

# Gufaina dam in Ma'rib Oasis is a model of transformative dams in the pre-Islamic Kingdom of Saba architectural field study

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**ABSTRACT**

*One of the major sources of Pre-Islamic Arabian civilizations were water dams, which were given an important attention and developed architectures. The dams were varying from reservoir dams and transformation dams. The dam of Gufaina in Ma'rib oasis in the heartland of Saba kingdom is seem a model of the transformative dam built by ancient Sabaeen. The Gufaina dam works to impound and divert the water that comes from the north of the northern water source of the old Ma'rib dam, and it is the water that does not descend into the course of Wadi Dhanna. of it, discharging it and protecting the oasis fields, which are fed by the waters of the old Ma'rib Dam. It is clear from the dam's architecture that it continued to play its role in regulating irrigation in the oasis to later periods, perhaps dating back to the first Islamic period. his study aims to identify the architectural technology and building materials that have been used in transformative ancient dams of Arabia, that will be through a field study of Gufaina dam, which its architecture details is still preserved, and could reveal the design of water system, drain and the water quantity reservoir techniques.*

**Keywords:**

*Transformative dam; Gufaina; oasis; technology*

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نشرت هذه الدراسة في دورية كان التاريخية للأغراض العلمية والبحثية فقط، وغير مسموح بإعادة النسخ والنشر والتوزيع للأغراض تجارية أو ربحية.

## Introduction

The dam of Gufaina is one of the ancient water system in the kingdom of Saba, and it's one of the developed water system in Ma'rib oasis, which is not far from Ma'rib dam. Although there are several visible outstanding remains of Gufaina dam but the studies conducted of architecture in the area were not focused on the dam, its architectural design and water drain system. Some notes mentioned by DAI mission in Sanaa, when they conducted large scale survey in Ma'rib dam, Ma'rib oasis, Bran temple, Awaam necropolis and temple. Brunner, U mentioned the site within his archaeological report about Ma'rib, as well as Norbert Nebes studied some of the epigraphy of irrigation systems in other similar sites.

Moreover, the research published some notes about Gufaina dam architecture as a kind of comparative study. This study will include the geographical location of Gufaina dam, building design in this topography and the architectural details from purification and building style. As well as the irrigation system that was carried out in Gufaina Dam, and the areas covered by the dam water and the field. Undoubtedly, the study of the Gufaina Dam could represent a kind of research about the transformative dams built by the Sabaeans, and the idea of its architecture developed from the architecture of the ancient irrigation facilities in the Ma'rib Oasis, followed by the architecture of the ancient Ma'rib Dam, which is among the most famous ancient irrigation organisation in Arabia in general.

## An Overview

Gufaina dam

N 15.41989	UTM Zone 38	Height above sea level
E 45.28396		1193 m.

Gufaina dam is built in the northern bank of wadi Dhanah, which represented the major irrigation system of Ma'rib dam in the south-west of Roba al-Khali desert, which is so-called Ramlaat al-Sabien (Kühn et al, 2010) (Fig 1). Gufaina dam is the transformative part of the extra water of the Ma'rib dam that had drained through the northern drain, which is located at the lowest point of Ġabal Balaq al-Qiblī. Whereas the suitable topography of dams building were available in the area, which helped to change the desert into green oases. The large and small oases played a great role of the kingdom development in term of administration and political

position between the people royal families. Thus, during that time, social relationships developed and common interests established between the people lived there through the Irrigation systems. As well as the establishment of the irrigation systems encouraged the people from the rural areas to being centralized around the dams and they developed the ancient cities around the productions areas belong to irrigation systems localities (Harrowe, 2009).

Wadi Gufaina is located on the major stream of the valley, but there are many estuaries of the valley to the north of Mount (Al-Balaq Al-Qibli), their branches drained into wadi Gufaina, which increased the water of the Gufaina wadi and some of the water drained into aoses west of Jebel Al-Balaq Al-Qibli and wadi ALathba (Tueaiman 2018). (Fig: 2).

## Historical Background

Irrigation is the main sources of human settlement, but rather a symbol of attraction for human presence and populations. The growing of habitations around the eastern wadis reverses of ancient Yemen created the large villages around the valley reverses and the small oases from 5<sup>th</sup> – first millennium B.C. Which ended with the establishment of the ancient southern Arabian kingdoms, such as Saba - Mu'in Qatban - Awsan and Hadhramaut. (Harrowe, 2009).

The date was confirmed by recent study supported by charcoal samples collected from fire stone stove found in the sedimentation of irrigation areas in the Ma'rib Oasis and dated by C14 to 2600 BC (Kühn et al, 2010), which is contemporary of the relative dates given by Brunner for irrigation in Ma'rib (Brunner, 1983). There are other archaeological field studies conducted in sites near Ma'rib concluded that there is a sophisticated engineering technique of irrigation systems in Ma'rib Oasis, which dates back to the beginning of the first millennium BC, and the Ma'rib Dam is one of the oldest models for the emergence of such a developed irrigations system in the area (Brunner, 2000).

According to the ancient South Arabian inscriptions, many of them confirming the importance of the irrigation in Ma'rib Oasis since the beginning of the first millennium BC. DAI mission of Yemen discovered several inscriptions in jebel Balaq al-Qiblī 1and jebel Balaq al-Qiblī 2" dated back to the Saba's Makrab period, Yath Amr between the second half of the eighth century BC (Nebes, 2015a)

The restoration of the Irrigation system in Ma'rib dam and oasis, which is the dam of Wadi Gufaina one of the irrigation installations for this system.

One of the main historical indications is what King Sharhabeel Yafar left in the inscription marked with (CIH) dated in the month of Dawn in the year 565 Himiri. Which corresponds to 450 AD. The restoration and conservations procedures in the dam included removing the silt accumulated, which might damage the dam, and the dam building by rocks later, as well, major water drainage channel have been constructed, which is mentioned in the inscription (Raham), and that was in (28) days (Robin 2013: ). The architecture of Wadi Gufaina dam may date back to pre-Islamic period, which is the period that the ancient Ma'rib Dam was reconstructed due to the similarity of building materials such as limestone and mortar with (Noura and plaster).

### Archaeological fieldwork

Based on the study aims to identified irrigations unit, our plan based on archaeological survey of the area surrounding the dam to identify the relationship of the dam to the ancient Ma'rib Dam, and the reserves of the wadis in which the waters of the Gufaina dam drained. The archaeological survey supported by architectural measurements of all dam features using meters and GPS coordinates. As well as Drone images were used to clarify the aerial picture of the dam in general. Moreover, the quality of building materials and components were studied from some samples have been taken.

### General description and irrigation system

Wadi Jufaina dam is located in the lands of the northern paradise, this area is mentioned in the inscriptions as (ABIN) and opposite it on the other side of the oasis of Janabiyah, which was mentioned as (YSRN). The length of the oasis is 22 km and its width is 8 km, and it was divided by Dhanah wadi into two main parts. The name of the oasis was mentioned in general as (SRI H W) in the form of Muthanna and the intention is the oasis of Marib (Shr 18/3), and the inscription (Fa 17-6). The area of the northern oasis is about 3750 hectares and the southern oasis is about 5700 hectares, in addition to Wadi Gufaina, which is located north of the oasis (Maraqten, 2005). (Fig: 3).

Wadi Gufaina dam occupies the lower area of Saila Wadi Gufaina. The depth of the dam's is about 10 meters from the level of the oasis (Northern Paradise). This is identified from the natural depressions in the silt deposits (irrigation residues), which were accumulated over the ages. That indicated of Gufaina dam buildings has been

completed later time comparing to the irrigation system in the oasis (Brunner, 1983)

Wadi Gufaina dam is a type of transformative dam. It's known by this name in relation to the valley where the dam was built. The dam function is focused on diverting water to agricultural lands near the dam site (Nebes, 2015a). Wadi Gufaina dam is located 2.7 km east of the northern bank of the ancient Ma'rib Dam. It is bordered on the north side by the volcanic *harrat*, and from the western side by Wadi Gufaina, and on the southern side by agricultural lands on the southern bank of Wadi Gufaina, and from the east by Sailat al-Wadi. A number of wadis that confluences into Wadi Gufaina, and those drained from the areas surrounding the dam from the north and west. The dam was built in an area that helps reduce the cost and effort of dam construction according the area topography from the rocky land and mountains. The dam of Wadi Gufaina was called (the building) AL-Mabna (Brunner, 1983).

### The general plan of the dam

The locations of the water administrations are usually chosen in specific topography in order to control the largest possible quantity of water, taking into account the construction of the dam by draining the amount of water rushing strongly, which is reflected in reducing the pressure on the dam walls and the main drainage channel, and thus we find that the general plan of the dam architecture taken into account the above standers. Where the dam has been divided into three main walls, extended in large space and different directions according to each wall function, these walls named as the following: A- B-C: (Plate: 1) Fig: 4-7).

Western Wall (A): The function of this wall is to transform the waters coming from the main Gufaina dam, and the wadis around it on the western part, as it came in a semi-straight design. It extends 183 m until it intersects with Wadi Gufaina, which is the total area of the (current) wall). According to the Drone image the wall extended more than 183 m, and this wall transformed the water drained from the main wadi which takes a diagonal shape with the valley fluid to confine the water to the wall (B) and control it through a single port between the wall (A) and the wall (B). (Fig: 8-9).

Middle wall (B): It is the wall that started at a distance of 5 m before the confluence point of the wall (A) and extends in a curve shape with a length of 42 m, and later on with a length of about 217 m and in a way line shape in the middle area of the dam. And is linked at its end in the northwest

direction to the small volcanic mountain. The width of the wall is about 3.73 m, and the wall covered an area of 3 m. The height of the wall in the current period is 4.5 m, which is an average measurement, while there are differences in heights based on the function of each wall unit (Fig: 4).

Middle wall (C): It is the third wall of the dam, and it is the wall that extended parallel to the middle wall B. This wall is longest than B. The extended in wavy shape and its length is about 289 m and thickness 5 m in the upper part and about 4.5 m in height. It is the most meandering wall between the volcanic *harrat* located north of the dam, and the dam wall ends with its connection to a small mountain in *harrat* (Fig:11-12).

At the confluence point of the walls A - B, there is a wall in the middle that complements the wall B, which is the wall through which the process of narrowing the water collection point takes place, and its architecture has varied more, so that it is 42 m long, 4.5 m high at the present time, and 3.5 m wide. The area of confluence, walls built by special architecture. And it is neighbor the wall C, is the most curved wall, and attached to the perimeter of the building is a small building (basin) at the curve point of the wall in wide 5 m (Fig: 5).

### Material buildings

It is well known that the natural materials available in the local area were the most favorite material in construction of ancient cities and architectural unites, taking into account the type of the architectural unit. The irrigations unit are much different from the other ancient buildings, such as castles, palaces or temples. Based on that we found the Gufaina Dam was built from the materials that are available locally, and some of them were manufactured in the area.

Rocks or stones: The architect will use stone materials based on the type of the rock and the way they are built in the longitudinal walls of the dam, and thus the construction of the walls was limited to black basalt stones (which are local stones of volcanic *harrat* located north of the dam site, and they were of different sizes, including medium, large and small slabs, These stones were widely used in randomly filling the area between the external courses to fill the gap and increase the height of the dam wall.

The architect also used balk stones (limestone), which is one of the types of stones that were brought from the western Baluk Mountains from close to the dam area. These materials were used in the external walla because it easy to reshape and

polishing in the architecture courses and its used in the external water outlet points (E-F).

Clay: The mud and natural soil around the dam area are among the materials that were used in building the dam. It is the accumulated mud material that was used to backfill and reinforce the dam wall (A) from the outside (southeast) so that the diversion dam wall could withstand the speed of the flowing water with high force from wadi Gufaina erosion.

Al-Qaddad: Since the building unit is a water architecture, the process of plastering the external parts of the building must be done, as all the external parts of the building on both sides were plastered with (Al-Qaddad), which is known as "Nora" and mixed with volcanic pebbles or gravels, and its grinding and fermented with water for long times, then plastered on the external walls, especially the walls facing the water (Fig: 13-14).

### Dam building technology

The construction design or technology are differing in water units, this difference comes from that it resists the largest amount of water force flowing with a high force from the wadi streams, and thus the technology of the walls rebounding inward and rising to the top was used as its building tapers to reduce the thickness of the wall. This technology reduced the force of the water impulse, and extend the life of the building with the factors of erosion and its interrelationship, especially in terms of height, as we find that the construction of those walls still retains a lot of architecture and building materials. Thus, only wall A and wall C were the most importance in terms of height. Wall A built by three setbacks at the bottom from its end point and ends with one setback to its highest point, and wall B constructed with three setbacks, while wall C built by five setbacks at the bottom, two of them in the middle and they are similar in measurements, the middle is smaller and on the top two similar setbacks in size.

The construction technique of walls E-F is different in terms of construction technology, as it is the area on which it depends in the water control, and therefore, it built carefully, where the architectural purification was known as the overlapping technique, which is the overlapping of the walls with each other, meaning that the stones of each course match the stones of the other course alternating between them and with lime stones of longitudinal sizes. Each course differs from the course below (Fig: 6-15).

## Water collection and irrigation system

The German mission field work in Ma'rib oasis tried to approximate the viewpoint about the irrigation system in the oasis in general, including Gufaina wadi Dam, which is known to them as the AL-Mabna dam. And published in their preliminary field reports, when the architectural researcher Brunner, U. His study was devoted in the second part of those reports, and they put the Gufaina dam as part of the ancient Ma'rib Dam system (Brunner, 1983).

Based on the field study carried out by the author and the results of the previous studies of the German mission (DAI), it is better to start with the question, what is the reason for building the dam in this region, as there is the ancient Ma'rib Dam which is among the most important and largest irrigation structures in the Ancient Arabian civilizations in general, but the main reason of Gufaina dam construction in this area is that Wadi Gufaina drops the waters from the small water channels or branches, which they drained from the area close by ancient Ma'rib dam concession. And therefore it is one of the wadis that are not included in Wadi Dhanna, where the dam was built. And the second reason is that the Gufaina dam is a diversion dam that transforms The torrential waters that drained during different seasons from the flow of the ancient Ma'rib Dam, which seemed to come from far away, and if the floods of the Jufaina Dam and the wadis near it may cause the destruction of the northern oasis fields, and thus the dam was built to divert, control and drain the waters of those channels to irrigate agricultural lands, which is located in the northeast of the oasis (Northern Paradise).

Hence, Gufaina dam has diverted water through two outlets, the first is the outlet that drained from the area in-between wall A and wall E, and the other outlet is the one for which the stone basin is allocated between wall C and wall D. The control is carried out through two narrow outlets by means of a closure place of it during the restoration time of the water, and the water should have opened at the time of need through wooden drains. The traces of the entrances to those wooden drains of the lime stone wall are still observed and differently (Fig: 6).

## Results

Results of this study about Gufaina dam as follows:

- Gufaina Dam is one of the major irrigation system in the Ma'rib Oasis in general, and it was part of the auxiliary system of the ancient Ma'rib Dam.
- Gufaina Dam is one of the diversion dams that diverts water from the wadis to irrigate agricultural lands in the northern Paradise fields from the Ma'rib Oasis, which did not reach the waters of the ancient Ma'rib Dam due to its location in the lowest drop point of about 10 m.
- Gufaina dam was built to protect the agricultural fields located within the lands of the oasis (Northern Paradise), which are in open areas and dams of neighboring areas may come during the rainy seasons and may lead to their destruction.
- The study clarified the main architectural technique of water drainage in the ancient Ma'rib Dam, with that technique in the drainage of the transformative dam in Gufaina dam.
- The study showed the different building materials in the construction of transformative dams in the pre-Islamic Kingdom of Saba.
- The study presented the technique of building rebound walls that relieve pressure on the dam wall from the force of water flow and increase its quantities.
- The study showed that the Gufaina Dam was built at the end of the irrigation use in the Ma'rib Oasis, and the continuity of irrigation in it continued until after the collapse of the ancient Ma'rib Dam at the end of the 6<sup>th</sup> century AD.

Appendix



Fig: 1 Map represents the location of Mārib in the map of Yemen and neighboring countries. Fig: 1



Fig2: 1(Map: 2) All the estuaries of the valleys adjacent to Wadi Gufaina, specifying the location of the dam. Francaviglia,2000,).



Fig: 3 Schematic plan of the ancient oasis of Mārib (Hitgen, 2005)

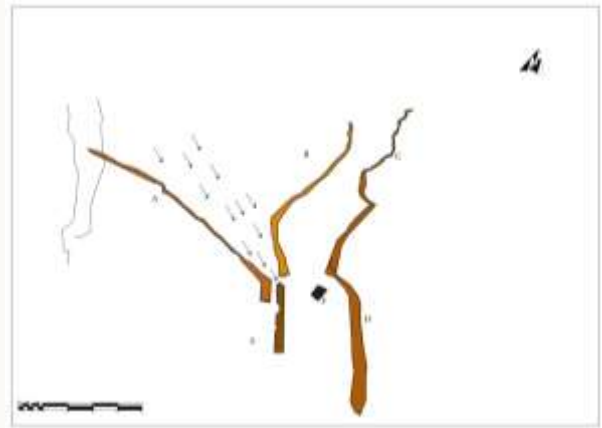


Fig: 4 Horizontal projection of the components of the dam building.

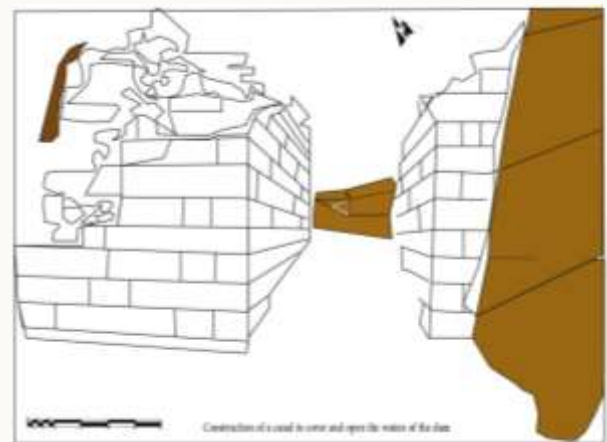


Fig: 5 The construction of the dam channel for the exit of water and its control.

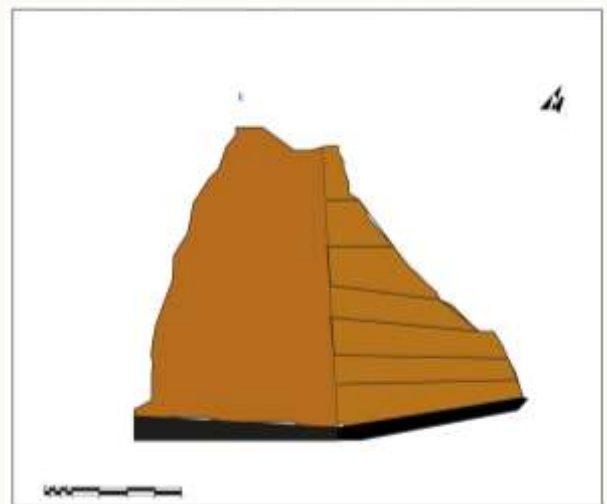


Fig: 6 Architectural facade of section (E) building in good condition.



Fig: 7 An aerial view of Wadi Gufaina Dam



Fig: 10 duct outlet wall (A)



Fig: 8 Picture from the south direction showing wall (A), wall (B) and wall (C).



Fig: 11 Extension of wall (B) from the eastern side.



Fig: 9 Picture from the east direction, showing the walls (A) (B) (C) (D) (E) (F).



Fig: 12 Dam wall architecture inserts (C).



Fig: 13 Building materials in the dam wall from the inside.



Fig:14 Water outlet building in the main channel.



Fig:15 Coherence of architecture at the confluence of the two walls (A) and (B).

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تُعَدُّ منشآت الري القديمة من أهم مقومات حضارة الممالك العربية القديمة قبل الإسلام، حيث اهتم بها إنسان تلك الفترة، وكثف جهوده في عمارتها، وقد تنوعت تلك السدود بين السدود التحويلية والسدود التخزينية ونحوها، وبهذا يعد سد وادي الجفينة في واحة مأرب بأراضي مملكة سبأ نموذجاً للسدود التحويلية التي شيدها الإنسان السبئي القديم، ويعمل سد جفينة على حجز وتحويل المياه التي تأتي من شمال المصرف الشمالي من سد مار ب القديم، وهي المياه التي لا تنزل في مجرى وادي ذنه، وإلى جانب ذلك كان يقوم السد بحماية الحقول الزراعية التي تأتي عليها فيضانات الأودية الشمالية من واحة مارب من أجل الاستفادة منها وتصريفها وحماية حقول الواحة التي تغذيها مياه سد مارب القديم. ويتضح من خلال عمارة السد أنه قد استمر يؤدي دوره في تنظيم الري بالواحة إلى فترات متأخرة ربما تعود إلى الفترة الإسلامية الأولى. وتهدف الدراسة إلى توضيح التقنيات المعمارية ومواد البناء والأسلوب المعماري في بناء السدود التحويلية القديمة في الجزيرة العربية، من خلال الدراسة الميدانية لسد وادي الجفينة، والذي ما زال يحتفظ بحالة جيدة من تفاصيل العمارة الدالة على تنظيم المياه وتصريفها بطرق وتقنيات تتناسب مع كمية المياه.

**كلمات مفتاحية:**

سد تحويلي؛ الجفينة؛ العمارة؛ الواحة؛ التقنيات