GROUND LEVEL RESERVOIRS AND ELEVATED STORAGE TANKS

Johan Smit
Department of Civil Engineering, University of Pretoria, South Africa

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Contents

Summary

The history of the development of service storage reservoirs for storing potable water is traced from Egyptian and Roman times to the present. The details of shape and materials used for creating ground level reservoirs and elevated water tanks are presented. Aesthetic and ecological principles for the creation of sustainable and attractive landmarks in cities and towns are outlined.

1. Introduction

The sustainability of all the activities of modern humans, especially in areas where large concentrations of population occur, is not possible without the availability of enough freshwater. To ensure an uninterrupted supply of potable water it is necessary to provide adequate storage capacity; for this purpose ground level reservoirs and elevated storage tanks are constructed.

2. Historical Background

In ancient times the Egyptians settled along the fertile valleys of the Nile river with sufficient surface water available at hand. In western Asia, large settlements took place along the Tigris and the Euphrates Rivers, within the area called Mesopotamia between the two rivers; once again abundant surface water was the key resource for agricultural and domestic needs.

As time went on, the water needs for expanding concentrations of people, further away from natural water sources, became more sophisticated, such that by ca. 75 AD, Rome, the capital of the Roman Empire, employed a Curator Aquarium, the famous Sextus Julius Frontinus, who was charged by the Emperor himself to take responsibility for the water supply of Rome.

In comparison with the modern cities of today, the Romans had quite a sophisticated lifestyle, with such facilities as public swimming baths and water on tap in multistory apartment buildings. This required the storage of water at different locations and elevations. By ca 206 AD, apart from nearby surface water sources, eleven aqueducts supplied the city of Rome with more than 1000 kiloliters of water per day. These aqueducts were built to suitable gradients to provide for the flow of water under gravity, thus eliminating the effort to carry water manually (see *Water Conveyance Systems and Flood Control Works*).

Some of these aqueducts were built over very large distances from the water source to the delivery point, elevated over depressions and sometimes tunneled through mountains to provide for a suitable gradient as shown in Figure 1. One of the aqueducts, the aqua Claudia, built ca 38 to 52 AD, was 69 km long, with a maximum height of 32 m over one of the valley crossings which was 11 km long. It is of specific interest here to note that the Romans had extremely well-developed construction skills which included the manufacture and application of concrete and the necessary shuttering systems.

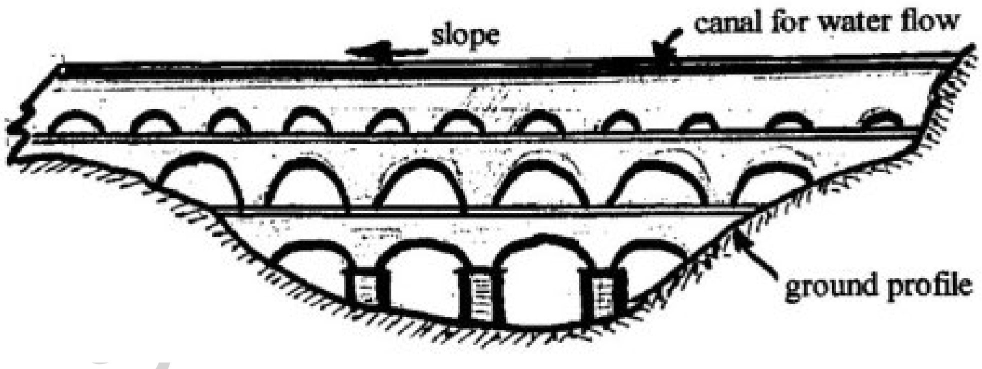

Figure 1. Typical elevated Roman aqueduct crossing a deep valley

With the water available from the aqueducts, near or at specific locations in the city, the necessity of storage facilities became apparent. Private domestic storage mainly consisted of spaces dug into the rock, but the big storage reservoirs which finally received water from the aqueducts were constructed according to one of three distinguishable types:

- chambers with pillars or columns, covered by vaulted roofs supported by columns, shown in Figure 2(a):

- barrel-vaulted chambers, shown in Figure 2(b); and
- parallel chambers.

It is appropriate here to note the difference between the metered water demand system of modern water authorities and the constant flow delivered by the aqueduct to major cities in Roman times. The latter difference makes it impossible to compare the storage volumes of the ancient cities with that required by the cities of modern times.

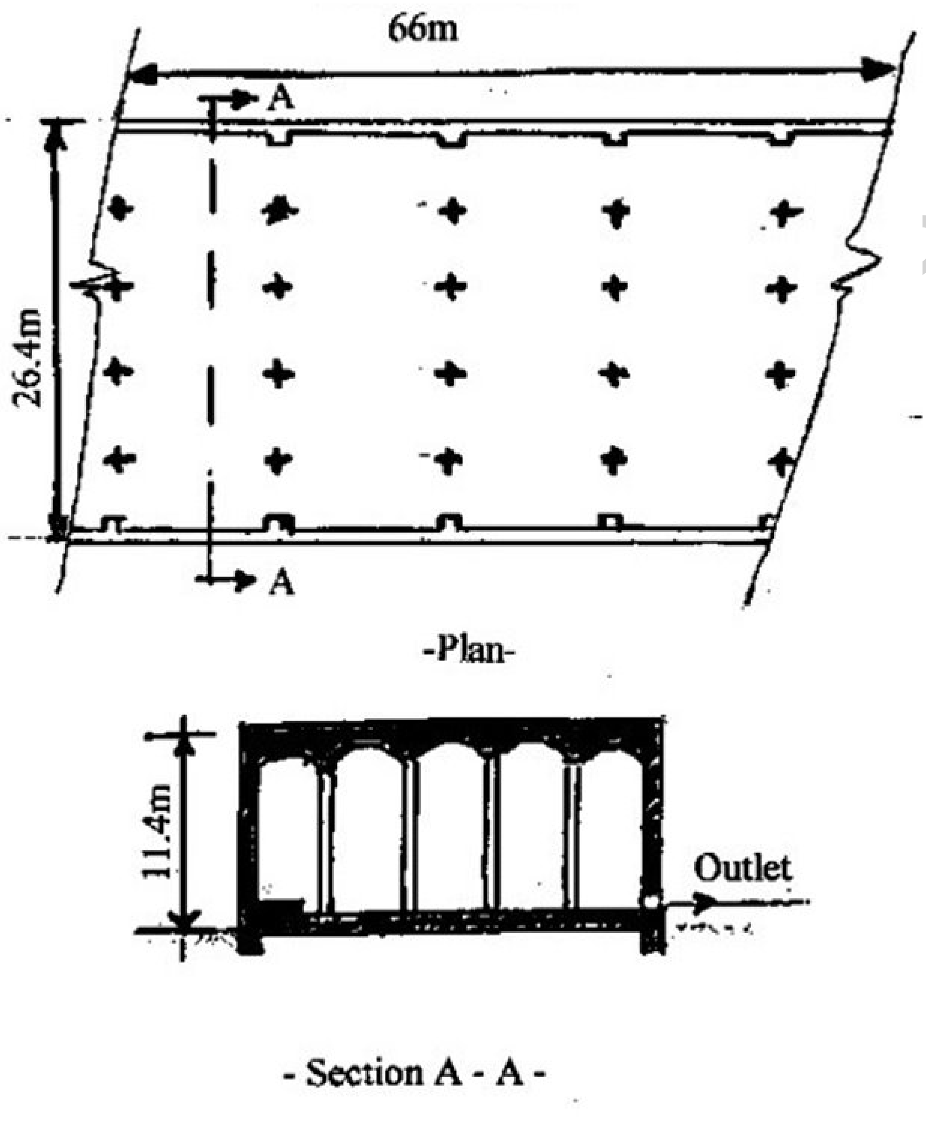

Figure 2(a). A Roman reservoir with vaulted roof supported by columns

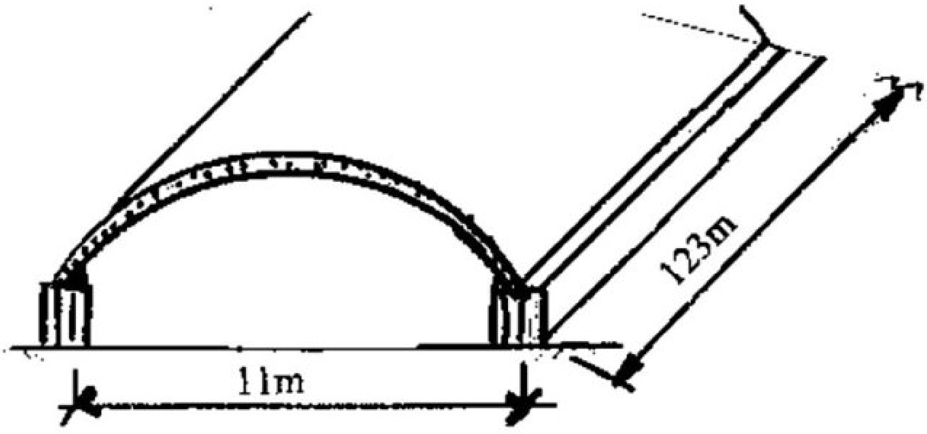

Figure 2(b). A Roman reservoir with barrel-vaulted chambers

3. Factors Influencing Storage Facilities Required for Reliable Water Supply to Towns and Cities

When engineers plan and design the water supply for a modern town or city they must determine the size of storage facilities required. The quantity of storage is influenced by various factors, such as population size, per capita daily consumption, commercial and industrial needs, public use, etc. The average daily per capita water consumption for American cities varies widely, with typical figures of 150 liters to more than 2000 liters per capita per day. Such variations are dependant on factors such as size of city, climate, characteristics of the population, cost of the water, efficiency of the works administration, etc.

The annual average daily consumption is a very useful figure for engineers, but does not tell the full story. Climatic conditions, such as hot dry weather cause days of higher consumption to occur, placing more severe demands on the reticulation and storage facilities.

Over a period of a 24-hour day, water consumption shows large typical variations, as shown in Figure 3. Note the typical peak when the day's activities commence and minimum values during the night.

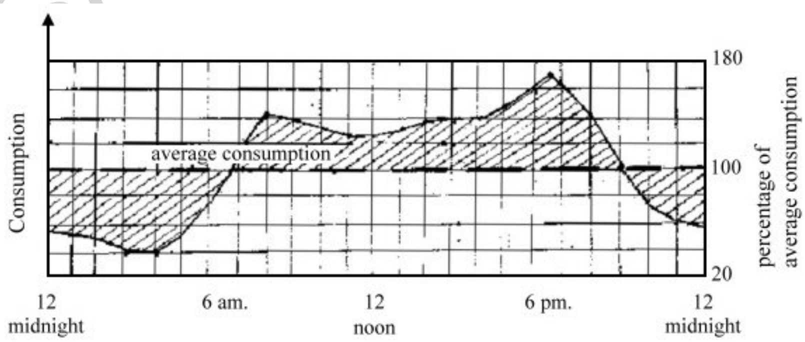

Figure 3. Typical variation in urban water consumption throughout the day

If the water is supplied to the storage reservoirs at a fairly constant rate, the size of the storage reservoir must be sufficient to allow for the above-mentioned factors causing fluctuations in the consumption.

The risk of an interruption in the supply to the storage reservoirs, as well as fire-fighting demands, must also be provided for. Covered service reservoirs form an integral part of the water distribution system, with their primary purpose the balancing of the daily fluctuations in demand on the one hand, and supply, such as the rate of pumping, on the other hand (see *Guidelines for Potable Water Purification Works*).

Service reservoirs are usually constructed at the highest possible level necessary to serve consumers at different lower levels. If the elevation of the available site is not sufficient, booster pumps and/or elevated storage tanks (water towers) may be required.

4. Types of Service Reservoirs for Storage of Drinking Water at or near Ground Level

Service reservoirs may be built on the ground or partially into the ground. For reservoirs built partially into the ground the excavated soil is used for banking material for the walls and covering the roof.

Water storage tanks are usually circular or rectangular in plan, with vertical or sloped exterior walls. In Figure 4 a few general types are shown.

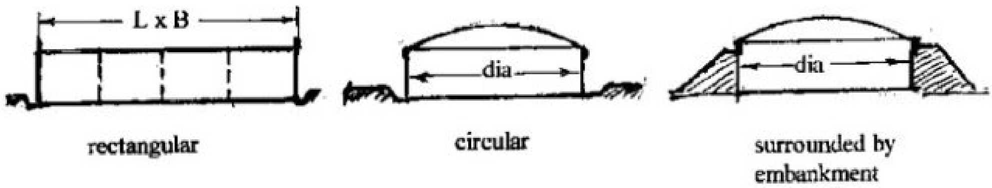

Figure 4(a). Typical 1 to 25 megaliter capacity reservoirs

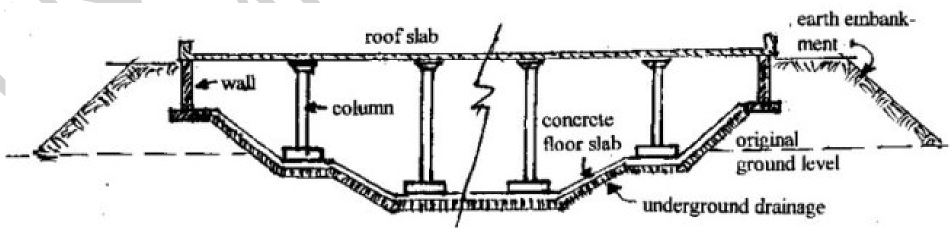

Figure 4(b). Vertical cross-section through a very large reinforced concrete reservoir of 50 to 500 megaliter capacity

5. Construction Details of Service Storage Reservoirs

It is common practice to construct large service reservoirs of structural concrete (reinforced and/or prestressed). Typical service reservoirs are usually circular in plan for volumes up to 50 megaliters, with a maximum water depth preferably not more than

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Biographical Sketch

Johan Smit is a Senior Lecturer, specializing in structural design. His special interest is in giving postgraduate design courses for water-retaining concrete structures, at the University of Pretoria, Department of Civil Engineering and its Department of Architecture, Landscape Architecture and Interior Design. He graduated from the University of Stellenbosch, in Science and from the University of Pretoria in Civil Engineering. He is a registered professional engineer in South Africa. He is a recognized authority in his field of specialty in structural design with engineering materials. He is active in consulting engineering practice in reinforced and prestressed concrete, and structural steel construction, in the water engineering field in South Africa. His specific interest is the design of concrete structures for water retaining vessels.