Conceptual design – a case study of a dam construction

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Executive summary

Dam is a system for stopping the water of a river or to stop the underground steam inside a certain place. The reservoirs made in a dam are not only uses as the way to stop floods but the reserved water can be used as many very important works also like to produce electricity using turbine and for water supply in a big city. From 1100 century the fundamentals of a dam is in the pages of history and now there are many very important dams in world that are providing a huge safety to many important cities. The general purpose of a dam is to store the excess rain water for using the water to produce electricity, for human consumptions and for many industrial uses.

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Introduction

One of the biggest dams of human history is the Glen Canyon dam. There is much kind of dams and Arch Gravity is one of them. The glen canyon is an arch gravity dam. In the town called page, this dam is situated on the Colorado River in North Arizona, United States of America. The dam is made by U.S Bureau of Reclamation (USBR) and took 10 years to make it from 1956 to 1966. This dam is 220 m high and having Lake Powell, one of the biggest men made reservoirs having the capacity of 27 million acre feet.

Design analysis

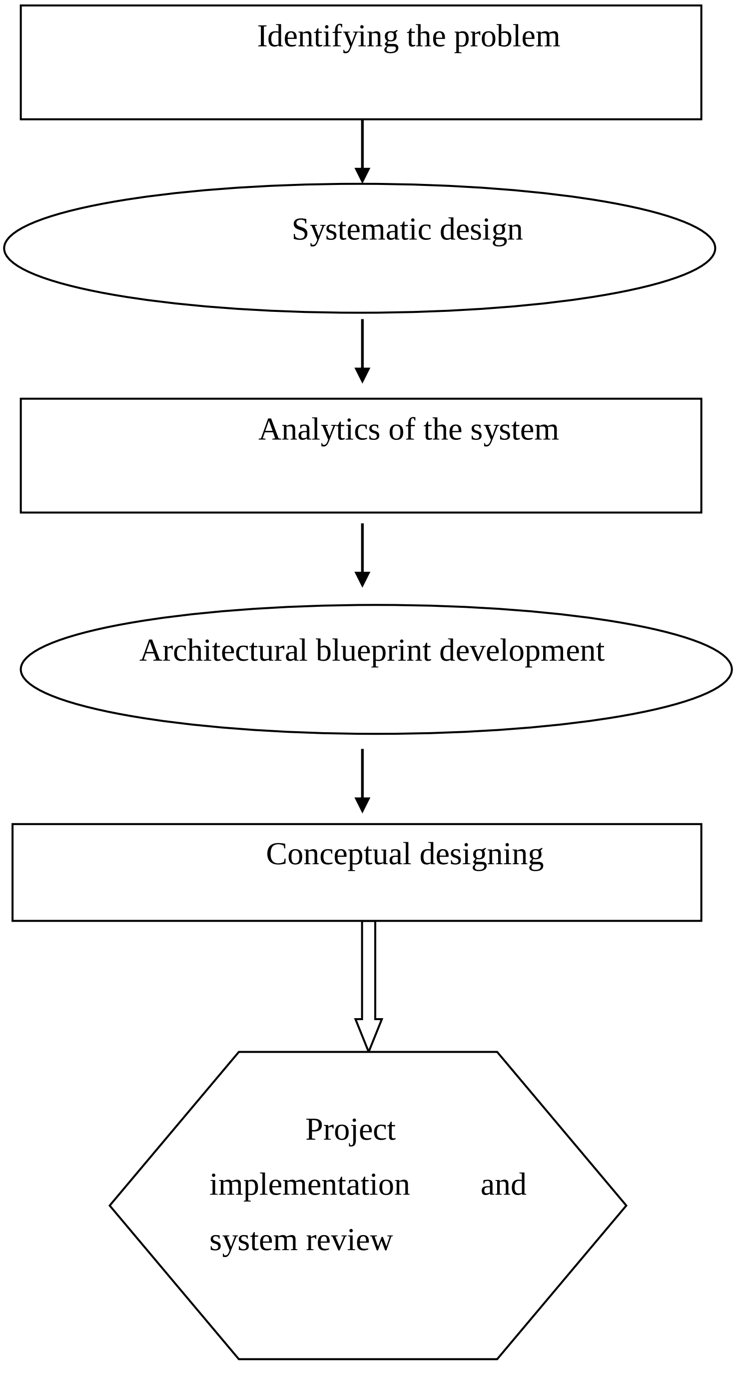

Figure 1: Entire project planning

(Source: Author)

This is the brief description of the entire project planning. In the following section of the report the detailed analysis according to this flow chart will be done.

Planning and architecting:

The planning and architecting has many phases. Some of the very important phases are described in the below;

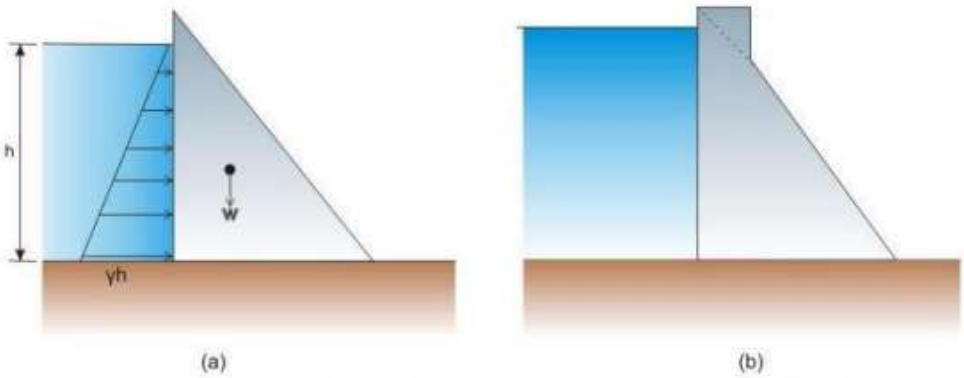

Figure: 2: Basic Layout of the Arch gravity dam
(Source: Guan, Ren, & Zhong, 2013)

Definition of program requirements:

As opined by Pan *et al.*, (2015) in system engineering programs for requirements means a lot. It means the probable needs to make a now project or to renew any old project. The total materials, technologies, number of workers, planning for doing the task has done in this stage. As a basic example, in case of glen canyon dam the foundation material is the porous sandstone prone not solid and hard granite as Hoover dam (Mata *et al.,* 2014). These changes, the materials all are planned in this phase as per the requirements made by the planners and the engineers.

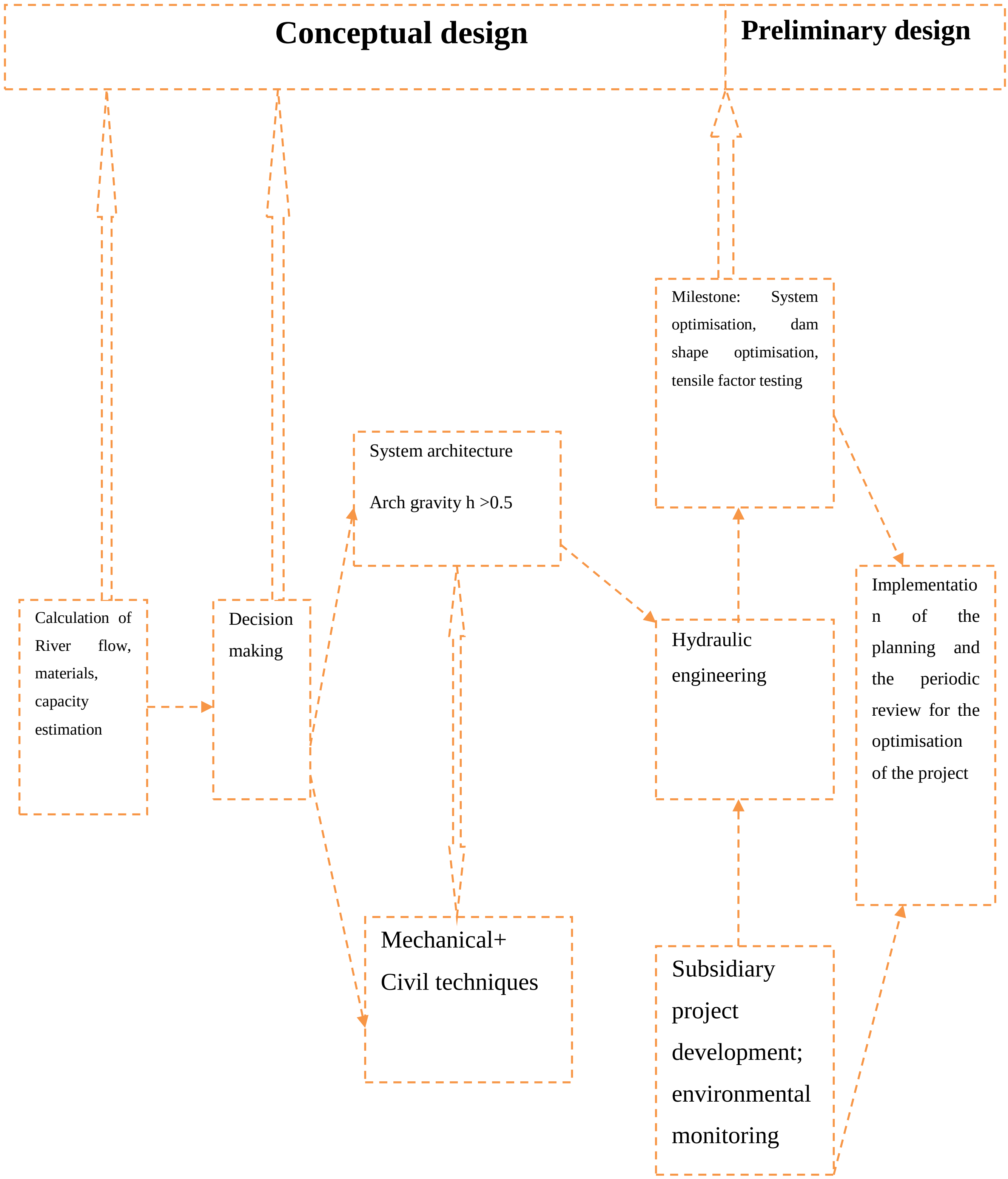

Figure 3: Project design

(Source: Author)

Program management plan – a program management plan or known as the project plan is the planning phase where there will be a group of employees called Project Management Body of Knowledge will take the most important decisions about the entire project by planning through many models and theories and by putting the real life valuations into those models or theories to evaluate the entire project. This part contains many things like documentation, approvals, taking decisions depending on assumptions for future, cost and time guidelines etc. This may be in detail elaboration of the entire project. In Glen Canyon dam, the authorities have taken the decision with the help of the management and by doing experiments. That decision will provide an excellent framework for this dam's operations for over 20 years (Salazar *et al.,* 2017).

System architecture – to understand or derive the structure, behaviour of a project this system architecture part is very much important phase. This phase may be called as the technical architecture phase. In this phase the technology is being selected depending on the practical situations.

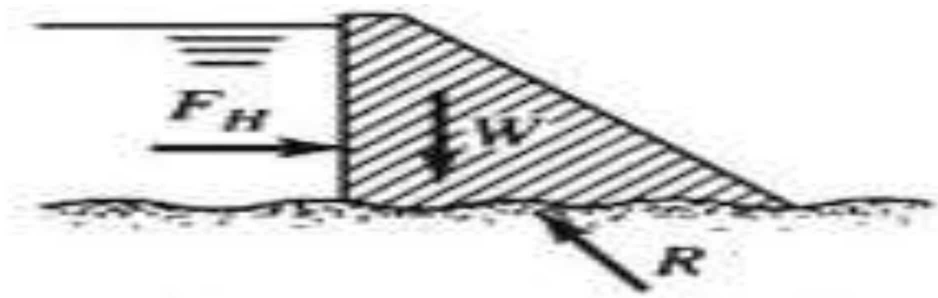

Figure 4: Resistance mapping against flow

(Source: Wu *et al.,* 2013)

Functional baseline – the functional baseline is the short form of the entire system performance and the total external system specifications. It can be told as the technical baseline. This is in short can be told as the technical specifications depending on the requirements of the users of the final project. The next state of the technical baseline is the change. Here in Glen Canyon, the seismic technology is used to make it.

- **System specifications –** the system requirements specifications (SRS) in short the system specifications is nothing but the collections of the most important technical information that will embody the requirements of the entire project. The requirement part is the technical requirement and the other requirements to fulfil a project successfully (Chen *et al.,* 2016). This dam is made of pure concrete to divert the Colorado River inside this dam. So as per requirement, a concrete plant was established which is capable of putting out 1450 tons of concrete per hour. More than 3000 of concrete blocks were made of 60 feet by 210 feet to make the dam.

- **System engineering management plan –** this phase is the simple communication phase between the designer, engineer and the contractor. In this phase the total material requirement is submitted to the contractor. Not only the materials, the human resource and the important tools are also communicated to the contractor. The contractor's capability, standard, configuration and the needed tool sets of the contractor is sighted in that phase. The contractor's capability is measured by a group containing project engineers and the project managers. In this project the number of laboures needed was 2500 with wage of 4$ per day for each labour.
- **Program implementation –** program implementation means the definition of the specific set of information related to the entire project and some set of specific activities designing to make it in the real life circumstances. Literally implementation means the real life working of the total theoretical and modelling planning. Here the main problem with implementation was to fill up the lake Powell inside the dam. Initially it was planned to fill up to 3490 feet. It could be done after 17 years but 13.4 million acre feet of water was lost due to the fluctuation.

System requirements definition

System requirement is the most important part of designing a project. This part is the most responsible for success or failure of any project. This part has many layers too. These layers are as described as follows

- **Advanced system planning and architecting –** it is nothing but the set of representations of a system whether the system is existing or it will be happening in future. These representations actually describe the general functions, planning, the possible outcome of the project and then in second stage more concrete descriptions and refined and detailed descriptions. This is the advance stage of the planning part.
- **Problem definition and identification needs -** this is the basic and the very first step of the problem solving part. Actually to solve the problems, this is very important to identifying the actual problems and the possible solve to all the problems. Every single project has its own problems and solutions based on the practical field

documentations. The problem can be stated as the real situation versus the planned situation. Initially the main problem was with the labours. As the problems were with the wage reduction and the labours were started doing strikes. Then it got solved by raising their wage and the work started.

- **Operation & maintenance –** this part is not theoretical at all. This part is depending on the on sight works. Operation is the way of doing the work of the project in a singular way. In this part the main technology and way of completing the work is developed. This part is depending upon the project manager and the sight engineer. Maintenance is something must needed matter to any project, as mentioned by Chen *et al.,* (2016). In a big project there are many types of machinery and tools are used. These all need to be maintained regularly as the breakdown of these can elongate the project. At Glen Canyon dam, the maintenance cost is huge. It is a year to year cost estimation system. The annual maintenance cost of glen canyon to 5 to 7 million dollars. For the generators of the power supply division, the maintenance cost is 5 to 20 million dollars. There are 35 workers who are doing this maintenance work regularly.
- **Technology development –** technology of a project is very important to be developed in a very early phase of the project. The changes in technology also must be done as per the user's demand. The success of any project is depending upon the technology part. If the technology is not that good and up to the mark then a project can fail. Many geological studies have been done the Glen Canyon dam and it is found that after 2004 there are no changes in technological aspect at Glen Canyon dam.
- **Researches –** through out an entire project, research must be going on. The research must be done not only the technology but for the possible outcome and the effects of the project on society and obviously on environment too. On the basis of the research the project work can be changed for the surviving of the project. Initially there were problems with ecology in this dam. But now after many researches, great changes are there. Now in lake Powell there are facilities like many water rides, fishing and ferry system is also there.

Life cycles of the system

Life cycle assessment for any design is a very important factor. This part is to be done at the initial phase of a project. The life cycle analysis can tell the outputs depending on the inputs and the technology and work culture. This analysis also has some steps as following

- **Conceptual design** – As per the views of Alembagheri and Ghaemian, (2016) conceptual design is the phase where the examinations to be done as per the needs or the requirements. Some major steps of that stage are – **a.** Identification of needs, **b.** Analysis of feasibility, **c.** Analysis of system requirements, **d.** Specification of proper system, **e.** Review of the system design. Here in Glen Canyon, the hybrid life cycle assessment (HLCA) is used.
- **Detail design & development –** detailed design and development is another very important stage of life cycle analysis. This stage is important for the initial design that must be upgraded by the information of the work field to a final and detailed design. This part of the life cycle analysis contains some steps like **a.** In detail designing, **b.** Total project synthesis, **c.** Selecting the models, **d.** Developmental revision, **e.** Process and material design, **f.** Critical design analysis. In Glen Canyon Dam, initially the material proposed was rock filled concretes (RFC). But the carbon di oxide level was so high that the plan got changed and it was the simple concrete used to make the dam.
- **Manufacturing and configuration design –** manufacturing and configuration is the part of life cycle where the main tools and machines are to be selected for doing the works in a proper way. Here in Glen Canyon, the concrete blocks were used to make the dam.
- **Constructions & operations –** in the time when a production or construction is going on than some products have to be made as per the demands of the project. Some predefined materials have to be checked as per the demands of projects. This stage is also having some steps like – **a.** System component construction, **b.** testing for acceptance of the components, **c.** Distribution of the system, **d.** testing of the operations to be done, **e.** Assessment of the system. Here in Glen Canyon, a extra concrete making plant was made and it was producing heavy quantity of concrete blocks.

- **System support –** if the project is started once and running successfully then the support system is a much needed one to run the project work successfully and effortlessly. In this stage of work there are some steps to do the work are like – **a.** Operation of the system under the user's environment, **b.** Changing in management, **c.** Modifying the system, **d.** Assessment of the system. Maintenance system is the best system support to a dam successfully. Here in Glen Canyon, the maintenance cost is around 25to 30 billion dollars per year.
- **Product use, phase out and disposal –** the proper use, effects on environment and efficiency must be checked throughout the life span of a project. If it loses its efficiency, what is an obvious thing towards any project is the time to stop the project Liu *et al.,* (2013). Every construction has its own life span after that this construction must not be used. This dam is now in use and producing a huge amount of hydroelectricity every year. Many amendments have done in every meeting of the authorities to make this dam more productive.

Conclusion

From the great canyon dam's example many things should be learnt. The design of that dam is a huge example of system designing and engineering. Every big project when started has to face lots of problems. This great canyon also had to face many problems from society. This canyon is having the largest reservoir so the support and the maintenance system also can be learnt from this case study.

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