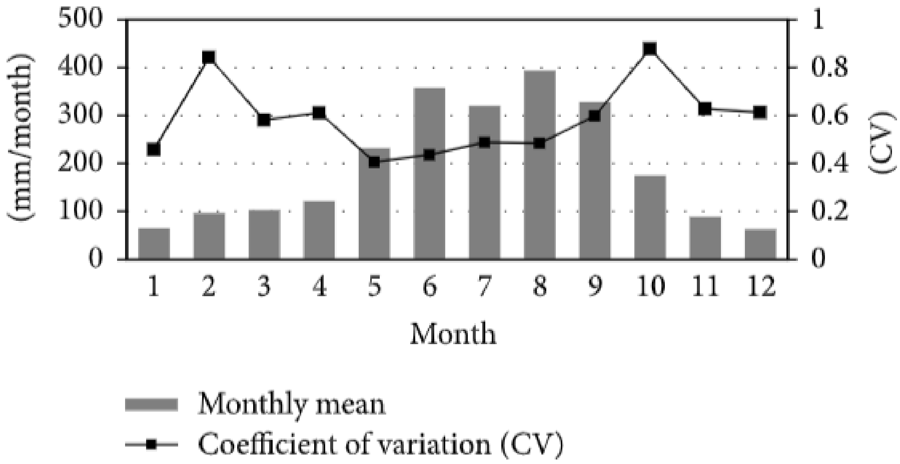


Figuur 3 Precipitation taiwan



(c)

Figuur 4 Precipitation taiwan



(d)

Figuur 5 Precipitation taiwan

Figuur 6https://www.hindawi.com/journals/amete/2016/3102895/fig1/

Taipei - Average precipitation			
Month	**Millimeters**	**Inches**	**Days**
January	85	3,3	14
February	170	6,7	15
March	180	7,1	16
April	180	7,1	15
May	234	9,2	15
June	325	12,8	16
July	245	9,6	12
August	320	12,6	14
September	360	14,2	14
October	150	5,9	12
November	85	3,3	12
December	75	3	12
Year	2405	94,7	166

Conclusion precipitation

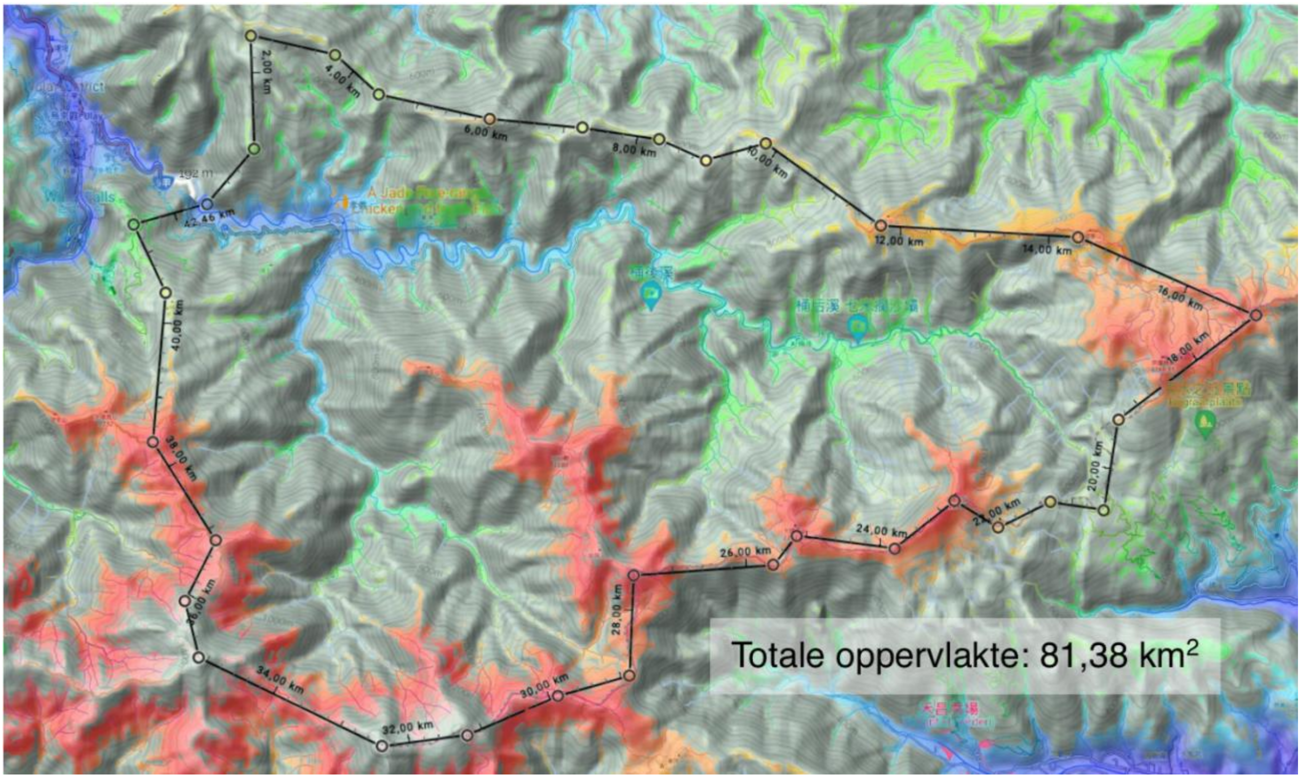
After research the average rainfall in Taipei is 2400 mm per year. However the dam does not need to be closed whole year. However in typhoon conditions more than 1000 mm of precipitation has been measured in a few days. By knowing this information we can make an estimation of how much rainfall we need to store during typhoons.

To create a safe storage during these typhoons the dam will be closed and needs to store at least the capacity of the typhoon which is 1000 mm + a margin of 750 mm is 1750mm precipitation. Also by designing a dam 75% of the volume rainfall is considered for designing the measurements of the dam, which is 0,75 * 2400 = 1800 mm, so 1750mm will do.

Calculation Storage

This precipitation will need to be multiplied with the area before the dam. This is the area from the top of the surrounding mountains to the dam. All this rain will flow down the valley in the river. This river flows to the dam, where it will be stopped.

The area is calculated through google maps and is approximately 81,38 km^2. Which is equal to 81.380.000 m^2.



The precipitation will partly infiltrate in the ground. The main soil type in Taiwan is inceptisol, which has a moderate permeability. Inceptisol exists out of ± 35% clay, ± 40% silt and 25% sand. A moderate permeability means approximately 0,1 m/day.

To find the infiltration we need to multiply the area with the permeability.

$$Infiltration\ \left(\frac{m^3}{per}day\right) = Permeability\left(\frac{m}{day}\right) x\ Area(m^2)$$

$$Infiltration\ \left(\frac{m^3}{per}day\right) = 0{,}1\left(\frac{m}{day}\right) x\ 81.380.000(m^2)$$ = 8.138.000 m^3/day.

The dam needs to be able to retain the water for 7 days in case of a typhoon. After the 7 days when circumstances calmed down, the water will be slowly released into the sea.

The total volume of the rainfall that the dam will need to stop can be calculated as following:

$$Total\ Volume\ (m^3) = \ Area(m^2)\ x\ Precipitation\ (m) - Infiltration\ (\frac{m^3}{7days})$$

$$Total\ Volume\ (m^3) = \ 81.380.000(m^2)\ x\ 1{,}75\ (m) - (8.138.000\ x\ 7)\ (\frac{m^3}{7days})$$ = 85.449.000 m^3

Conclusion

The dam will need to be able to store 85.449.000 m^3 of rainfall

Dam design

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.

Steps for designing a dam

Steps for designing a dam

For designing a dam following steps in nutshell are required.

1.Find catchment area.

2.Find 75% yield.(Volume of water at 75% dependable rainfall)

3.Decide volume of water you want to store.

4.On the basis of area capacity table, findout at what height required storage is available.

5.Add for flood lift and free board.

6.This will be the height of dam.

It looks very simple, but each component needs thorough investigation and precision. Design of a major dam requires years for investigation and design. Construction also takes minimum 5 years . (Khassaf, Gravity Dams, 2020)

Dam dimensions

Het oppervlaktewater dat naar de rivier toestroomt, die op zo'n 200 tot 400 meter hoogte ligt, komt soms van 1200 meter hoogte. Het stroomgebied is extreem ruig,, en bergachtig en daarom ook overstromingsgevoelig. De dam dimensies kunnen worden bepaald met de volgende formules.

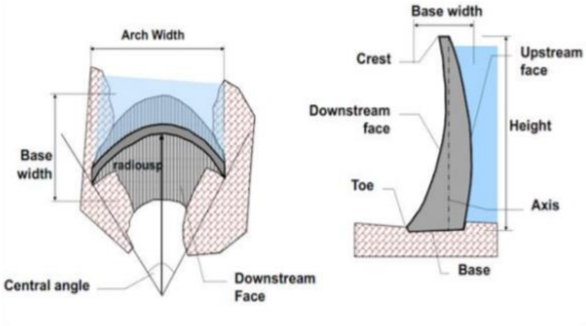


Figure (4.3) cross section of arch dam

Height dam

It is virtually impossible to calculate a good height of the dam with the little data. That is why we chose to determine a height based on several other dams in Taiwan.

Techi Dam

The Techi Dam is a concrete thin arcjh dam on the Dajia River in Taiwan.The dam is providing hydroelectric power, water for irrigation, and flood control. The dam has a height of 180 meter. The dam is build in in a narrow slot canyon. The dam has an total capacity of more than 175,000,000 m^3

https://en.wikipedia.org/wiki/Techi_Dam

Ronghua Dam

The Ronghua Dam is crossing the Dahan River. The dam has a height of 82 meters, with a total capacity of 16,700,000 m^3 and an installed capacity of 40 MW. (Wikipedia, sd)

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 dam

The selection method of design an arch dam depends on the structural behavior that will be considered such as cantilever or ring member. For ring behavior the Thin Cylinder Theory method will be used and for cantilever behavior 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

Width of the dam

By looking at the dam placement in maps a rough estimation can me made on the width of the dam at bottom level and top level. The width taken into the calculations at top level, will be the point where its foundation hooks into the mountain at each side. The width at the bottom will be the point where its foundation is in the ground and from where it will start growing in height.

At bottom level it is approximately 100 meter width. At top level the dam reaches 400 meters in width.

Thin Cylinder Theorie Method

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.

(Khassaf, dams and reservoir, 2020)

$$R = \gamma_w * h * r_e \text{..........} 4.3$$

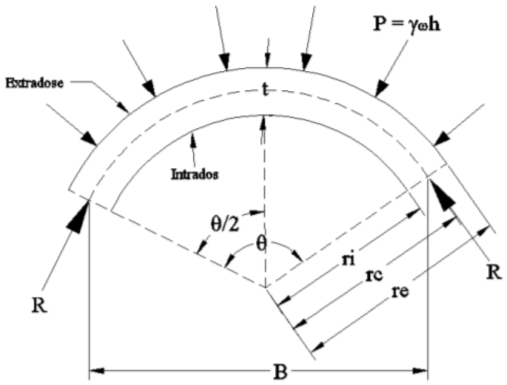
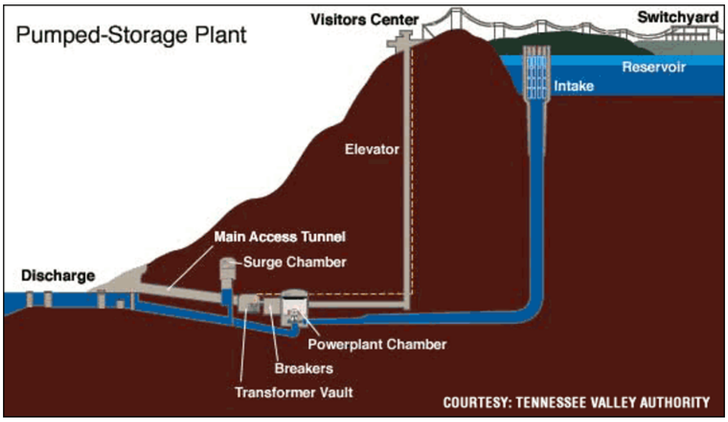


Figure (4.4) force arch dam in thin cylinder theory

Hydro Energy

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 "reserve" 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. (Power Station, sd)



About 234MW of energy is generated in the 180-meter high Techi Dam. The dam has 3 power turbines of 78 MW. We have chosen to place 2 of such 78 MW turbines in the dam. (Techi Dam, sd)

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