Technology and Techniques Applied in Ancient Sri Lanka in Constructing Dams

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Abstract

The knowledge of *Amunu* or dams (anicuts) and the water management techniques that associated with them in ancient Sri Lanka form an integral part of the island's national heritage. The concept of 'achieving the targets of needs' has been well responded by the inhabitants of the Dry Zone by generating a considerable knowledge experimented over the ages and proved successful. The techniques that they applied in water management were practical in all aspects. The dams constructed in ancient Sri Lanka provide us an ample ground for research into their location, construction plan, friendliness to the environment and varied utilization.

The excess water of a river that flowed down stream is diverted to an area where water is much needed. The diverted water was used not only for agriculture but also for other human needs as well. Accordingly the objectives of the ancient dams were multifaceted.

The Dry Zone plains in the island are enriched with a considerable number of rivers and the excess water of many of them has been managed successfully by way of dams. At least one or several dams survive with these rivers for us to study. Before construction of large tanks, the dams played an important role in local water management system. The durability, easy maintenance, security of land and people have been the factors that promoted construction of dams.

My recent research conducted on the dams revealed much hither to unknown facts that could even be useful for modern society. The on site excavations of this research, supported by evidence recorded in the chronicles and inscriptions concluded with great success. The facts included the selection of sites, distribution pattern, methods of construction, material used and above all planning and creativity, which are worth sharing at a forum of archaeologists and those interested.

Introduction

One of the main factors, which indicate to identify the ancient civilization in Sri Lanka, is the local irrigation system. Ancient people, whose main occupation was paddy cultivation based on agriculture selected the Dry Zone for their settlements. The main reason for the selection was the physical and natural resources suitable for agriculture. The construction of dams and the tanks were done in the areas such as North-Central, North-Western, Southern and Eastern dry regions, where the settlements were established during the period of Indin migration. This was done to collect rain water during the dry season. First, the ancient Sri Lankans, who lived in Dry Zones, constructed small tanks in their villages. Later, as the population increased, they were compelled to build large tanks with developed irrigation systems. Water-based civilization, which existed from 1st century B.C. to the 13th century A.D., witnessed the kingdoms in Anuradhapura and Polonnaruwa (Codrington. 1922, Nicholas. 1955 (1973), 1959).

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Henry Parker has highlighted his views about dams, while proper attention was not paid by researchers or any other person on dams. Here, Brohier has made an attempt to report on many ancient dams in his book. Yet, these studies are not sufficient enough to get a very clear picture about technology of ancient dams, construction style or techniques of constructions.

It reveals that a proper study on the construction of ancient dams and technology has not been done. It is a great shortcoming of the study on the ancient irrigation constructions. Therefore, my effort in this research is to fill the gap to a certain extent.

Location of the ancient dams in Sri Lanka

Research Methodology

This research is an independent one because this has been done on the data collected through field researches. But, I have collected necessary facts, by studying historic sources, modern research studies and articles on ancient irrigation technology. And also, in addition to the field researches, necessary facts and data have been collected, from several selected research excavations. A special attention has been paid on data analysis, identifying different rocks and studying ancient plaster mixtures. Information and support from educated personnel on relevant fields have been obtained.

Geographical and Environmental Background

Sri Lanka is situated as an island in the Indian Ocean to the south of the Indian Peninsula between northern latitude 6 and 10 and eastern longitude 80 and 82. Its extent is 25,332 square miles (65610 square kilo meters). The length of the island from north to south is 270 miles and the width from east to west is 140 miles.

The geographical situation of the island has directly affected to form different climatic zones. Average rainfall of Sri Lanka leads 900mm. to 6000 mm. The country is mainly divided into two geographical parts as Dry Zone and Wet Zone depending on the rainfall it gains. Northeast monsoon

is between December and February and it brings rainfall of 500mm. – 250 mm. to the Dry Zone of the Country. In the Zone, which gets annual rainfall higher than 1500 mm. Reddish Brown Earth can be seen. This earth, which is very suitable for agriculture has directly affected the establishment of settlements in this zone. There are 103 river valleys in the island and out of them 83 valleys are found in the Dry Zone (Arumugam. 1969, Cooray. 1984:81-114 and etc).

Contents

One ancient system of agriculture to collect water was to build a dam across a stream and divert water through canals. This dam was called "*amuna*" in Sinhala. According to Sanskrit and Pali languages it was named "*Avarana*" and later in Sinhala *awarana >awuna>amuna*. This analysis was done by Prof. S. Paranavitana (EZ. V: 39, IC. Vol I P. I: 103). When studying the facts about ancient dams in Sri Lanka, Epigraphs and genealogy reveal much information.

The main aim of this type of dam was to divert water a canal. But, there were some other benefits: to supply water for agriculture fields, to release water to a tank simultaneously, to release water into water sources in case of a shortage of water and to carry water to distant places. In this case, the dam is equally important with tanks. It is very obvious that the dam was a very important device in the history of Sri Lanka, in the field of irrigation.

Elahera dam of Amban ganga

One very significant heritage of Sri Lanka was the knowledge, experience and techniques of ancient Sri Lankans based on local irrigation system. The ancient Sri Lankans inherited advanced technology knowledge and mental power to construct dams, canals and tanks. The field studies, which were conducted to examine the ancient constructions of dams, reveal many facts regarding the technology and techniques under four sections.

1. Selecting land.
2. Mode of constructions
3. Planning and creativity
4. Technology of constructions

1. Selecting the land

When compared with the tank, the dam is equally important in local irrigation system. Although there is a close connection between the tank and the dam, the function of the dam is different from that of a tank. The main feature of dam is the construction of a bund blocking the flowing water of a river, stream or canal. The bund of the dam should stop running water. Two factors are taken into consideration when selecting a land.

1. The support of the earth to build dam stronger
2. To divert water to necessary fields.

1.1 The support from the earth to construct the dam stronger

The bund of the dam should have the quality of resistance in sustaining the pressure of running water. Therefore, in selecting the land is very important to consider the place suitable for it.

The natural situation of the underground rock was the main fact for the construction of a dam across a river, stream or a canal. This was revealed when the ruins of ancient dams were examined. To avoid the breaking down and sinking of the dam the natural underground rock layer was important. The ancient people, who paid attention for the safety and durability of dams, tried their best to select a suitable place for the construction of a dam band. Quartzite ridge, vertical granite gneiss, biotite hornblende gneiss, crystalline rock has been selected for the constructions.

A large number of place witness the foundation of dams with this type of granite under dames. Among them, Elahera and Angammedilla of Amban Ganga, Ridibendiella (Sukaranijjara), Walpaluwa (Doradatthika), Welimaluwa, Kımbulwana, Hakwatunawa of Dedaru Oya, Yaka Bemma, Palamkadawala, Nilibemma and Alubedda at Kala Oya, Habagama, Wilewewa, Wahalkanda Amuna with Yan Oya, Hattota Amuna at Kaluganga, Galkadawala, Galpottegama and Halpan Ela, Kandara, Thekkam of Malwathu Oya and ancient Yakabendi Amuna at Ma Oya are the clear examples.

Natural rock surface in Elahera dam

In some occasions, the rocks which have naturally come up with ridges have been used to build the dam. One clear example for this is the dam built using the rock-ridge at the place called Welimaluwa in Deduru Oya. To construct the lower part of the dam timber and granite have been used. In Deduru oya itself, when constructing Doradatthika Dam, large and long rock has been used. Only small part has been built across. Another example is the part of ancient Alubedda dam in Kala Oya which has been built with a high rock with ridges.

The ancient technicians have paid their attention to large rocks, which were situated naturally on earth. The main reason was to support the dam connecting both sides with very strong rocks.

In some places, the bund of the dam had been washed off or cracked because the rock layer was not suitable for the construction. The rock layer of Sukaranijjara and Kimbalwana Oya dam has been completely damaged because the rocks were not suitable to build bunds on them. This situation can be seen at ancient Yakabendi Amuna which had been built across Ma Oya.

Ancient technicians had paid their attention to the places, where the rocks were not situated naturally, but the other features of the earth were suitable for construction. In such places, timber has been used instead of granite blocks. Big logs have been pressed into the layer of clay, underground close together. This type of log or timber made- bunds are reported from Deduru Oya and Maha Mankada at Pallama area.

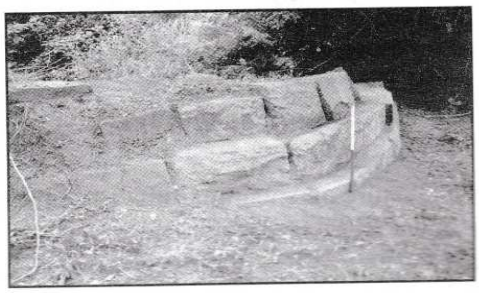
1.2 Feasibility of directing water of the dam towards target fields

The expected target of a dam is to divert water towards necessary land or field through a canal. Therefore, a dam should be constructed at a place, where the earth suitable for digging a canal. In ancient times, special attention had been paid when selecting a ground in constructing a dam.

It has been revealed that attention was paid to select a place, where a canal could be made to reduce the slope of ground towards the water source. This means the ancient technicians had paid their attention to the elevation of the land. Although some dams had been constructed on the facts based on the quality of the earth, they applied some alternative to divert water out of the dam. The best example is Sukaranijjara dam at Deduru Oya.

The main objective of constructing the Sukaranijjara dam, which was done by King Mahasen, to supply water was to Maha Gallaka Wapi (Magalla tank in Nikaweratiya). There was no need of digging an artificial canal, because there was a natural canal called Thalagalla Ela above southern bank of Deduru Oya. The water collected at this dam was taken along this canal for about 800 meters to a higher elevation and from there the water was taken to Magalla Tank through the canal made at the lower elevation. When comparing with the maximum height of the ancient dam bund it is obvious that the artificial canal begins from Thalagalla Canal, which is situated about 99 cm. below.

When constructing the canal, it was started at a higher point on the dam bund. It was done for the safety of the dam bund. It is clear that necessary safety measures have been taken to avoid erosion of the place where the main canal started. Granite blocks have been used to cover this place. A very good example is the Halpan Ela ancient dam built at Malwathu Oya.



Avoid erosion of the Halpan Ela Dam of Malwathu Oya

In ancient times, much attention had been paid to the construction of a canal, which carries water to a tank or paddy fields. Contour lines of the land had been followed by the ancient techniques when constructing canals. They considered mainly the level of lands when constructing canals through valleys. Canals were made through lands naturally situated. The ancient canals were with many bends and they were longer than the modern canals. The Yodha Ela, which runs from Kala Wewa to Thisa Wewa is a very good example for this. They applied this method to lake water from the dams through canals. Ancient people had the experience of floods and rivers overflowing when constructing canals. Very rarely they constructed artificial canals. This reveals that ancient technicians applied the experiences mastered with nature.

Ancient technicians have applied two water directing systems when constructing canals to carry water from the dam to the fields. These two systems were:

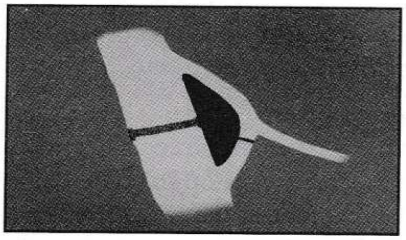
A. Water Diverting system of *Angammadilla* type

B. Water Diverting system of *Rideebendilla* type

A. Diverting system of *Angammadilla* type

The main feature of Angammadilla type diversion was that water was released from the main canal and excess water again drained into the main canal through other sub canal. Elahera and

Angammadilla dams built at Ambanganga and Minipe dam built at Mahaweli River are the examples for *Angammadilla* type diversion.



Water diverting system of *Angammadilla* type

Angammadilla dam was built at a point where large quantity of water was collected. The special feature of this type of diverting system is that the water collected at the dam circulates below the main canal and runs through a sub-canal and that water was again collected to the water in the main canal. According to *angammadilla* system, sub canal was made at a point where the water pressure of the main canal was loaded towards the river bank.

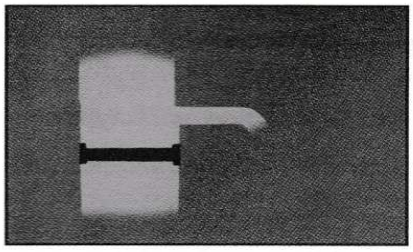
The sub canal which deviated from the main canal was found man-made at the beginning, but later it changed it artificial quality due to the continuous water flowing for a long period. While sub canal and main canal were built parallel to each other, the earth ridge between the two canals can be seen at elahera and Angammadilla dams. A safety bund has been built to avoid the erosion at the point where main canal begins. This can be seen very clearly at Angammadilla dam. And also to avoid the washing of the banks of the sub canal granite block have been laid in the form of steps.

There are two definitions for the term "Angammadilla". According to it, the first definition sub canal is separated from main canal at the beginning and then again joins both of them together later at a certain distance. The second definition says, building an extra bund to control the main canal which is disturbed by sub-canal. Anyway, both definitions bring out the same meaning of "controlling".

The special and important feature of Angammadilla system is the protection or safely of dam bund in case of sudden pressure of water. Excess water flows over the main bund and there by the can be seen as an environment friendly system.

B. Water diverting system of *Rideebendilla*

The ancient dam constructions in Sri Lanka were very closely connected with the Rideebendilla water diverting system. This type of water diverting was used to supply water sources. Medium type of water sources, such as Deduru Oya, Kala Oya, Malwathu Oya and Yan Oya were the examples for this type of ancient water diverting systems. Constructing a dam either on the left or right river bank across the stream of water was the clear evidence for this method. The special feature of this type of dams is that the water blocked by the dam is easily diverted to the canal. In some places, canals have been built on both sides, right and left, where the dam is built up. Sukaranijjara at Deduru Oya, Yakabemma at Kala Oya and Yakabendiella at Ma Oya are the examples.



Water diverting system of *rideebendilla* type

The term "Rideebendilla" is defined as how a person ties a silver chain round his waist and one end of the chain hanging down several dams of its type have been named with the term Ridee. Rideebendiella dam at Deduru Oya, dams called Rideege Palama at Kala Oya and Malwathu Oya, Rideebendiella at Kimbalwana Oya are the examples.

Although the construction of this type of dams is easy, there is one disadvantage. Type is a possibility of damaging the water gates because the high pressure of sudden water raised effect directly the dam and the canal.

Because of higher capacity of water at an unexpected moment the main canal, the tanks and paddy fields may be seriously damaged. Therefore this method has not been used to construct dams with large scale water sources.

2. Medium of construction

According to ancient *Deegha Nikaya* text soil, dried leaves, granite, clay and pieces of clay pots and pans had been used. Yet, constructing permanent dams to ensure the durability, the dam should have been built so that it resists the pressure of water. It is obvious that ancient technicians had paid attention to durable and strong media in building dams. According to the nature of earth of the particular place, they selected the material. Mainly granite was used. Apart from that, bricks and plaster mixture were used to fix stones. Sometimes, semi-established dams had been built and in such cases timber, clay or gravel had been used.

2.1 Stones

According to research studies done on ancient dams, it is revealed the main medium of construction was stone. The weight, the strength, the durability, water resistivity, easy supply and feasibility of fitting together were considered in selecting stones. Among these stones, gneiss and granite can be seen. Special attention was paid to stones (granite) since they could be easily placed on the natural rock layer on which the dam was built.

In constructing dams, stone blocks and planks with different shapes were used while mostly blocks with proper shape used. This type of stone blocks has been used with Nilibemma and Alubedda dams at Kala Oya. The stone blocks used at Nilibemma were 7.5 metres long, 5 m, wide and the height of a block was 3 metres. A block weighs nearly 17 tons. For both dams Alubedda at Kala Oya and ancient dam at Kimbulwane Oya this type of natural stone blocks were used. Mostly stones were used at the point where the dam was connected to the river bank. Stone collected from streams and closer places were not with proper size or proper shape. The river bank was dug into a certain length, bigger stones were laid up to the granned level and small size stones were laid tighten. This can be seen at Habagama and Vahalkada dams at Yan Oya.

Stone blocks and planks were used to build dams mainly. These shaped blocks and planks were fixed or placed together strongly so that the shape of the dam at its quality was protected; Elahera, Sukaranijjara, Galkadawala, Yakabendiella and Wahalkada are the examples for this.

Ridibandi ella (Sukaranijjara) dam of Deduru oya

Another advantage of these shaped blocks and planks was the necessary stone is constructing the dam bund very strongly and fixing method of these stones was easily done. Different types of stone fixing methods, such as properly shaped pikes, pits made in different shapes and different shape points, were used. This type of stone fixing techniques can be seen at Yakabendiella and Ma Oya and Sukaranijjara and Doradathika dams.

2.2 Bricks

It is found that bricks have been used in the construction of dams. To control the water leaks bricks have been used. Evidence is found to prove the use of broken with several dams such as Yakabemma at Kala Oya, Sukaranijjara at Deduru Oya, Elahera dam at Amban Ganga, Galkadawala dam at Malwathu Oya, in two places in a dam bricks were used to control the water leaks.

1. Constructing a bricks layer on the surface of the dam
2. Brick layer after two layers of stones

Examples for the first type are found at Yakabendi dam and Elahera dam. The brick layer on the surface of Elahera dam can be seen in the form steps. About 4 or 5 brick layers have been put up with the help of lime mixture plaster. From the ground level up to the height of 3.5 meters this brick cover has been constructed. This type brick construction is found at Yakabemma dam. Space between brick layer is filled with plaster mixture to avoid leak.

Bricks layer in Ridibandi ella (Sukaranijjara dam) at Deduru Oya

In ancient dams brick layer has been laid between stone layers. In Ridibandi Ella (Sukaranijjara) dam at Deduru Oya this can be seen very clearly. This is revealed with the excavation, done at Ridibandiella ancient dam.

2.3 Plaster

In constructing dams with stone and bricks plaster was used as the medium of building. To fix layers of stones and bricks and to fill the space among them this plaster mixture was used. In same places plaster has been used to fill layer gaps. Clear evidences are found at Sukarnijjara dam at Deduru Oya and Yaka Bemma dam at Kala Oya. The Sukarnijjara dam at Deduru Oya provides enough examples to prove that plaster was used in different ways in ancient dam construction.

Limestone plaster of Ridibandiella

Other material was used along with the plaster depending on the place and occasion. A very thin layer of plaster was used to bind or fix two layers of bricks. To fill big concrete plaster has been used. Round shape quartz, granite of 40 cm. and boulders has been added to plaster mixture. This composition was prepared and used according to the place where necessary. It is obvious that the plaster was prepared mixing small size stones and that mixture was poured onto the bigger stone layers. Sukamijjara dam provide evidence for this type of plaster mixture used in dam construction.

2.4 Timber

It is believed that the timber was used as a medium of construction build semi-stable dams in the past. According to some epigraphs and genealogies dams had been built in some places where there is no evidence of stone made dams. It means that timber had been used for the construction. According to the Minvila inscription King Kutakanna Abhaya (Ic. Vol II P I No I) had built a temporary dam made of timber across Mahaweli River which was washed off after every flood and repaired again and again. In this study, my attempt is to prove this fact with evidence.

There is enough evidence for this type of timber made dams at Deduru Oya. Molaeliyamankada dam at Pallama, Mahamankada dam at Mugunuatawana had been constructed with timber when using timber for dam constructions, different designs and techniques had been applied. When there no necessity of constructing a stone made dam, semi-established dams were built with timber. For this type of constructions bottom of the river with a thick layer of clay beneath the sand layer was selected. Molaeliyamankada dam had been built with wood placed each other close together. In Mahamankada dam at Deduru Oya with timber vertically. Later this wooden dam was covered with earth and clay pressed tightly. Iron clips which were fixed at the end of each timber column have been found at this place.

Timber made dams at Deduru oya

Different kinds of timber which do not deep in water, such as Hora (Dipterocarpus zeylanicas) and Kumbuk *(Terminalia arjuna)* were used to construct ancient dams, according to samples found at these places. A large amount of big and small timber columns were used at Molaeliyamankada dam and at Mahamankada dam.

The main dam bund was usually constructed with stones and same times both stones and timber had been used. The square shape holes made on the stone ridge of Welimaluwa dam at Deduru Oya reveals that, logs and planks had been used to cover some parts of the dam. These holes were used to fix logs vertically and planks were fixed to these logs horizontally.

3. Planning and creativity

The planning and the creativity of the construction were the main reasons or the facts for strength, durability and its efficiency of a dam. Still the ruins of ancient construction of these dams are found in spite of long term, various damages caused and that proves the creativity and the advanced techniques used by ancient technicians. Different designs were used to maintain the durability of dams. Here their attention was paid for two main facts.

A. The nature of the land selected to construct the dam

B. The speed of the water flow and flowing system

In ancient times two other factors were taken into consideration when constructing a dam.

1. Shape of the dam
2. Size of the dam

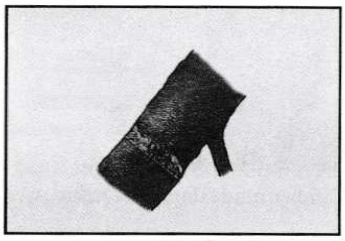
3.1.1 The shape of the dam

When designing the shape of a dam in Anuradhapura and Polonnaruwa periods, ancient technicians considered the nature of the earth where the dam was constructed, style of water flowing it's speed and the capacity of water. While constructing the dam bund according to the design they selected. They paid their attention for the strength of the bund, the durability and in efficiency. According to the shape of the dams they can be put into their categories.

1. Dams which blocked water directly
2. Dams with semi-circle or arch shape
3. Slantwise dams to block water

3.1.1.1 Dams which blocked water directly

This type of dams can be seen among most of the ancient dams. The main feature of this type of dam was joining the two banks of a river directly. At these dams the earth or the ground was blocked so that the water could be diverted easily towards the land. Sukaranijjara, Doradatthike dams at Deduru Oya, Yakabendi Ella at Ma Oya, Yakabemma at kala Oya, Galkadawala dam at Malwathu Oya and ancient dams at Yan Oya had been built according this system. Another two examples are Angammadilla at Amban Ganga and Haththota Amuna at Kalu Ganga. This method has been applied when constructing Minipe dam at Mahaweli River which is longer than the other dams of this type.



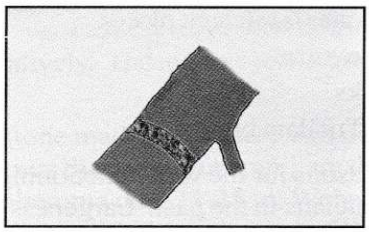
The bunds of these dams were wider than the other dams. The speed of water contact with upper edge of the dam since the dam bund is directly built across the water flow. The water pressure runs along the edge of the dam. The base of the dam was wider than the surface of the dam. To maintain the strength of the dam bund the dams of this shape were Sukarnijjara dam of which the width was 18 m. Yakabemma 10. 45m, and Galkadawala dam 40 m.

3.1.1.2 Dams with semicircle of arch shape

The dams of this shape had been built at ancient times. Dams were built with this shape so that the dam bund sustain the water pressure. When constructing a dam, blocking a water stream on a land with slope, the most suitable method was the semicircle or arch shape bund. According to this method, the pressure of the water flow touched the center of the bund and runs to the two ends of the dam. According to the evidences revealed at the study, two different types were found.

A. The dam bund with a complete semicircle.

B. A part of the bund with semicircle shape.



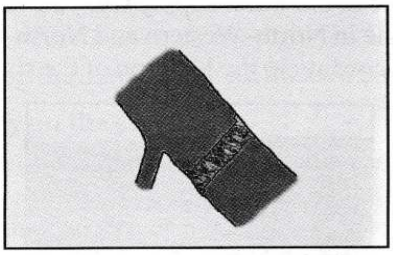
According to the ruins remained at present it is clear that Kimbulawana Oya ancient dam has been designed following the first type. To control the speed of water, this method had been applied with the ancient dam at Kimbalwana Oya because that place was with bends. The second type of design had been applied with Elahera dam at Ambanganga.

Semicircle shape dam of Kimbulwana Oya

When constructing dams with semi-circle or arch shape design, a system of laying stone with different ways and design had been used to sustain the pressure at water.

3.1.1.3 Dams built slantwise

Some ancient dams are found with a dam bund built slantwise. According to this system one end of the bund was built little above on one of banks and the other end of the bund was connected to a rather lower point of the other bank. Alubedda ancient dam at Kala Oya and Molaeliyamankda at Dedurru Oya built with timber are clear examples for this type.



Ancient irrigation technicians designed this type of dams for the lands where the speed of the water flow was slow or the water of the stream flew closer to one of the two banks.

3.2. The size of the dam

Special attention was paid at the very beginning of designing a dam for the size of the dam. Following facts were taken into their consideration.

A. Width of the stream
B. Nature of the soil or earth
C. The speed of the flow
D. Water capacity
E. The area and distance of water supply

Apart from the above facts, following points also were considered.

A. Feasibility of directing water is relevant places
B. Sustainability of water pressure
C. The control of water leaks
D. Stopping the washing off of dam bund

Above facts were the main reasons for the well-functioning and durability of the ancient dams which were built by efficient technicians in the past. Largeness of a dam was decided by its length, width and the height.

3.2.1 The length of a dam

The largeness of a dam is decided by its length. Two factors decide the length of a dam.

A. The width of a stream
B. The shape of the dam

A. Width of the stream

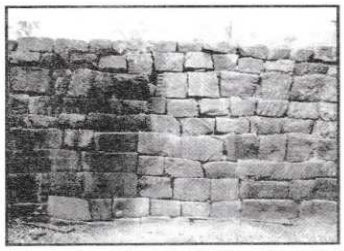
The length of the dam was mainly decided by the width of the stream. According to information found so far, the ancient longer dam had been built at Mahaweli Ganga and Ambanganga. Minipe dam at at Ambanganga and Yakabendiella at Ma Oya are the examples for this type of dams. According to the evidence, found Minipe ancient dam was nearly 220 m long and the length of Elahera dam was 185 m. and Angammedilla dam was a long as Elahera dam. Galpoththegama dam at Malwathu Oya was 140 m long and Yakabendiella dam at Ma Oya was about 100 m ancient dam built at Hakwatuna Oya comparatively a small stream was 9.80 m. long.

B. The shape of the dam

The length of a dam was connected with its shape. Although the river or stream was narrow at the point where it was built the dam was not built directly but with the shape of arch or slantwise. Arch shape Elahera dam was 185 m.

3.2.2. The height of the dam

When selecting a place to construct a dam across a river or a stream the height of the banks, the speed of water flow and the distance of the water supply were the factors that decided the height of the dam bund. The research study done in North-Western and North-Central Provinces reveals that the height of the dams was decided according to the location of the river or stream.



The highest ancient dam in Sri Lanka, Elahera dam

The highest ancient dam found at present is the Elahera dam remained with ruins. The highest is about 4.75 m. The place selected for the construction of this dam at Ambanganga was with a slope. Therefore the dam was built higher. The Elahera dam bund was built higher so that the bund reached closer to the surface of the banks. This dam was built to supply water to a distant area. When the capacity of water was much the water level rose up and water started running easily through the canal.

3.2.3. The width of the dam

According to the research studies, it is revealed that ancient technicians paid attention to the width of a dam. The ancient dam was wider than the present concrete dams. The strength of a dam in ancient times depended on the width of the dam. The width of the dam could resist the water pressure;

avoid cracking of the bund due to flow of excess water and leaks. Therefore the ancient dams were wider than the present dams comparatively. The main construction medium was stones and it was the reason for this factor.

When examining the ancient stone made dams there was not a clear change in the width. The width of the following dams was shown this way. Sukaranijjara dam 18 m. Galkadawala dam 16 m, Kimbulwewa Oya dam 14 m, Yakabemma dam 11.25 m, Wahalkada dam 11.5 m, Alubedda dam 10.5 m. The space between the two lines of timber columns at Deduru Oya Molaeliya dam was 9 m.

Yakabemma dam at Yan Oya

The ruins of the ancient largest dam Elahera dam witnesses a dam built with height and width relatively. Therefore the bund of this dam is wider than that of other dams. The width of this dam is 24 m. This nature of the Elehera dam has been so much beneficial to sustain the pressure of the water collected at the dam. The centre of the bund had been filled with earth or clay according to the remaining ruins.

4. The technology and the techniques

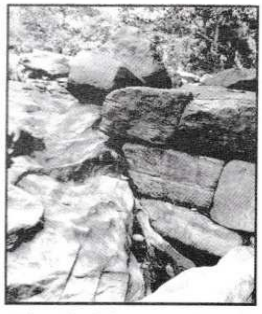
It is very obvious that the ancient technicians have applied very successful and effective techniques to construct dams very strongly with durability. Efficiency of the dam was expected to sustain the water pressure and to avoid leaking water from the dam. Different techniques had been applied depending on the place selected for the dam and medium selected for the construction.

1. Holding the dam bund on the earth firmly
2. Strength of the bund
3. Techniques of connecting the dam bund with the two banks

4.1 Holding the dam bund firmly on the earth

At ancient time technicians followed natural techniques to hold the bund on earth. This method varied according to the place where the dam bund was built and the medium they selected. This has been revealed with the evidence found. Although the water was not collected frequently and the speed of water changed the dam bund should have the withstanding quality.

In ancient time a suitable place with a natural layer of rock was selected to build stone made bunds. The stone blocks and planks were fixed together well to avoid slip off of stones.



Fixed with natural rock

On the natural stone layer, shallow trenches were dug up and stone blocks were fixed on it. This method has been applied at Elahera dam. If the rocks were not properly shaped stones were laid and fixed to level the surface. Ancient Haththota dam and Sukaranijjara dam are the example.

Molaeliyamankada at Deduru Oya is a very good example for a dam built with timber columns fixed on to the earth directly. The timber columns were dipped into the sand layer these logs had been dipped.

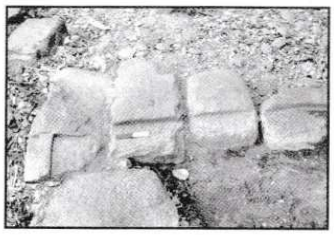
4.2. Maintaining the strength of the Dam bund

Technicians of Anuradhapura and Polonnaruwa period paid their attention to build the dam stronger at the very begging of the constructions. They had applied different techniques to put up the dam bund strongly on the earth they paid their special attention for the following:

1. Fixing stone block and planks with each other firmly
2. Protecting the vertical strength of the dam bund
3. Fixing the dam bund to banks properly
4. Controlling the washing off of river bank

4.2.1 Fixing stone block and planks firmly

When constructing a stone made dam, it was very necessary to fix stone blocks and plans so they do not slip off. The ruins found at these ancient dams prove this. This method differed according to the size of the blocks and planks and the nature of soil earth on which they were laid. Even at the same dam different methods had been applied. Among these, laying blocks and planks methods was popular. Evidence is found at Sukarnijjara and Yakabendiella dams for this.



Cuts on the stone blocks at Ridibandi ella dam

In some places, different fixing systems are found when laying blocks and planks. At Sukaranijjara dam to avoid the stone blocks' slip of cuts had been made in the form of ridges. Yakabendi Ella of Ma Oya is a good example for this. The larger stone blocks with heavy weight had been used. The clear evidence is the remaining ruins scattered on the ground.

Plaster applying system was use at the places where the stone block and planks could not be fixed with each other. Lime mixture, which becomes solid with the contact of water, had been used.

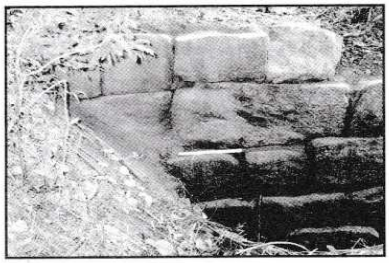
4.2.2 Maintaining the vertical strength of the dam

Evidence is found with the dams which were built to the height of 6-7 m. according to the location of the place. Elahera dam and Galkadawala dam at Malwathu Oya provide examples for this type. Ruins found reveal the Ilukwewa dam at Yan Oya and Yakabandiella at Ma Oya also was built to the same height to sustain the pressure of water. The dam bund was built wider to protect the dam bund. Ancient technicians followed other techniques to maintain the vertical strength of dams.

At Galkadawala dam it is found that, among the stone layers the stone pillars were fixed vertically. The Galkadawala dam is the best example for this. Even at Elahara dam evidences are found to prove that this type of vertical stone pillars had been fixed. Square shape holes made on the rocks at Ambanganga provides the examples. Ilukwewa ancient dam at Yan Oya, which is completely ruined at the moment also provide some evidences. The best and very clear example for this type is the dam Ilukwewa at Yan Oya.

4.2.3. Fixing the dam bund with river banks

The strength of a dam bund depends on the way it is connected with the banks of the river. Ancient technicians tried their best to construct dam bunds so that the dam bund did not slip off due to the water pressure and to control the washing at of river banks. Another fact or was to stop water from leaking ancient ruins provide examples for their things.



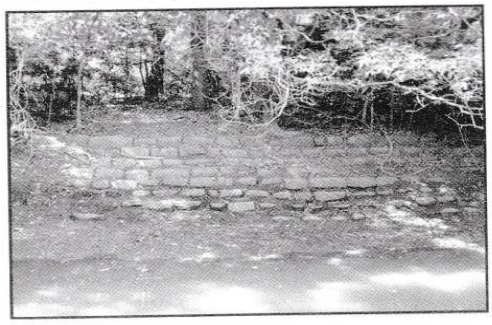
Dam connected with river bank at Ma Oya

The successful and effective techniques applied to connect the bund with banks are found with the ruins available at Yakabendiella at Ma Oya, Habagama and Wahalkada dams at Yan Oya and Yakabamma at Kala Oya. However according to my research studies I have been able to find many facts about the construction of Sukaranijjara dam at Deduru Oya. The escalation done here to collect information for my study has been the first study which reveals many things about dams.

In the past a trench with a length of 10-12 m. was dug from the river bank towards the land until the natural rock. This method had been applied specially in Sukaranijjara dam at Deduru Oya and some other dams. This technique was applied to ensure the safety of the dam.

Even with timber made dams the connection with the bund was properly maintained at Molaeliyamankada dam at Deduru Oya this can be seen. The left bank was dug into the earth, timber columns were fixed and filled with a layer of clay. The timber columns remained at the bottom near the bund and can be taken as very clear evidence.

4.2.4. Controlling the washing off of river bank



Sada panawa in Elahera dam

It was very important to protect the river bank close to the dam with the water over flowing the dam bund. There is a feasibility of damaging the bund of the dam which is affected by execs water flowing. The ancient technicians built safely ridges near the bank where the dam was built, to avoid the bund washing off. For this purpose large and big stone blocks and planks were used. This safely stone ridge was called "*Sada Panawa*"in ancient periods. This type of safety ridges or "*Sada Panawa*" can be seen at Kimbulwana Oya, Elahera and Angammadilla dams and some ancient dams at Yan Oya and kala Oya. Sometime these ridges were built rather above the river banks. Evidences are found close to Elahera dam on both sides of the banks of Ambanganga.