Chapter One

Introduction

1.1-General

Water harvesting means capturing rain water where its falls and capture the runoff from catchment and streams etc. generally water harvesting is direct rain water collection this collected water could be stored for later use and recharged in to the ground water again.

The following storage and distribution systems are described in the Fact Sheets

1- concrete-lined earthen reservoir;
2- reinforced concrete reservoir;
3- elevated steel reservoir; Ferro cement tank Distribution
4- public stand post;
5- domestic connection;
6- Small flow meter.

These lists are not exhaustive, but have been selected as being most relevant to small community water-supply systems. Of the storage options reviewed, the concrete-lined earthen reservoir is the only system that is suitable for storing raw water, and the O&M of such a system should consider the possibility that a raw water source will be used. A water- lifting method to get the raw water to the storage reservoir may be necessary and this should also be considered in the O&M implications. In many cases, a concrete-lined earthen reservoir can be used instead of open concrete reservoirs. Flow meters are only discussed in general, and no comparison is made between types and brands, because this is outside the scope of this manual. However, the decision to install flow meters has important operational and organizational implications.

1.1.1-Background

The survival and development of human beings depend on water; its quality and quantity. For ages, many people have been under the illusion that water is abundant, taking for granted that it is a gift from nature and is an inexhaustible resource that is there for the taking.

Safe water and sanitation coverage in Uganda is still low and this remains one of the biggest develop- mental challenges. It has been estimated that access to safe water within 1 km distance is 65% in rural areas (MWE, 2015). Access to safe water and sanitation services has not been equitably distributed to communities in Uganda due to lack of adequate surface and groundwater potentials in water stressed areas.

The goal of “Safe Water and Sanitation for All” set by the International Water Supply and Sanitation Decade (IWSSD) in the 1980s and now extended to the year 2030 may only be a distant dream at best if there is no increased investment in water supply.

One way to address this formidable challenge is to encourage investment by the families, schools and health centers. In the past this has been possible as families and some institutions would invest in traditional rainwater harvesting technologies that would range from pots to jars to tanks, to provide convenient water supplies that they manage and maintain themselves. Many rural people value these water sources for their convenience, taste, productive use and most importantly, the actual ownership and control bestowed. Relatively small investments by families could thus add up to the massive investment needed to reach the national target on safe water access.

Rainwater harvesting through roof catchments is being promoted in the Water sector because it is an optimal method, affordable and manageable by communities in the water stressed areas both at household and institutional levels through construction of rainwater harvesting tanks, mobilization of communities, sensitization and advocacy and training of the private sector to enhance and boost on their skills in RWH tank construction and its management.

The uptake of rainwater harvesting in all Districts in Uganda is still very slow. Very few families or even schools and health centers have been able to take up the technology as a viable option for provision of water. Moreover, Uganda is endowed with high levels of rainfall in most parts. According to the Uganda Bureau of Statistics, National household survey (2009/2010), at least 62% of houses in Uganda had an iron roofs and hence can harvest rainwater. Rainwater harvesting particularly through roof catchment, is being promoted because it is an optimal method, affordable and manageable by the low-income community members both at household and institutional levels.

The (MWE,2015) would like to promote rainwater harvesting in every family and institution through provision of this Handbook. The objective of the Handbook is to provide communities and Institutions a range of rainwater storage options that can be promoted in various parts of Uganda. Under each technology option technical details on design, Materials, tools required, construction guidelines/steps, and esti-mated costs, among others, are provided.
History of Rainwater Harvesting in Uganda Traditionally, communities and private individuals have owned and managed water sources with minimal government support. Rain water harvesting technologies which included banana stems and collection in containers like saucepans and pots were very common. During the colonial period large water storage systems were particularly constructed at administrative buildings.

The year 1997 witnessed the unsuccessful re-introduction of institutional rainwater harvesting collection. The limitations in managing these facilities led to the shift to household collection and storage (Domestic Roof Water Harvesting). In the same year, the Uganda Rain Water Harvesting Association (URWA) was established in the sector to promote Domestic Roof water harvesting technology and has done much to raise awareness and identify potential and technical solutions. The years 2003 – 2004 the Go U prepared a strategy for rainwater in Uganda, centering on promotion and capacity building of communities and the development of enterprise to provide facilities. It divided the promotion of the technologies into an NGO delivery mode, involving promotion and capacity building of communities and a private sector mode, which is based on the development of enterprises to provide facilities. Domestic Roof Water Harvesting Started to be included in the activities of other NGOs throughout the country. Most of these organizations were building facilities for water users. Some were training masons and women's groups to construct facilities. The usual concept was to support the masons to construct demonstration facilities to trigger other households to invest their own financial resources in them. Traditional savings groups, with revolving loans were among the strategies used by households to finance construction. In 2004 MWE further supported the piloting of Domestic Roof Water Harvesting, through NGO delivery mode, sending a signal of growing government support of technology.

1.1.2-Advantages and Disadvantages of Rainwater Harvesting

1-Advantages

There are a number of advantages from rainwater harvesting as a low-cost technology for household and institutional water supply.

I. It is affordable for low-income communities.

II. Beneficiaries have improved water security, better quality of water and majority of the technologies are user friendly and have a long life span of over 10 years (URWA Bulletin August 2005).

III. Time is saved from collection of water from other conventional sources (springs, boreholes, shallow wells). This is a key benefit for women and children especially the girl-child who bear the burden of collecting water for the family.

I. Localizing water facilities at household and institutional levels provides a better opportunity for proper operation and maintenance and utilization of water facilities by users themselves.

II. During the wet seasons, the presence of rainwater storage within the compound would encourage the household and institutions to use more liters per person per day with the corresponding associated health benefits.

III. Opportunity for skill development and income generation among individuals such as masons (Figure 3)

IV. There are associated health benefits as a result of access to safe water.

V. Promotes agriculture production hence generating income for many households

VI. Water from Domestic Rainwater Harvesting (DRWH) tanks is comparable in cleanliness to that fetched from protected rural point sources, averaging faucal coli form counts of around 10 per 100 ml (just about WHO 'low risk'). Chemical quality and laundry-softness is superior and taste generally is superior to water from rival sources. Affordable techniques are known by which quality can be further improved if required (URWA, 2006)

2-Disadvantages

(i) Storage systems are expensive and not affordable by many households.

(ii) Depends on seasons – may not provide water throughout the year.

(iii) The quality of rainwater is affected by cleanliness of the catchment surface.

Domestic roof water harvesting.

1.2-Research Problem.

Millions of Sudanese suffer from lack of potable water, and although the country is stretched by the Nile River, the water crisis is a concern for a number of Sudanese states, where many people depend, especially in distant states, on rainwater, underground and surface wells and many rural areas. The population and their livestock are partners in the water resource, often "fossils or canals". It is not an exaggeration to say that the water crisis in Sudan has become an integral part of the Sudanese diaries. They either have to buy water or use traditional means to store it, in the hope that the government's promises will be realized.

1.3-Significant of research.

The importance of research in the design of two reservoirs for water storage using the Egyptian Code in the design of drinking water purification plants and the British Code in the design of concrete floor tanks and upper reservoirs

1.4-Research hypotheses.

1- What is the type of water harvesting reservoir?

2-What are the guidelines for designing the pipe line according to EYGEPT CODE.

2-What are the guideline for designing the underground R.C water tank & elevated steel water tank according to BS CODE.

1.5-Objective of Research: -

1-To know type of water harvesting.

2-To make study about the design of pipe line.

3- To make study about the analysis and design of underground R.C water tank.

4- To make study about the analysis and design of elevated steel water tank.

1.6– Methodology of conduct a search

In this case we take the construction of agadi water supply project surrounding villages' phase (2) we use the Egypt code to design this station from Egypt code No (101) – 1997 ECP 901-1997.

Chapter Two

Literature Review

2.1-Introduction

As mentioned in Chapter one, there are many ways of harvesting water. All these methods basically fall under three main categories viz.:

- Surface water collection.
- Ground water collection.
- Augmentation of ground water recharge.

The methods which are particularly useful in augmenting drinking water availability especially in the rural areas and which can be easily adopted at a moderate cost with the involvement of the local people are discussed in the following pares.

2– Roof Top Harvesting

Rain water may be harvested in areas, having rainfall of considerable intensity, spread over the larger part of the year e.g. the Himalayan areas, northeastern states, Andaman Nicobar, Lak shad weep is land sand southern parts of Kerela and Tamil Nadu. This is an ideal solution of water problem where there is inadequate groundwater supply and surface sources are either lacking or insignificant. Rain water is bacteriologically pure, free from organic matter and soft in nature. in this system, only roof top is the catchment (see Figure 2.1, 2.2 and 2.3). The roofing should be of galvanized iron sheets(G.I.), aluminum, clay tiles, as best or concrete. In case of thatch-roof, it may be covered with waterproof LDPE sheeting. For collection of water, a drain is provided (Gutter) along the edge of the roof. It is fixed with a gentle slope towards down pipe, which is meant for free flow of water to the storage tank. This may be made up of G.I. sheet, wood, bamboo or any other locally available material. The down pipe should be at least100mm diameter and be provided with a 20 mesh wires screen at the inlet top event dry leave sand other debris from entering it.

During the period of no rain, dust, bird droppings etc. accumulate on the roof. These are washed off with the first rains and enter the storage tank to contaminate the water. This can be prevented by two methods:

(a) Simple diversion of foul water

(b) Installation off our flush system

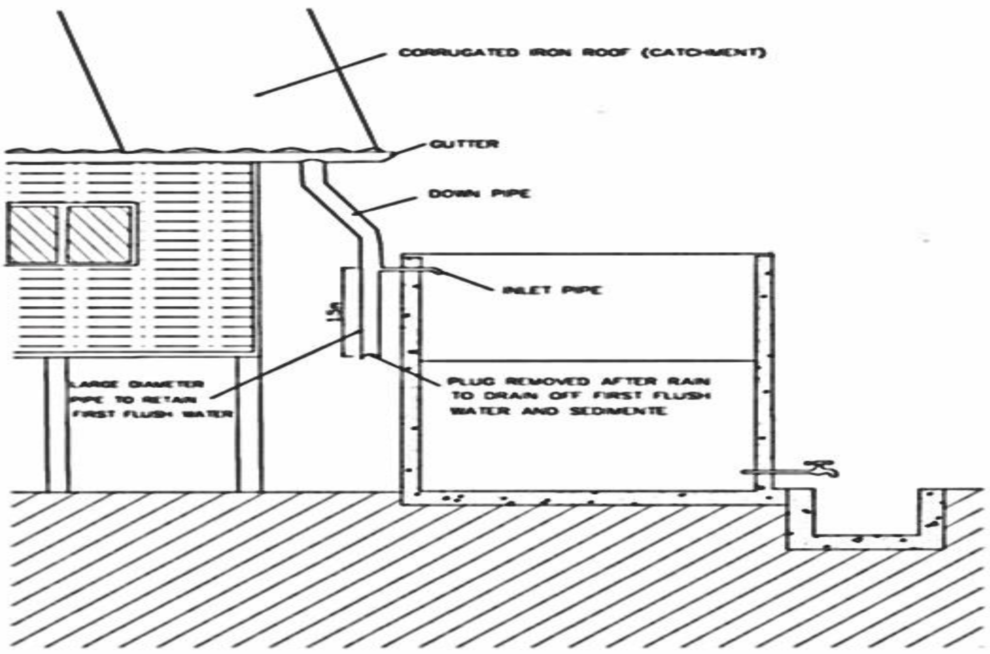


Figure 2.1: Typical Roof Top Harvesting Structure

Under method (a), the down pipe is moved away from the inlet of the storage tank initially during the rains, until clean water flows. Under method (b), storage provision for initial rain is kept in a pipe. These are cleaned off after each heavy rain. These are provided between down pipe and the storage tank. Filter materials such as sand, gravel or coconut/ palm be telnet fiber etc. Are used as filter media. Storage tank can be constructed underground or above ground. The underground tank maybe masonry or R.C.C. structure suitably lined with water proofing materials. The surface tank may be of G.I. sheet, R.C.C., Plastic/ HDP or Ferro cement Tank placed at a little higher elevation on are is platform. To facilitate Tec leaning of the tank, an outlet pipe may be fitted and fixed in the tank at bottom level. The size of the tank will depend upon the factors such as daily demand duration of dry spell, catchment area and rain fall. The tank is provided with: a manhole of 0.50m×0.50 m size with cover m Vent pipe over flow pipe (with screen) of 100mm dia. Drainpipe (100mmdia.) at bottom Choice of the tank depends on locally available material sand space available. When the tank is constructed underground; at least 30 cm of the tank should remain above ground. The withdrawal of water from the underground tank is made by installing hand pump on it. In case of surface tank, tap can be provided. Before the tank is put into use it should be thoroughly cleaned and disinfected with high dosage of chlorine. Since the water shall remain stored for quite a long time, periodical disinfection of stored water is essential to prevent growth of pathogenic bacteria. Typical drawings of roof water harvesting structures are shown in Figure 2.1, 2.2 and 2.3.

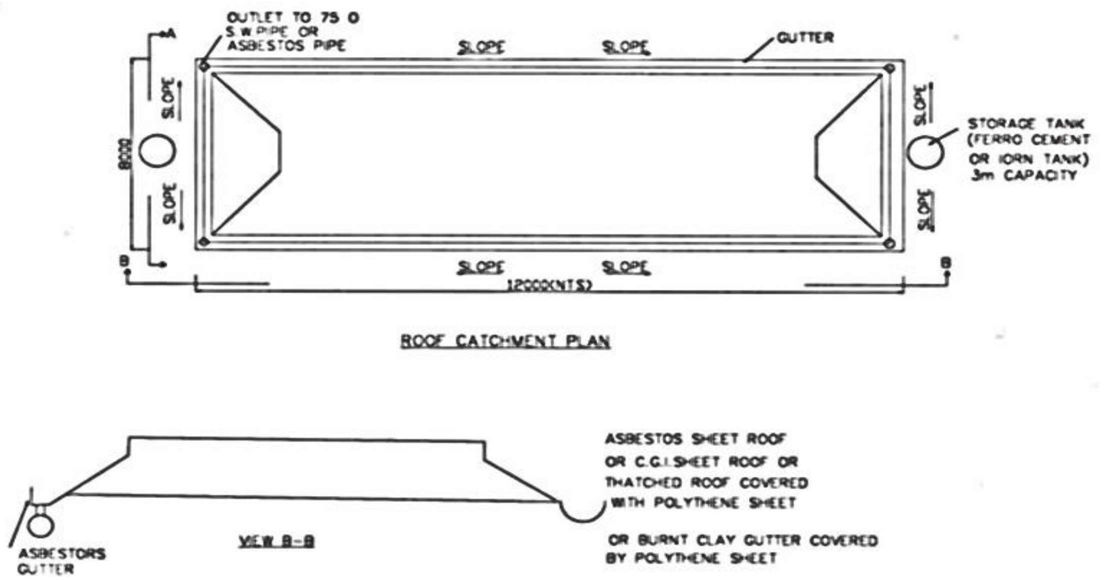


Figure 2.2: Roof Water Harvesting Scheme

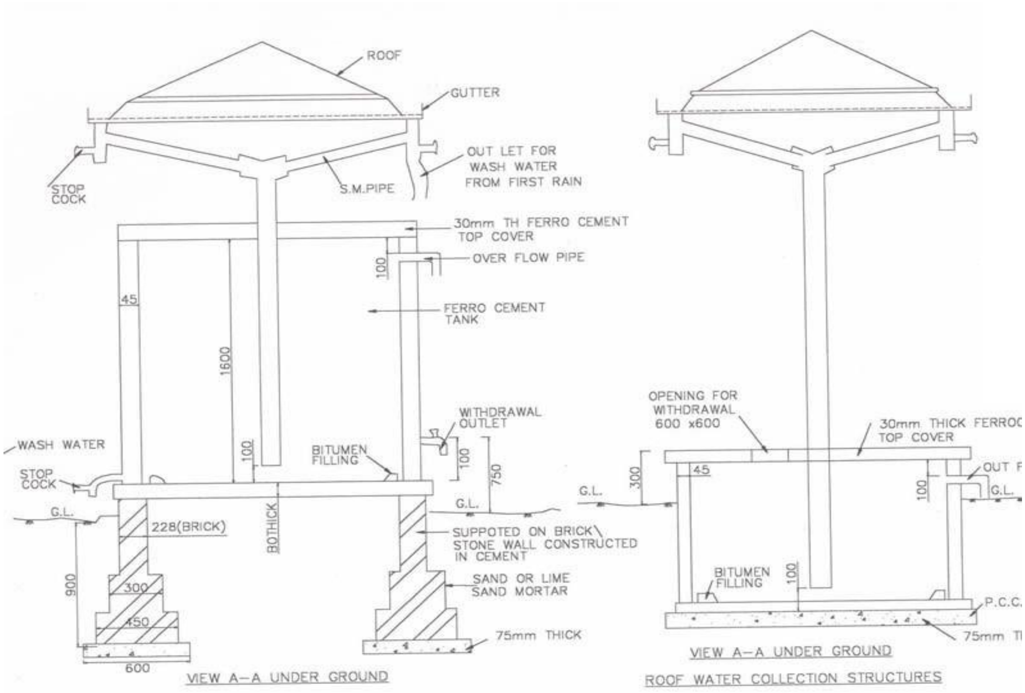


Figure 2.3: Roof Water Collection Structures

2.2-Water Availability

Since the available roof area is usually limited, the system issued to meet water requirements during the summer months i.e. about 90 days Water availability for a given roof top area and rain fall can be determined.

1-Site Assessment

Assessing the site conditions together with the future tank owners is the first step towards a sound system design. The five main site conditions to be assessed are: -

- Availability of suitable roof catchment.
- Foundation characteristics of soil earth house.
- location of trees.
- estimated run off to be captured per unit area of the roof.
- Availability and location of construction material.

2-Estimating the Size of the Required Systems

In actual field conditions, the size of the collector and storage system is dictated by the available roof area and the rainfall. Both these factors are beyond our control except that some modifications can be made in the type of roof covering to improve runoff. The water harvested from the available roof area, therefore, is more or less fixed and has to be judiciously used. In rare cases we have the real option of building enough roof area to meet the predetermined per capita requirement of a given family or community. However, for the purpose of illustration, the planning and design procedure for such a system is discussed below:

The size of the catchment area and tank should be enough to supply sufficient water for the users during the dry period. Assuming a full tank at the beginning of the dry season (and knowing the average length of the dry season and the average water use), the volume of the tank can be calculated by the following formula:

$$V = (t \times n \times q) + et \quad \ldots\ldots\ldots \quad (2.1)$$

Where: -

V = Volume of tank (littre)

t = Length of the dry season (days)

n=Number of people using the tank

q=Consumption per capitated day (liters) et=Evaporation loss during the dry period.

Since evaporation from a closed storage tank is negligible, the evaporation loss (et) can be ignored (=zero)

2.3- The technique of water harvesting projects construction: -

1- What is water harvesting?

Rainwater harvesting is the collection and storage of rainwater for reuse on-site, rather than allowing it to run off. These stored waters are used for various purposes such as gardening, irrigation etc. Various methods of rainwater harvesting are described in this section

2- An Introduction to Rainwater Harvesting

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. The techniques usually found in Asia and Africa arise from practices employed by ancient civilizations within these regions and still serve as a major source of drinking water supply in rural areas. Commonly used systems are constructed of three principal components; namely, the catchment area, the collection device, and the conveyance system.

3- The history Rainwater Harvesting: -

The history of rainwater harvesting in Asia can be traced back to about the 9th or 10th Century and the small-scale collection of rainwater from roofs and simple brush dam constructions in the rural areas of South and South-east Asia. Rainwater collection from the eaves of roofs or via simple gutters into traditional jars and pots has been traced back almost 2 000 years in Thailand (Pre murid and Chat uthasry, 1982). Rainwater harvesting has long been used in the Loess Plateau regions of China. More recently, however, about 40 000 well storage tanks, in a variety of different forms, were constructed between 1970 and 1974 using a technology which stores rainwater and storm water runoff in ponds of various sizes. A thin layer of red clay is generally laid on the bottom of the ponds to minimize seepage losses. Trees, planted at the edges of the ponds, help to minimize evaporative losses from the ponds (UNEP, 1982).

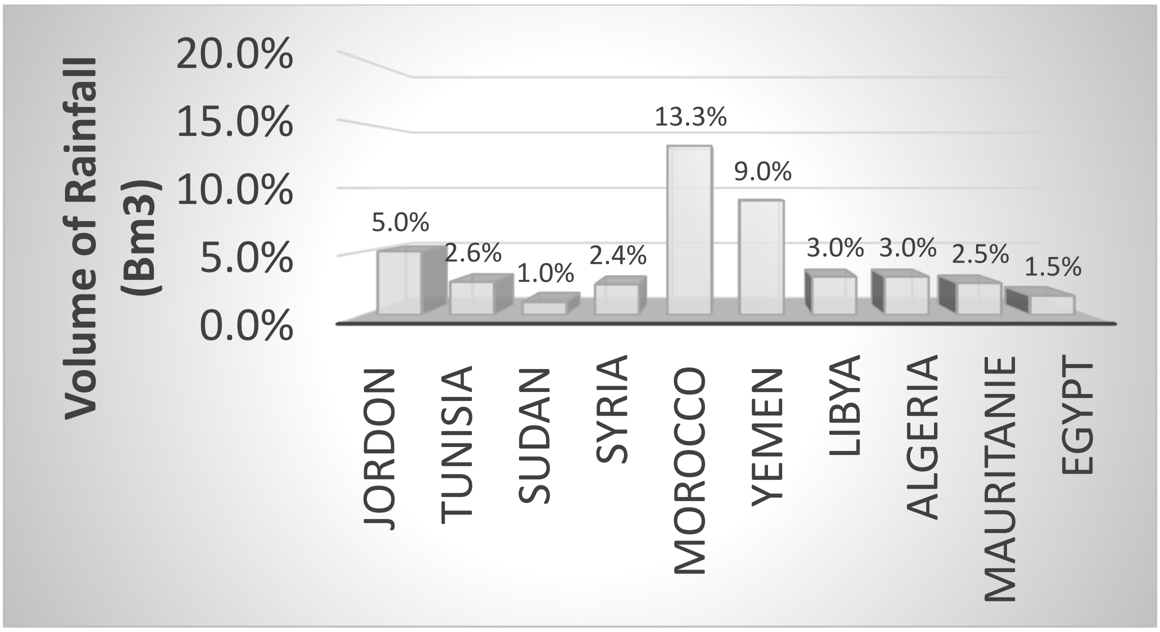


Figure2.4-Percentageof harvested water in some Arab countries.

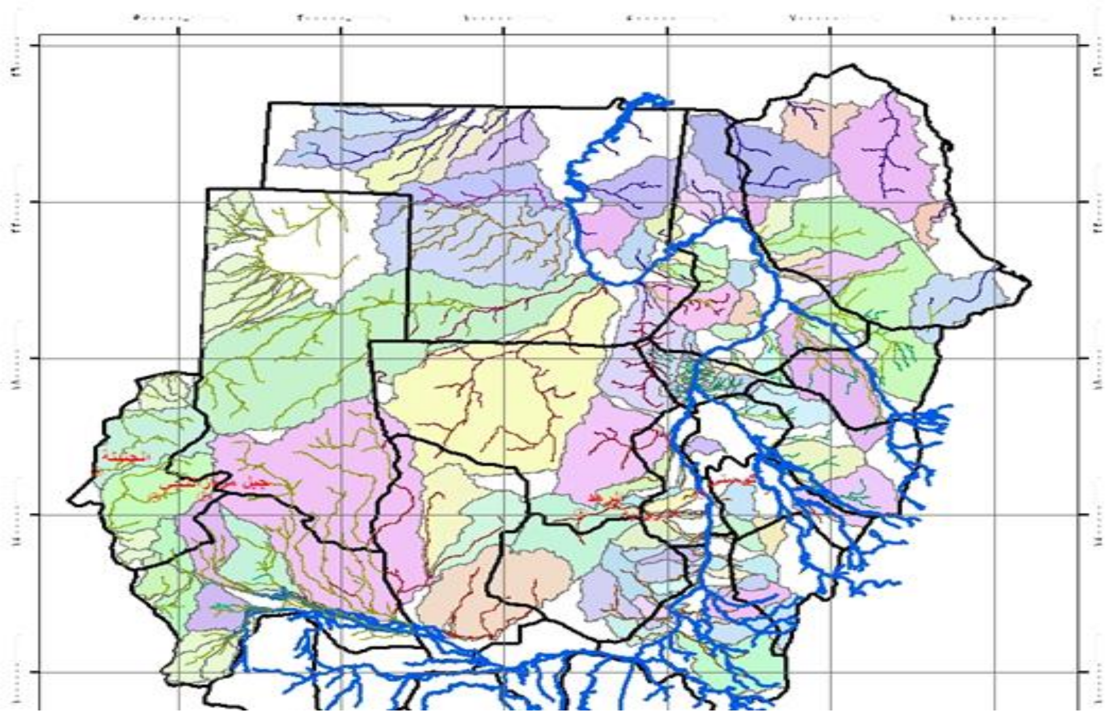


Figure2.5 -Good potential of rain water harvesting due to good distribution of wadis all over Sudan

Figure2.6 - Traditional ways of water harvesting

Figure2.7- Alaawag Dam – White Nile State

Figure2.8 - Alaawag Dam – White Nile State

Figure2.9 - Abu-Hadeed Dam – N.Kordofan State

Figure2.10 -Wadi Bulbul: Removal of siltation & Wadi Training which protect Tulles town from flooding & Irrigate agricultural area of 5,000 acres

2.4-Water Harvesting in Sudan.

1- Introduction

In semi-arid zones such as North Darfur where the rainfall is concentrated over short periods of time, balancing water demand with supply is difficult. The regularity of rainfall and quantity of rainfall in North Darfur has been decreasing; for example, the mean rainfall in Kutum has dropped from 345mm to 243mm between 1967 and 1982. The increase in desertification of agricultural land through changing climatic conditions and exploitation of the natural resources is forcing farmers and agro-pastoralists to adapt to their changing surroundings. This has led to the spread of water harvesting techniques particularly those aimed at catching water in times of flood.

The degradation of farmland has hit the poor first; the rich have monopolized the fertile growing areas known as Wades in Northern Darfur which are areas of land with subsurface water and therefore more capable of producing crops. Farmers in Darfur have worked to overcome the problem of irrigation, whilst avoiding the high costs of many modern irrigation techniques, through the rehabilitation and expansion of traditional water harvesting techniques in the area. Water harvesting techniques Rain water harvesting techniques have been developed for various types of water collection from domestic rain water harvesting schemes through the micro to the macro flood control levels. The harvesting schemes shown below discuss two methods of water harvesting, the first looks at floodwater harvesting through the building of dams, these as discussed vary in design.

The second method is the collection and slowing of water through contour systems. It is important when choosing a water harvesting technique to consider not only the physical aspects of the project but the socio and economic requirements of the community it is to serve. These may include the initial costs, the quality of the water, operation and maintenance requirements of the technique. Lower risk and cheaper alternatives such as springs or shallow wells should be given consideration before large-scale projects are taken on.

Technical criteria for water harvesting The basic principle of water harvesting is shown in a very simple diagram.

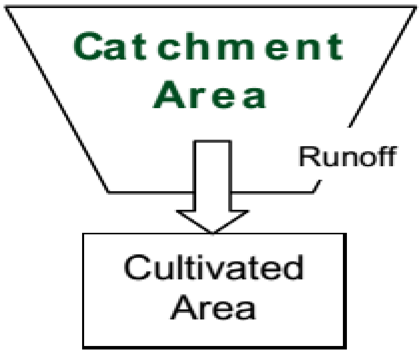


Figure 2.11: Basic principle of water harvesting Slope

Water harvesting is not recommended on slops of over 5%, as there is likely to be an uneven distribution run off and the requirement of large earthworks, which is often uneconomical.

2-Soils: -

The soil should have the ability to be fertile, i.e. they should be deep, not saline or sodic.

Sandy soils are limiting to water harvesting as their infiltration rate is high and thus water runoff does not occur.

3-Costs: -

Earth/stonework movement directly affects cost and labor intensity of the scheme. in the next section four major water harvesting techniques for large and flood scale water harvesting are outlined.

2.5-Floodwater Harvesting

1-Check Dams: -

The check dam is usually located where there is a stream in a narrow valley; the velocity of the water during a rainy season will often lead to soil erosion. The dam acts to slow the water, allowing percolation and the recharging of aquifers. Over time the dam will gather fertile silt carried down the valley, which enhances the soils fertility. Check dams vary in complexity; the simplest are the buildup of stones in lines across the rivers path. When the rainfall is less regular or more destructive, it is often necessary to introduce schemes to allow the control of the amount of water behind dam such as sluice Gates, spill ways and channels. This also allows a more controlled spread of the water.

1.1-Permeable Rock Check Dams: -

These check dams primarily act as a spreader of water across the valley slowing water rather than containing it. The dam is built across a gully or riverbed.

1.2-Sizes: -

The dam may range in length considerably, from 50m to 1000m at extremes. The larger and longer the dams the costlier the operation so it is beneficial to estimate the required size previous to construction. The expected catchment can be used to determine the height of the dam within the gully; the dam height may also vary depending on whether there are a number of dams in series. In this case, starting from the highest dam the lower dam should come to the height of the base of the previous dam. It is often beneficial to locate a dam where there are high sides so as not to risk huge areas of flooding behind the dam and the creation of large shallow pools. Where back flooding does take place it is often necessary to build embankments to protect the village etc. It is important to have seized the system as a whole and compared it to the expected the rainfall characteristics of the area. This ensures that the project is not undersized and unable to cope with the predicted amount of water, which may damage the structure. Also due to the nature of the projects they are often low technology and on low budgets, it therefore important not to have oversized the project for the predicted rainfall characteristics as making a dam and embankment system stronger requires a larger capital which often not feasible for the community.

1.3-Layout: -

Dams are often used in series with each other down a valley providing stability throughout. Where dams are on a prominent slope the dam edges are swept back to follow the contours, on flatter slopes the dam may become straighter acting a spreader on to the flood plain. Dam designs may also include spillways, sluice gates, channels and embankments to allow control of the water at times of flood. The use of channels allows the water to be directed to certain areas of land. Consideration of how floodwater may affect any local housing must be taken; Embankments are often used where back flooding from a dam may affect housing.

1.4-Stages to construction: -

Stage 1: Site identification, characteristic analysis, design choice; depending on the characteristics of the rainfall the design will vary, if rainfall is very low and irregular then the dam may be required to store more water than act just as a spreader. The larger amount of

Water held back may require more control mechanisms such as spillways, sluice gates and canals. A control mechanism such as a spill way or a sluice gate allows excess water during excessive rainfall to be released, preventing damage to the dam, through the release of water at certain times the silt build up on the upstream side of the dam is released preventing any blockages. The characteristics of the gully will also affect design as a rule of thumb where a gully is greater than 1m in depth then a spillway may be added as a control measure.

Stage 2: Permanent construction: The spillway needs to be designed using stones, which cannot be moved during a flood, gabions (stones sealed in cages) are most appropriate for this. A sluice gate will also require a permanent construction, which needs to be built first within the gully. The control mechanism is often wooden planks/ logs, which are removable.

Stage 3: Alignment of the bund with contours; this is why the shape of the dams is swept back until the bund becomes parallel with the watercourse. The contours can be measured using a water tube or line level.

Stage 4: A trench is then dug along the line of the bund so as to lower the bund below the surface; this adds stability and also prevents percolated water undermining the structure. This trench can also be lined with gravel this is appropriate where the soil is particularly Susceptible to erosion.

Stage 5: Bund construction: The core of the dam is built using smaller stones packed together, the more packed these stones are then the less permeable the dam. The core is then sandwiched with larger facing stones, which provide protection from erosion and stability. The dam is not symmetrical in cross section, the slope of the upstream side is far less than that of the downstream, the lower slope adds stability but increases cost. Construction in layers, as in wall building, provides a more stable structure as the rocks are interlinked laterally.

Stage 6: Dam series: if a series of dams are to be constructed it is advisable to start with the dam at the upper most end of the valley. This will allow the distance between the dams to be set. It is rule of thumb that the height of the lower dam should be at the base level of the upper dam.

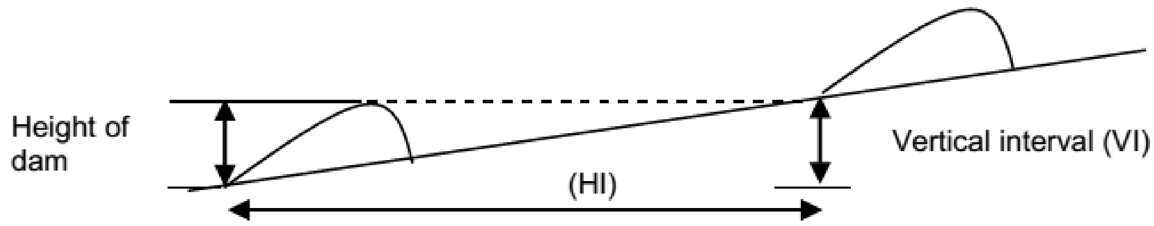


Figure 2.12: Shows the ideal distance between dams.
Horizontal interval = (VI x 100)/%slope)

2-Hafirs: -

The ‘hafir’ is the local name in Sudan for water reservoir. The hafir is a hollow dug in the ground designed to store water runoff after a rainy season; the hafir is usually used in semi-arid regions where rainfall is annual but over short periods and storage is required for the rest of the year. The hafir can be natural or manmade, water storage is not a new concept, and however the technology of today can improve the efficiency of the traditional water storing methods. The water is used by all the community, farmers, nomads, livestock and for domestic drinking water.

2.1-Requirements: -

1-Situated in clay soils so filtration is reduced allowing maximum storage and less labor requirements to provide an impermeable base.

2-Near an annual water source, allowing the hafir to be refilled, as well as filling from surface runoff and its own catchment.

3-Basic filtration system, to prevent the deposition of silt in the hafir.

2.2-Layout: -

The hafir is often a considerable distance from the area that it is supplying. This is because of the requirement for a clay soil type and a nearby annual water source, a hafir is normally found in areas where no underground occurs, this formation is known as a “basement Complex”, because of this many towns in Sudan are reliant on the water that hafirs can store. Water from the source is diverted to the hafir through a dug canal. The hafir can vary in size and shape an average volume would be 30000m^3, the hafir is often conical in shape with an average depth of approximately 3.5m.

Figure2.13: The Azagarfa hafir in Darfur, Sudan

2.6- The design of pipe

According to the ECP101-1997

-Bases of the design of pipe: -

1-the velocity of water in pipe in take not less than 0.6m/s
& exceed 3 m/s
2-calculate the losses

$$q = Av = \frac{HQ^2}{4} v \ldots\ldots\ldots\ldots\ldots\ldots\ldots . (2.2)$$

q =The discharge (m^3/s)

A= section area of pipe (m^2)

H= Height (m)

V= velocity (m/s)

– Methodology of conduct a search

1-Pipe Friction Loss Calculations

Flow of fluid through a pipe is resisted by viscous shear stresses within the fluid and the turbulence that occurs along the internal pipe wall, which is dependent on the roughness of the pipe material.
This resistance is termed pipe friction and is usually measured in feet or meters head of the fluid, which is why it is also referred to as the head loss due to pipe friction.

2- Head Loss in a Pipe: -

A large amount of research has been carried out over many years to establish various formulae that can calculate head loss in a pipe. Most of this work has been developed based on experimental data. Overall head loss in a pipe is affected by a number of factors which include the viscosity of the fluid, the size of the internal pipe diameter, the internal roughness of the inner surface of the pipe, the change in elevation between the ends of the pipe and the length of the pipe along which the fluid travels. Valves and fittings on a pipe also contribute to the overall head loss that occurs, however these must be calculated separately to the pipe wall friction loss, using a method of modeling pipe fitting losses with k factors.

3-Darcy WeisBach Formula: -

The Darcy formula or the Darcy-Weis Bach equation as it tends to be referred to, is now accepted as the most accurate pipe friction loss formula, and although more difficult to calculate and use than other friction loss formula, with the introduction of computers, it has now become the standard equation for hydraulic engineers. WeisBach first proposed the relationship that we now know as the Darcy-Weis Bach equation or the Darcy-Weis Bach formula, for calculating friction loss in a pipe.

Darcy-Weis Bach equation:-

$$h_f = f \left(\frac{L}{D}\right) * \left(\frac{V^2}{2g}\right) \quad \ldots\ldots\ldots\ldots..(2.3)$$

where:

h_f = head loss (m)

f = friction factor

L = length of pipe work (m)

d = inner diameter of pipe work (m)

v = velocity of fluid (m/s)

g = acceleration due to gravity (m^2/s)

The establishment of the friction factors was however still unresolved, and indeed was an issue that needed further work to develop a solution such as that produced by the Colebrook-White formula and the data presented in the Moody chart.

4-The Moody Chart (appendix A)

The Moody Chart finally provided a method of finding an accurate friction factor and this encouraged use of the Darcy-Weisbach equation, which quickly became the method of choice for hydraulic engineers. The introduction of the personnel computer from the 1980's onwards reduced the time required to calculate the friction factor and pipe head loss. This it has widened the use of the Darcy-Weisbach formula to the point that most other equations are no longer used.

5-Hazen-Williams Formula: -

Before the advent of personal computers, the Hazen-Williams formula was extremely popular with piping engineers because of its relatively simple calculation properties. However, the Hazen-Williams results rely upon the value of the friction factor, C h_w, which is used in the formula, and the C value can vary significantly, from around 80 up to 130 and higher, depending on the pipe material, pipe size and the fluid velocity. Also the Hazen-Williams equation only really gives good results when the fluid is Water and can produce large inaccuracies when this is not the case. The empirical nature of the friction factor C h_w means that the Hazen-Williams formula is not suitable for accurate prediction of head loss. The friction loss results are only valid for fluids with a kinematic viscosity of 1.13 centistokes, where the velocity of flow is less than 10 feet per sec, and where the pipe diameter has a size greater than 2 inches.

Notes: Water at 60° F (15.5° C) has a kinematic viscosity of 1.13 centistokes.

Table (2.1) Common Friction Factor Values of C h_w used for design purposes are:

Asbestos	Cement	140
Brass	tube	130
Cast-Iron	tube	100
Concrete	tube	110
Copper	tube	130
Corrugated steelt	tube	60
Galvanized	tubing	120
Glass	tube	130
Lead	piping	130
Plastic	pipe	140
PVC	pipe	150
general	Smooth pipe	140
steel	Pipe	120
Steel	Riveted pipe	100
Tar coat cast iron	tube	100
Tin	tubing	130
Wood stave		110

These C h_w values provide some allowance for changes to the roughness of internal pipe surface, due to pitting of the pipe wall during long periods of use and the buildup of other deposits.

6-Minor head loss in pipe and tube systems can be expressed as

$$h_{minor\_loss} = \xi\, v^2 / (2\, g) \quad \ldots\ldots\ldots (2.4)$$

Where: -

h_{minor_loss} = minor head loss (m)

ξ = minor loss coefficient

v = flow velocity (m/s)

g = acceleration of gravity (9.81 m/s^2)

Table (2.2) Minor loss coefficients for some of the most common used components in pipe and tube systems

Type of Component or Fitting	Minor Loss Coefficient - ξ -
Tee, Flanged, Dividing Line Flow	0.2
Tee, Threaded, Dividing Line Flow	0.9
Tee, Flanged, Dividing Branched Flow	1.0
Tee, Threaded , Dividing Branch Flow	2.0
Union, Threaded	0.08
Elbow, Flanged Regular 90^o	0.3
Elbow, Threaded Regular 90^o	1.5

Type of Component or Fitting	**Minor Loss Coefficient** - ξ -
Elbow, Threaded Regular 45°	0.4
Elbow, Flanged Long Radius 90°	0.2
Elbow, Threaded Long Radius 90°	0.7
Elbow, Flanged Long Radius 45°	0.2
Return Bend, Flanged 180°	0.2
Return Bend, Threaded 180°	1.5
Globe Valve, Fully Open	10
Angle Valve, Fully Open	2
Gate Valve, Fully Open	0.15
Gate Valve, 1/4 Closed	0.26
Gate Valve, 1/2 Closed	2.1
Gate Valve, 3/4 Closed	17
Swing Check Valve, Forward Flow	2
Ball Valve, Fully Open	0.05
Ball Valve, 1/3 Closed	5.5

Type of Component or Fitting	Minor Loss Coefficient - ξ -
Ball Valve, 2/3 Closed	200
Diaphragm Valve, Open	2.3
Diaphragm Valve, Half Open	4.3
Diaphragm Valve, 1/4 Open	21
Water meter	7

Table (2.3) Minor Loss Coefficients (K is unit-less)

Fitting	K	Fitting	K
Valves:	*Elbows:*		
Globe, fully open	10	Regular 90°, flanged	0.3
Angle, fully open	2	Regular 90°, threaded	1.5
Gate, fully open	0.15	Long radius 90°, flanged	0.2
Gate 1/4 closed	0.26	Long radius 90°, threaded	0.7
Gate, 1/2 closed	2.1	Long radius 45°, threaded	0.2
Gate, 3/4 closed	17	Regular 45°, threaded	0.4
Swing check, forward flow	2		
Swing check, backward flow	Infinity	*Tees:*	

		Line flow, flanged	0.2
180° return bends:		Line flow, threaded	0.9
Flanged	0.2	Branch flow, flanged	1.0
Threaded	1.5	Branch flow, threaded	2.0
Pipe Entrance (Reservoir to Pipe):		*Pipe Exit (Pipe to Reservoir)*	
Square Connection	0.5	Square Connection	1.0
Rounded Connection	0.2	Rounded Connection	1.0
Re-entrant (pipe juts into tank)	1.0	Re-entrant (pipe juts into tank)	1.0

2.7- Rested and underground water tank:

There are two types of Rested and underground water tank

1- Rested water tank.

The floor of the reservoir shall be grounded in **fig (2.15)**

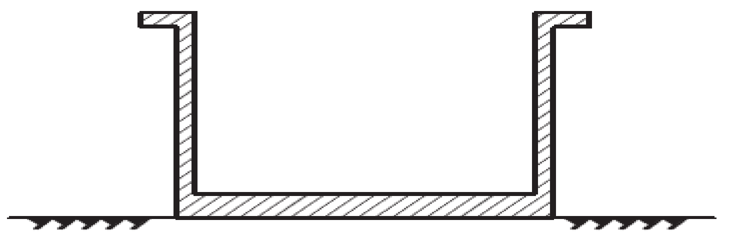


Figure (2.14) rested water tank

2- Underground.

Where the reservoir is fully underground as show on fig (2.16)

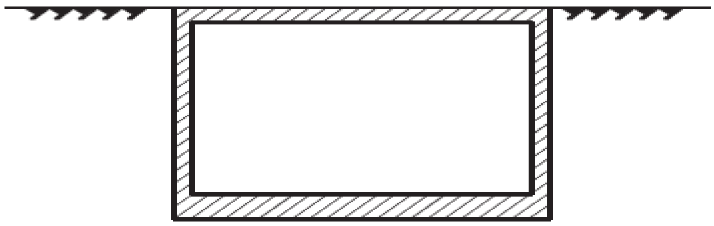


Figure (2.15) underground water tanks

Or be the highest point in the reservoir below the level of the earth's surface as show on fig (2.17) below

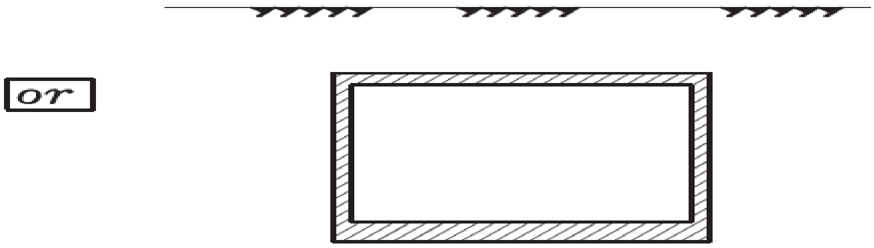


Figure (2.16) underground water tanks

Or be the highest point in the reservoir below the level of the surface of the earth and in the case of underground water tank the calculation of the earth pressure on the walls of the reservoir.

2.8-Tanks supported on ground surface are classified as: -

1-Tank on rigid foundation

Where we assume that, the distribution of the stresses on the soil on a regular basis on the entire surface of the reservoir and require the following in this hypothesis as show on fig (2.18) below.

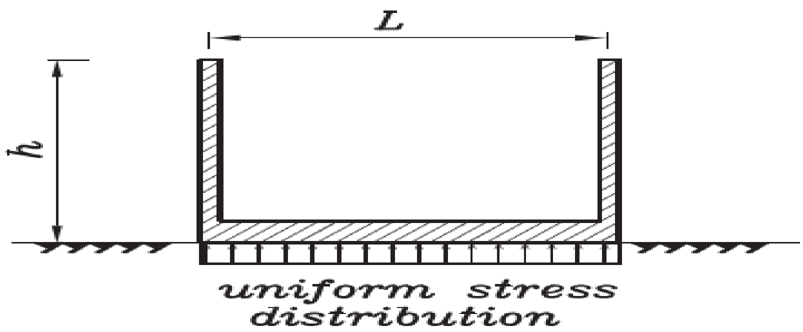


Figure (2.17) tanks on rigid foundation

$$\boxed{L \leq 2h \;,\; t_f \geq 40 \text{ cm}}$$

L= Where is the smaller length of the tank

H=height of tank

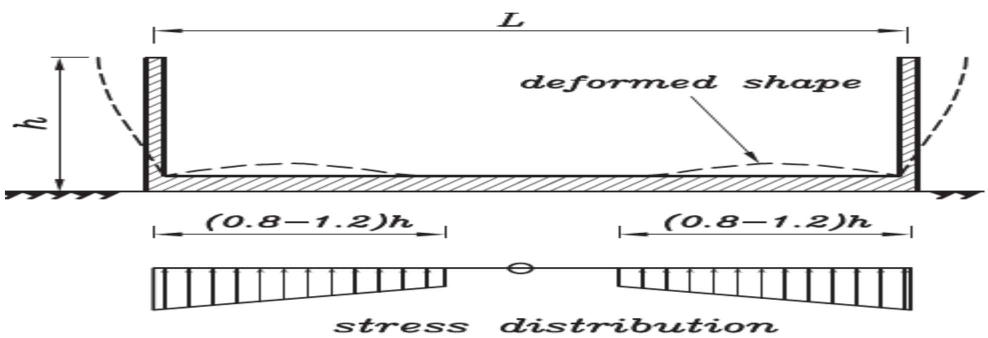
2-Tanks on elastic foundation or tanks on compressible soil: -

Where the distribution of the stresses is irregular on the soil where the stresses are large at the edges of the tile and less whenever we turn to the inside and occurs in the case that as show on fig (2.19) below.

$$\boxed{L > 2h \quad \text{or} \quad t_f < 40 \text{ cm}}$$

L= Where is the smaller length of the tank

t_f= thickness of foundation



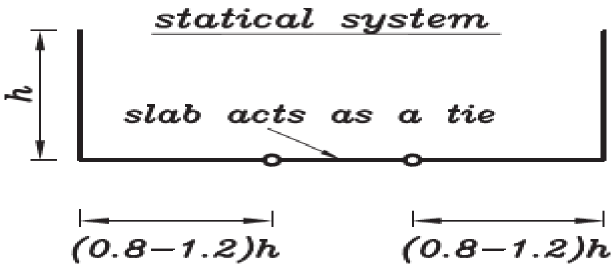


Figure (2.18) Tanks on elastic foundation or tanks on compressible soil

Thus, the affected part of the object transferred from the wall to the floor shall be at a distance between **(0.8-1.2) h** and the rest of the tile shall be on it only transferred from the wall to the floor.

2.9-Required checks for water tank: -

1-check bearing capacity for rested and underground

$$\mathbf{f_{gross}} = \frac{\sum \mathbf{W}}{\mathbf{A}} \text{…………... } \mathbf{(2.5)}$$

Where: -

$\mathbf{f_{gross}}$=The stress transferred to the soil without calculating water weight.

∑W= weight of floor slab, walls cover slabs, beams and water (kN/m)

A=area of the base of the tank (m^2)

Note: -

If $f_{gross} \leq$ bearing capacity of soil——— safe

$f_{gross}>$ bearing capacity of soil ——un safe

Then we have to increase dimensions of floor

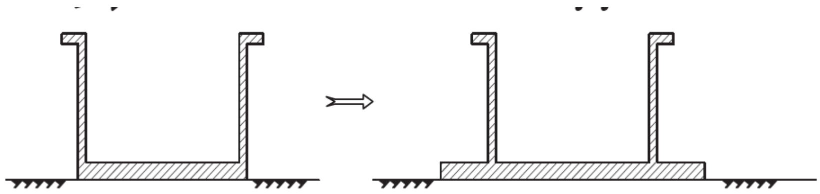
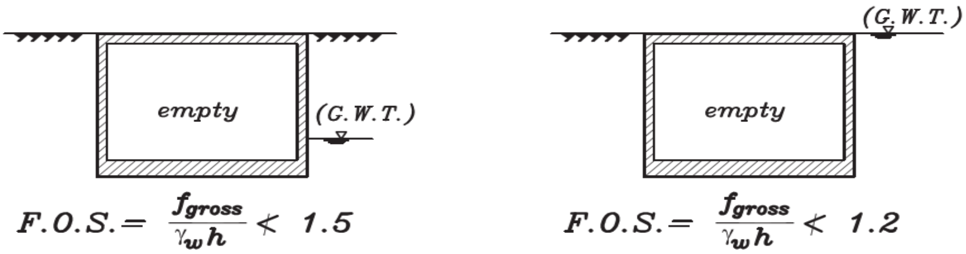


Figure (2.19) check bearing capacity for rested and underground

2-Check uplift for underground water tank:

A check must be made to avoid at the occurrence uplift for tank in the case of groundwater, which is as follows



There is a potential for a high level there is no likelihood of (G.W.T) a high level (G.W.T)

Figure (2.20) uplift for underground water tank

f_{gross}=The stress transferred to the soil without calculating water weight.

2.10-Steps of analysis of rested water tank: -

1-Stability check.

a- Uplift check.
b- Check stress on soil.

2- Strength.

a- Design of critical section.

1-stuability check

Uplift check

In case of ground water during maintenance dead loads > uplift loads

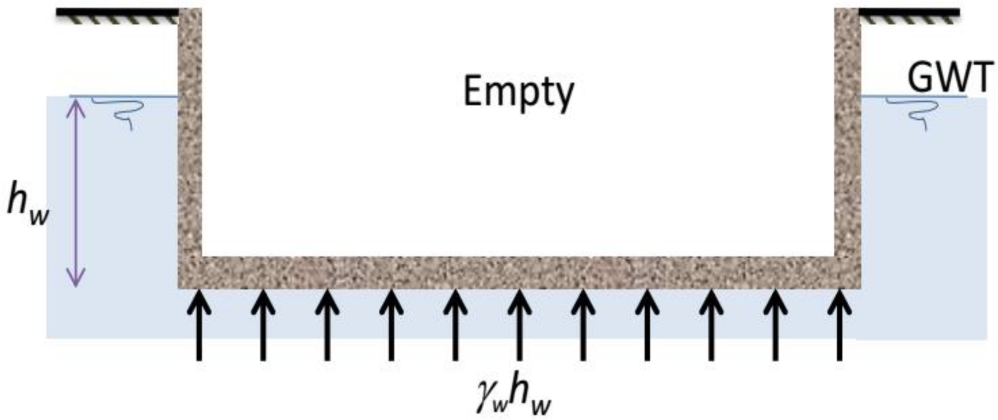


Figure (2.21): uplift check

b- stress on soil in case of full tank, just after construction

Stresses on soil < allowable stress

Figure (2.22): stress on soil in case of full tank

a- Up lift check: -

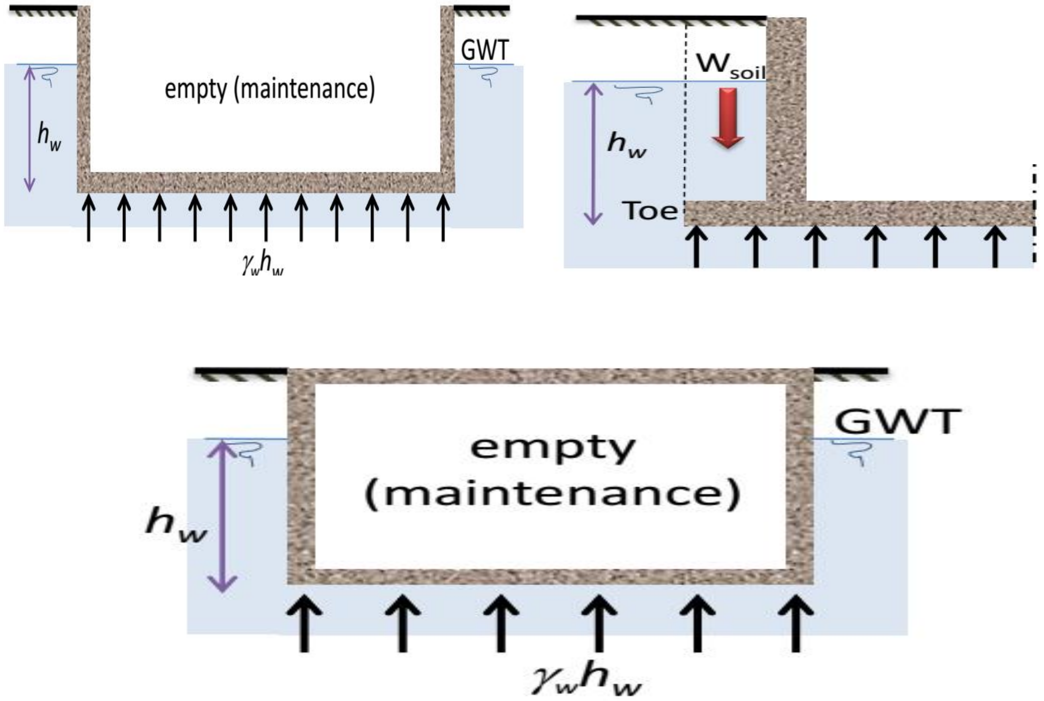


Figure (2.23): uplift check

1- calculate total weight including walls

$$W_{Tank} = W_{floor} + W_{walls} + W_{roof}\,(if\ any) \quad \text{…… (2.6)}$$

2-calculate total uplift.

$$Uplift = \gamma_w h_w \times Floor\ Area \quad \text{….. (2.7)}$$

3-check FOS

$$FOS = \frac{W_{Tank}}{Uplift} \geq 1.2$$ For maximum level of water table

≥ 1.5 If water table can rise

4-if unsafe

a- Increase floor thickness.
b- Use plain concrete inside tank (above RC floor).
c- Use plain concrete below RC floor (connected with steel dowels)
d- Use toe to include soil weight
e- Use tension piles.

1-calculate total weight including walls.

b- Check of stresses on soil: -

1- Tank resting on firm soil (rock or coarse sand)

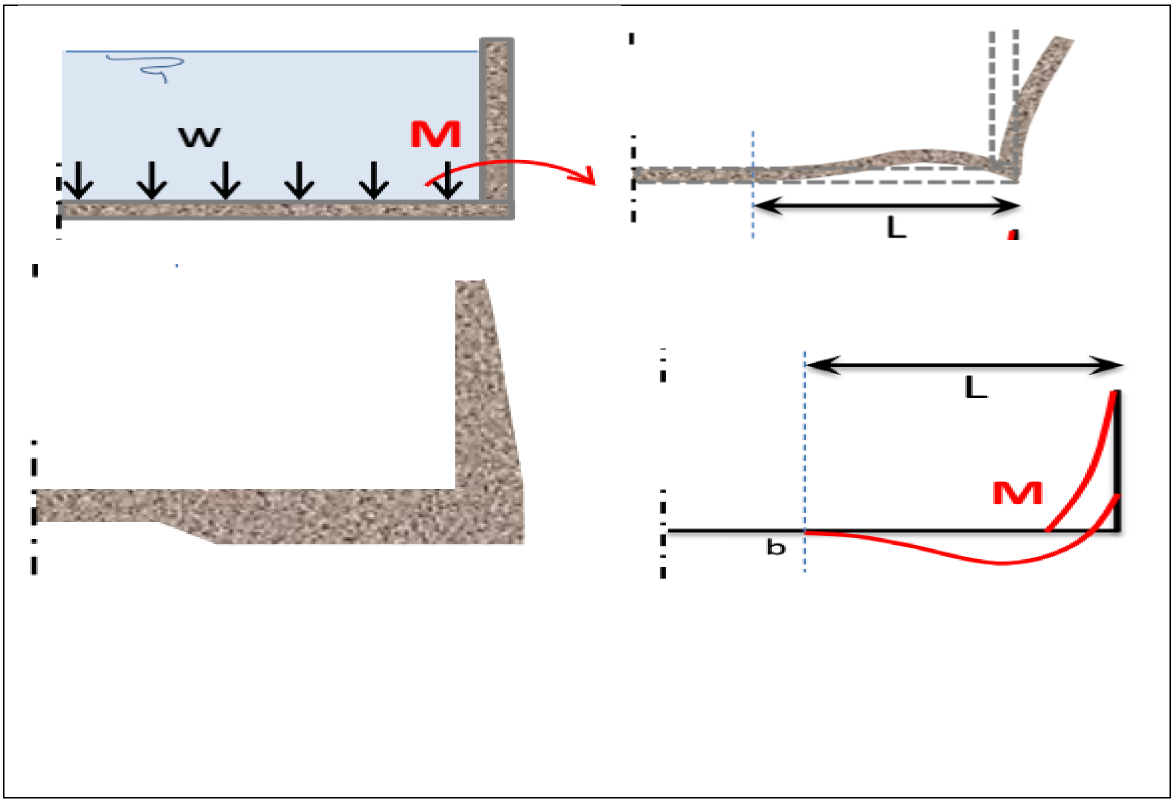


Figure (2.24): tank resting on firm soil (rock or coarse sand)

1-no need to check stresses on soil

2-distance (L) of floor that carries moment reverse from wall (unsupported length) is calculated as

$$L = 2\sqrt{\frac{M}{w}}$$

w= floor weight + water weight

M= is calculated considering wall fixed @bottom

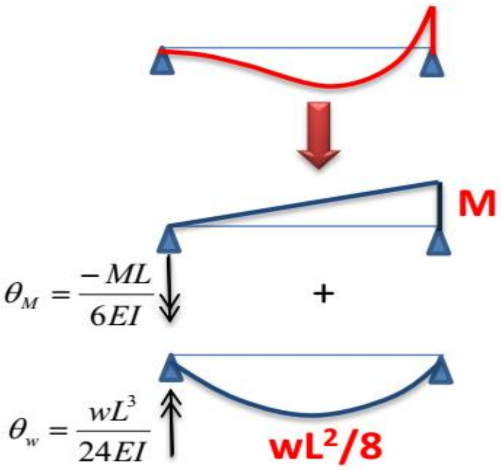
Proof

Rotation @ point b=0.0

$\theta_b = \theta_M + \theta_w = 0.0$

$$\therefore \frac{-ML}{6EI} + \frac{wL^3}{24EI} = 0.0$$

$$\therefore L = 2\sqrt{\frac{M}{w}}$$



2- Tank resting on medium soil (medium sand , silt or clay):-

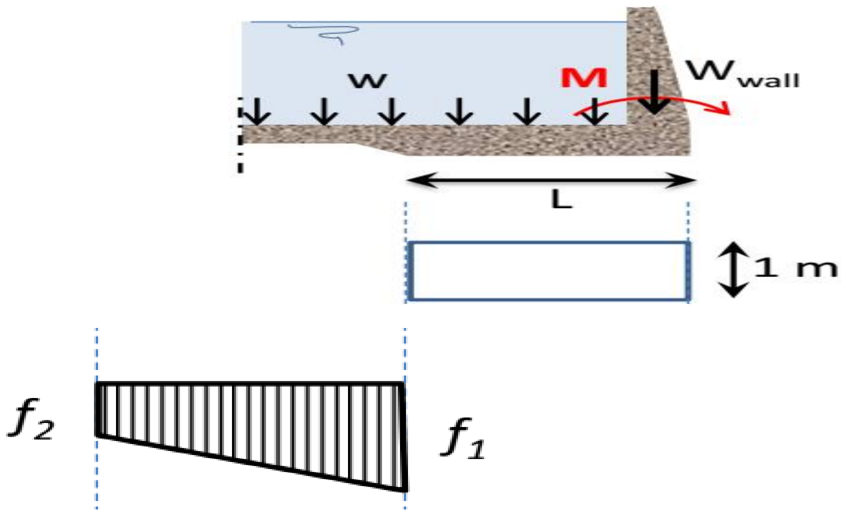


Figure (2.25): tank resting on medium soil

a- Stresses on soil must be checked.

b- L=0.4H (for sandy soil).

c- L=0.6H (for clayey soil).

d- Consider 1m strip.

e- Calculate weight of tank (kN/m^2) (W).

$$w = \gamma_{RC} t_f + \gamma_w H \quad \text{............. (2.8)}$$

W= weight of tank (kN/m^2).

γ_{RC}=reinforced concrete unites weight(kN/m^3).

t_f=thickness of foundation(m).

γ_w= unites weight of water(kN/m^3).

H= height of tank (m)

f- Calculate weight of wall (W_{wall}) (kN/m^2)

$$W_{wall} = \gamma_{RC} t_{wall} h_{wall} + \text{roof reaction(if any)}$$

W_{wall}= weight of wall (kN/m^2).

γ_{RC}=reinforced concrete unites weight (kN/m^3).

t_f=thickness of wall (m).

γ_w= unites weight of water (kN/m^3).

H= height of wall (m)

g- Check normal stresses on soil

$$\left.\begin{aligned}
&f_1 = \frac{N}{A} + \frac{M}{I}y \ \& \ f_2 = \frac{N}{A} - \frac{M}{I}y \\
&or \\
&f_1 = \frac{N}{L} + \frac{6M}{L^2} \ \& \ f_2 = \frac{N}{L} - \frac{6M}{L^2} \\
&f_1 \le soil\ bearing\ capacity \\
&f_2 \ge 0\ (for\ sand) \\
&f_2 \ge f_1/2\ (for\ clay)
\end{aligned}\right\}
\begin{aligned}
&\text{Where;} \\
&N = W_{wall} + wL \\
&M = M + W_{wall}\,(L/2) \\
&I = 1*L^3/12 \\
&Y = L/2 \\
&A = 1*L
\end{aligned}
\qquad \text{...... (2.9)}$$

h- Check of stress on soil for underground water tank.

Figure:(2.26) stress on soil for underground water tank

$$f_{gross} = \frac{W_{Total}}{Base\ Area} \leq soil\ \ bearing\ \ capacity$$

$$W_{Total} = W_{water} + W_{floor} + W_{walls} + W_{roof}\ (if\ \ any)$$

i- If stresses on soil are unsafe: -

1- Use toe.

Figure (2.27): toe in tank resting on medium soil

2- Use deep foundations (piles).

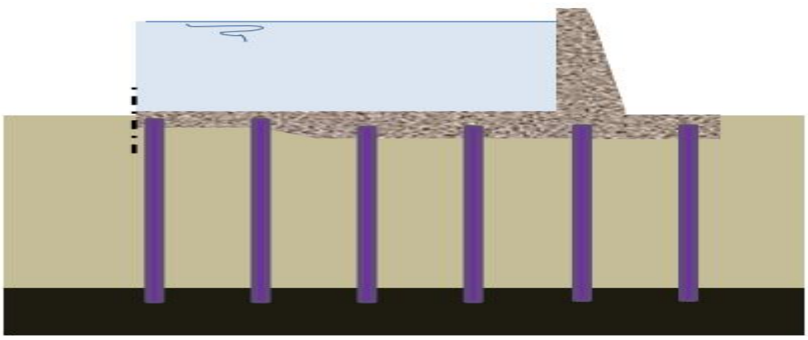


Figure (2.28): deep foundations (piles) in tank resting on medium soil

3- Make soil replacement.

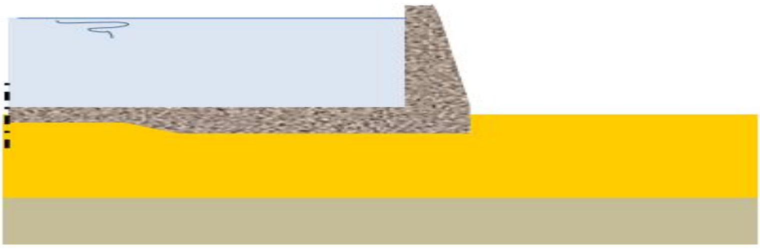


Figure (2.29): soil replacement in tank resting on medium soil

c- Design of critical sections.

1-Case of water pressure

Sec 1→W.S. S (M&R).

Sec 2→W.S. S (R only). Sec 3→W.S.S (M_3& only).

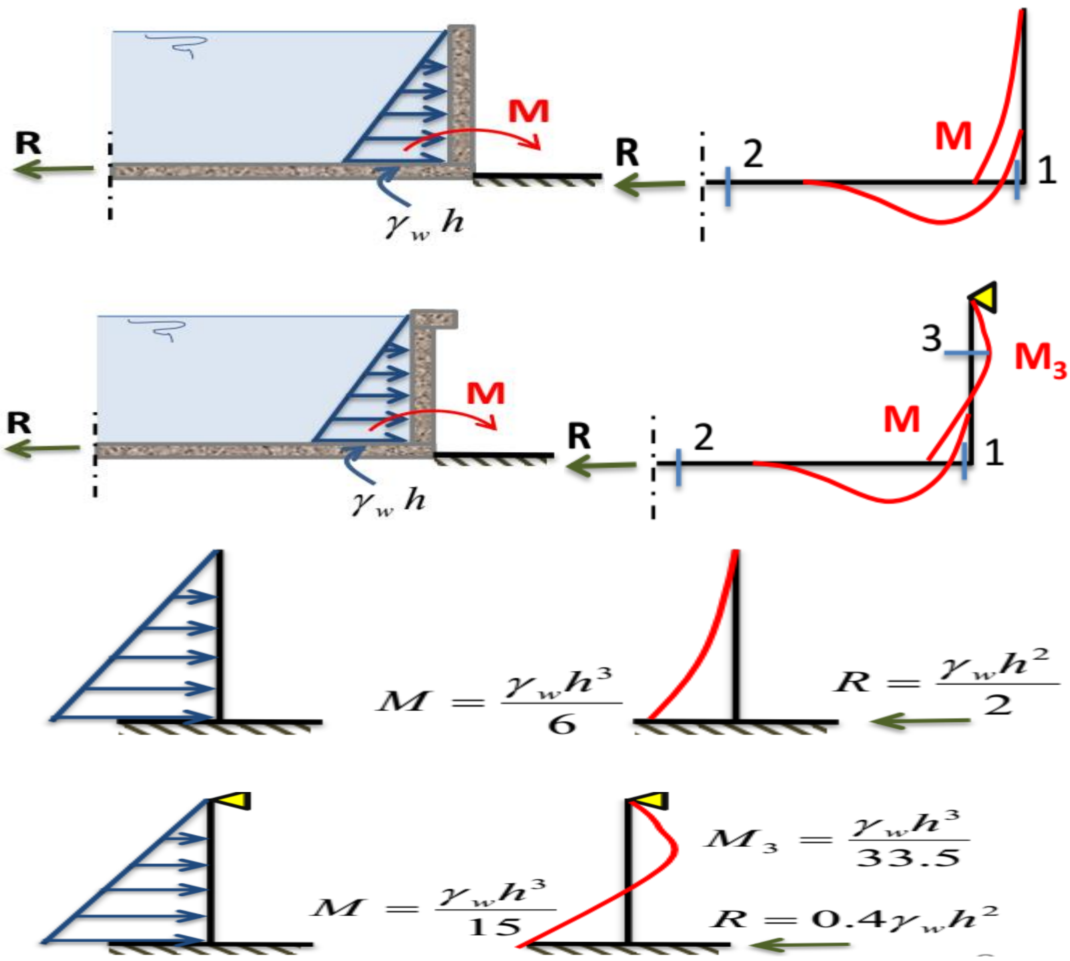
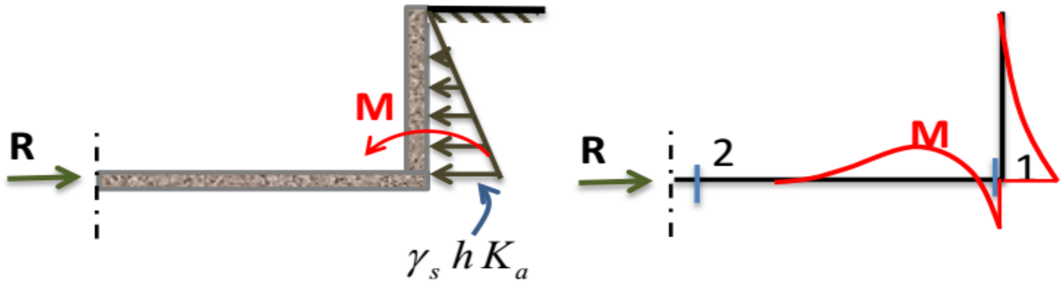


Figure (2.30): toe in tank resting on medium soil

2-Case of earth pressure: -

Sec1→WSS (M&R).



"If no ground water or surcharge"

$$e_s = \gamma_s h K_a \cong 2 \times h \times \frac{1}{3} \cong \frac{2}{3} h$$

$$e_w = \gamma_w h = h$$

$$e_s \cong \frac{2}{3} e_w$$

$$A_{s)earth\ pressure} \cong \frac{2}{3} A_{s)water\ pressure}$$

If there is a ground water or surcharge → calculate M and calculate A_S) earth pressure

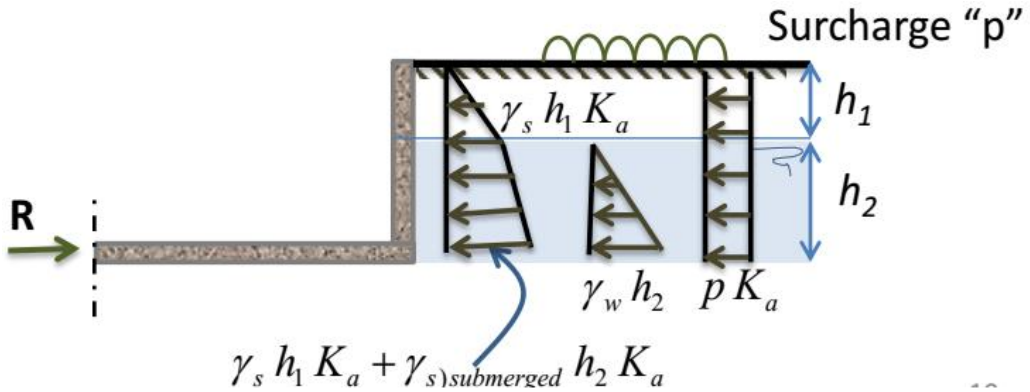


Figure (2.31): earth Pressure

d- Detailing: -

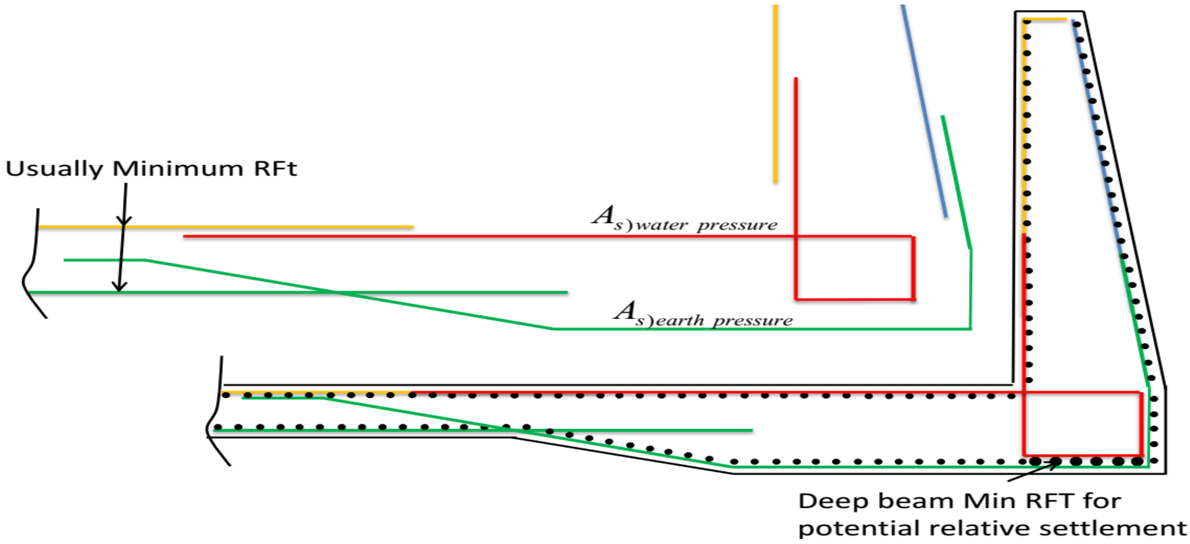


Figure (2.32): details of underground water tank

Chapter Three

Result and discussion

3.1 – Design of pipe line

1- From Egypt code No (101) – 1997 ECP 901-1997.

$$\boldsymbol{q = Av = \frac{\pi D^2}{4} v \ldots\ldots\ldots\ldots\ldots (3.1)}$$

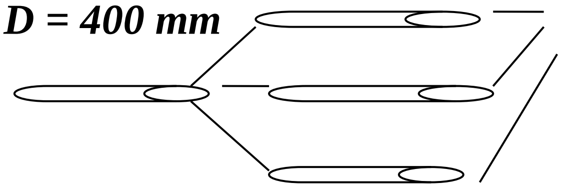
Where: -

Q= the discharge (m^3/s)

V= velocity in pipe (m/s)

D= pipe diameter (m)

D = 450 mm D = 400 mm



The velocity in pipe takes it not less than 0.6 m/sec and not exceeds 3 m/sec. (appendix A)

From Agadi receiver (Altadamon station)

Assume the first diameter of pipe (in take)

D = 450 mm= 0.45 m (from appendix A)

The discharge =0.168 m^3/s for the first diameter (from appendix A)

From eq(1):

$$q = 200\, m^3/hr$$

$$q = \frac{200}{60 \ * 60} = \frac{200m^3}{3600\, sec} = 0.056\, m^3/sec$$

$$0.168 = \frac{\pi D^2}{4} v = \frac{\pi * (0.45)^2 v}{4}$$

$$\Longrightarrow 4 * 0.168 = \pi * (0.45)^2 v \Longrightarrow v = \frac{4 * 0.168}{\pi * (0.45)^2}$$

$$\Longrightarrow v = \frac{0.672}{0.63585} = 1.056\, m/sec$$

$$0.6 \ \leq 1.056 \ \leq 3 \ \Longrightarrow \boldsymbol{Ok}$$

The second diameter of pipe takes

D = 400 mm (from appendix A)

$$\mathrm{q} = 0.056\ \mathrm{m}^3/\mathrm{sec}$$

From (1):

$$0.056 = \frac{\pi * (0.40)^2 \mathrm{v}}{4}$$

$$0.056 * 4 = \pi * (0.40)^2 \mathrm{v}$$

$$\mathrm{v} = \frac{0.056 * 4}{\pi * (0.40)^2} = \frac{0.224}{0.5024} = 0.446 \frac{\mathrm{m}}{\mathrm{s}} < 0.6 \quad \mathrm{notOk}$$

To calculate diameter (D):

1-Take v =0.6m/s for minimum velocity

From (1):

$$\mathrm{D}^2 = \frac{4\mathrm{q}}{\pi \mathrm{v}} \Longrightarrow \mathrm{D} = \sqrt{\frac{4 * 0.056}{\pi * 0.6}} = 0.346\ \mathrm{m}$$

Take D=0.35 m

2-Take v =3m/s for maximum velocity

$$D^2 = \frac{4q}{\pi v} \Longrightarrow D = \sqrt{\frac{4 * 0.056}{\pi * 3}} = 0.154 \text{ m}$$

Take the D=0.35m because the velocity is it in reverses with the diameter and the maximum velocity that mean maximum friction losses

Similarly, for pipe High-pressure.

Design pump Q = 0.056 m^3/sec

The velocity in pipe is range between (0.6-3) m/sec

D=0.35 m Q=0.056 m^3/sec

2-Losses in pipe: -

Friction losses: -

According to the Egypt code.

Head loss (m):

Pressure loss due to friction:

$$\mathbf{hf = \frac{FL}{D} \cdot \frac{V^2}{2g} \text{……….. (3.2)}}$$

Where: -

hf= Friction losses (m)

F = friction factor

L =length of pipe (m)

V=the velocity in pipe (m/s)

g=acceleration of gravity (m^2/s)

$g = 9.81\ m^2/sec$, V=velocity = 0.6 m/sec, D= 0.35,   L=5500 m

F=friction factor = 0.02

$$hf = \frac{0.02*5500}{0.35} * \frac{(0.6)^2}{2*9.81} = 5.76m$$

- **Calculate minor loss coefficients**

$$\boldsymbol{hm = \frac{\sum KV^2}{2g}} \ldots\ldots\ldots\ldots\ldots\ \textbf{\textit{(3.4)}}$$

$$\mathbf{Q = Av = A = \frac{\pi D^2}{4}} \ldots\ldots \textbf{(3.5)}$$

Where: -

hm= Minor loss (m)

$\sum$ K= Sumofminiorlosscoefficients

v= the velocity in pipe (m/s)

g=acceleration of gravity (m^3/s)

$$\sum \mathbf{K = Sumofminiorlosscoefficients}$$

$V =\ 0.6\ m/sec$, g = 9.81 m^2/sec, L= 5500   length of pipe =12.5m

$$\text{NoofNode} = \frac{5500}{12.5} = 440$$

12.5 flanged = 0.2 * 146 = 29.2

K for anion = 0.08 * 146 = 11.68

u for elbow the added = 1.5 * 146 = 219

k for gate value = 0.15 * 2 = 0.3

$$\sum \mathrm{K} = 29.2 + 11.68 + 219 + 0.3 = 260.18$$

$$\mathrm{hm} = \frac{260.18 * (0.6)^2}{2 * 9.81} = 4.77 \text{ m}$$

$$\mathrm{hm} = 4.77 \text{ m}$$

$$\mathrm{totalLosses} = \mathrm{hm} + \mathrm{hf} = 5.76 + 4.7 = 10.46 \text{ m}$$

$$\mathrm{hL} = 10.46\mathrm{m}$$

$$\mathrm{slope} = \frac{\mathrm{hL}}{\text{total length}} = \frac{10.46}{5500} = 0.001 = 0.001$$

Slope = 0.001≅ 1 m

Power transmitted to the fluid by the pump in water

$$\mathbf{P = Q\rho.H * 9.81 \quad (wat)} \text{........ } \mathbf{(3.6)}$$

P = (watt).

$\mathrm{q} = \mathrm{flowinm}^3/\mathrm{sec}$

g = density of the liquid in Kg/m^2 = 1000 Kg/m^3

H = paizometric height in metal of water assume (m) =110m

$$\mathrm{P} = 0.168 * 9.81 * 110 * 1000 * 1000^{-3}$$

$$\mathrm{P} = 181.2888 \quad \Longrightarrow \quad \mathrm{P} = 181.3 \text{ wat}$$

3.2-Design of rectangular water tank with to equal compartment as shown soil unit weight

1-Introduction

A water tank is used to store water to tide over the daily requirements. Underground water tanks are quite common, as they are used for storage of water received from water supply mains Operating at low pressures, or received from other source. Underground water tanks are of two types:

1-Rectangular tanks.

II. Circular tanks.

Generally circular tanks are used for large capacity, for tanks of smaller capacity the cost of Shuttering for circular tanks becomes economical. However rectangular tanks are normally not used for large capacities since they are uneconomical and also, its exact analysis is difficult.

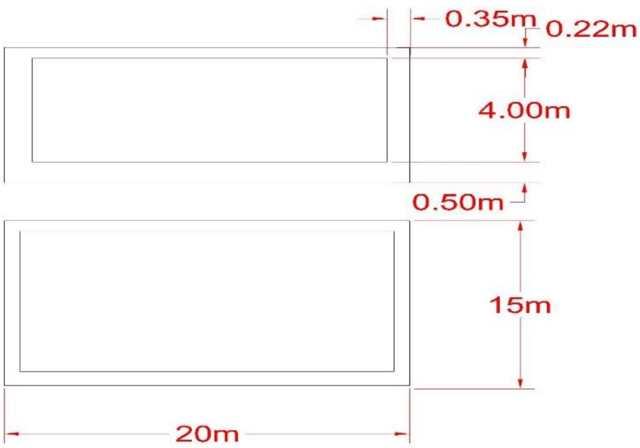


figure (3.1) rectangular water tank

Soil unit weight γ_{SOIL} (kN $/m^3$)= 160kN $/m^3$

Coefficient of friction Φ = 30o

Water unit weight(kN$/m^3$)γ_W =10 kN/m^3

Concrete unit weight (kN /m^3) γ_C=25kN/m^3

Bearing capacity of soil = 160 kN/m^2

Calculate total weight of tank including wall (*from appendix A)*

W_{tank} =W_{floor}+W_{wall}+W_{roof}……………....(3.7)

$W_{tank} =$ $total$ Weight of tank (kN/m^2).

W_{floor}=Weight of floor (kN/m^2).

$W_{wall} =$ Weight of wall (kN/m^2).

W_{roof}=Weight of roof (kN/m^2).

$$w = \big((20 * 15 * 0.5) + (15 * 4 + 20 * 4) * 2 * 0.35 + (20 * 15 * 0.22)\big) * 25$$

= (150+98+66) *25=7850Kn

1- Calculate total uplift

Uplift =γ_W*h_W* floor area…..…..(3.8)

γ_W =Water unit weight (kN/m^3)

$h_W =$ High of water (m)

Floor area= area of foundation (m^2)

Uplift=10*2*20*15=6000kN

FOS =$\frac{W_{tank}}{uplift}$ ≥ 1.2…………….(3.9)

Where: -

Fos = total uplift

W_{tank}=total weight of tank(kN/m^2).

$uplift$= total uplift(kN/m^2).

FOS=$\frac{7850}{6000} =$ 1.308≥ 1.2 ok

2- Check of stresses on soil

$$\mathbf{f}_{gross} = \frac{\mathbf{W}_{total}}{\boldsymbol{base\ area}} \leq \boldsymbol{soil\ bearing\ capacity} \ldots\textbf{(3.10)}$$

Where: -

f_{gross} = stresses on soil

W_{total}= total weight of tank (kN/m^2)

$$\mathbf{W}_{total} = \mathbf{W}_{water}\mathbf{W}_{floor} + \mathbf{W}_{wall} + \mathbf{W}_{roof} \ldots\ldots\ldots\textbf{(3.11)}$$

$$W_{total} = 10 * 4 + 25 * 0.5 + 25 * 0.35 + 25 * 0.22 = 56.75 \text{ KN}/m^2$$

$$f_{gross} = \frac{56.75}{15*20} = 189 \text{ kN} \leq 160k\text{N not ok}$$

Floor (20 × 15)

R, ß, α= distributions factor

$$R = \frac{0.76 \times 20}{087 \times 15} = 1.165$$

$$\alpha = \frac{r\,4}{1 + r4} = 0.\,65$$

$$ß = \frac{1}{1 + r4} = 0.35$$

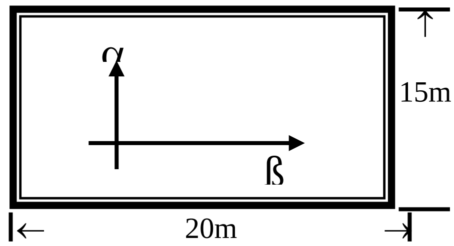


Figure (3.2) Load factor

Wall

$$R = \frac{0.76 \times 20}{0.87 \times 4} = 4.37$$

$$\propto = \frac{(4.37)^4}{1 + (4.37)^4} = 0.998$$

$$ß = \frac{1}{1 + (4.37)^4} = 0.002$$

e = γ_W* h …………….(3.12)

e= water pressure (kN/m^2)

γ_W=unit weight of water (kN/m^3)

h= high of water (m)

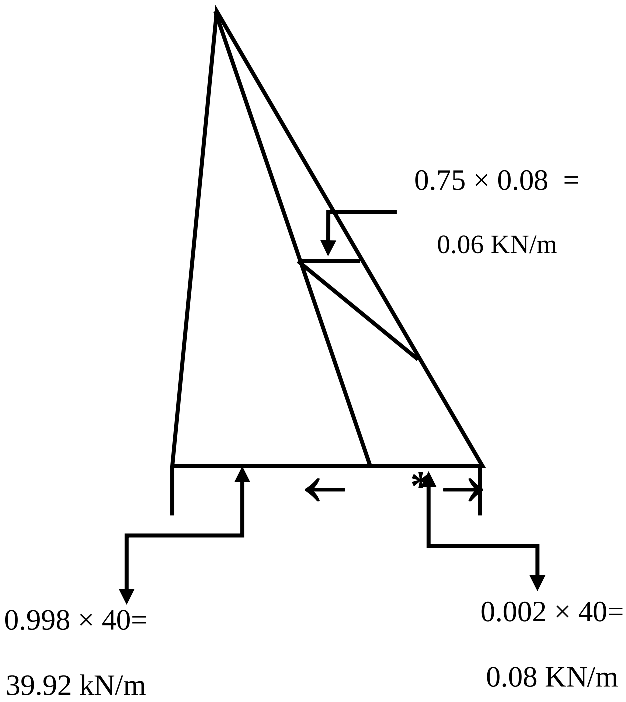


Figure (3.3) Load analysis

e = 10 × 4 = 40 kN/m^2

Analysis of Strips: -

Calculate element force& reaction: -Strip (1) Sec (1 - 1)

$$\frac{\text{I base}}{\text{I w}} \text{……….. (3.14)}$$

$$F_{emba} = \frac{WL^2}{I5} + \frac{WL^2}{117} F_{emba} = \frac{39.92\ (4)^2}{15} + \frac{0.08\ \times 4^2}{117} = 42.6 \text{ kN}$$

$$F_{embc} = \frac{WL^2}{12} = \frac{6.85\ \times (20)^2}{12} = 228.33 \text{ kN.m}$$

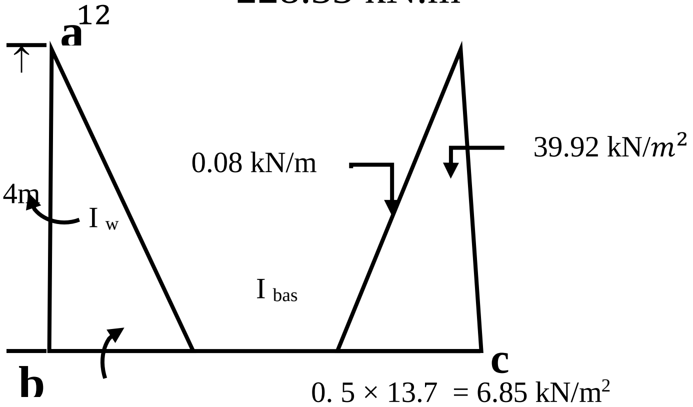


Figure (3.4) moment distributions

Ra × 4 = 79.84 × 1.33 + 0.04 * 0.33 - 87.4 =

4 × Ra = 106.1872 + 0.0 1 32 - 87.4

Ra = $\frac{18.8004}{4}$ = 4.7001 kN

R_b = 79.84 + 0.04 - 4.7001

R_b = 75.18kN

$\left[\frac{\times}{4} \times \ 39.92\right] \times \frac{\times}{2} = 4.7$

9.98 $\times^2$ = 4.7

X= 0.68 m

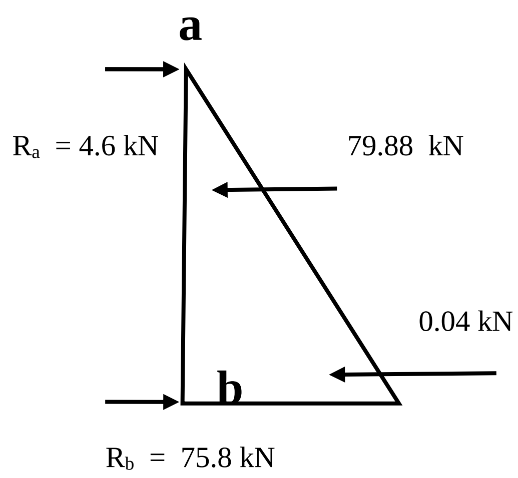


Figure (3.5) reaction analysis

Design of Section: -

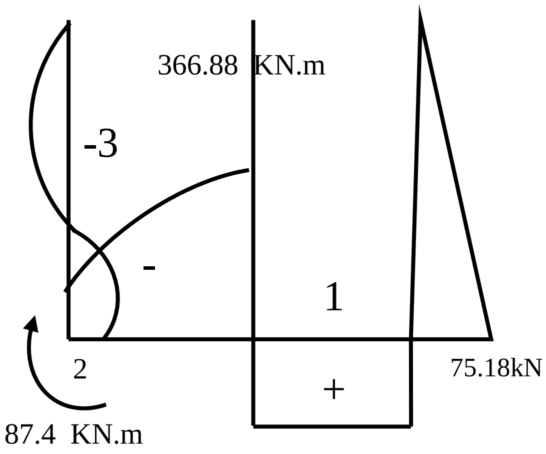


Figure (3.6) Load distributions

$T_{working}$ = 75.18kN

b = 1000 mm

M = $T_{working} \times$ L = 4.88 × 75.18 = 366.88 kN.m

Design of Section: -

Sec (1 - 1) water section

$M_{working}$ = 366.88 kN.m $T_{working}$ = 75.18kN

b = 1000 mm

Where: -

$M_{working}$ = working moment(kN.m)

$T_{working}$= force working (kN)

b= width (mm)

T = thickness (mm)

-Stage (1): -

Calculate thickness of floor (mm)

$$\mathbf{T\ (_{mm}) = \frac{\sqrt{M \times 10^3}}{factor} + 35mm \ldots\ldots\ldots (3.12)}$$

$$= \frac{\sqrt{366.88 \times 10^3}}{0.28} + 35mm \quad = 640mm$$

Take t = 600mm

-Stage (II)

$\boldsymbol{M_{ull}}$**= 1.5*$M_{working}$………………. (3.15)**

M_{ull}= ultimate moment (kN.m).

M_{ull} = 1.5 × 366.88 = 550.32 kN.m

$\boldsymbol{T_{ull}}$ **= 1.5*$T_{working}$………………. (3.16)**

T_{ull}= ultimate shear (kN).

T_{ull} = 1.5 × 75.18 = 112.77 kN

$$\mathbf{e = \frac{\boldsymbol{Mu.L}}{\boldsymbol{Tu.L}} \ldots\ldots\ldots\ldots (3.17)}$$

$$= \frac{550.32}{112.77} = \quad 4.88 \text{ mm} \quad > \frac{T}{2} \text{ - cover}$$

$$es = e - \frac{T}{2} + C = 4.88 - \frac{0.60}{2} + 0.04 = 4.62 \text{ m}$$

M_{us} = 112.77 × 4.62 = 521 kN.m

$$460 = C_1 \frac{\sqrt{521 \times 106}}{1000 \times 35} =$$

C_1 = 3.77

J = 0.347

$$As = \frac{1}{Bcr} \times \left| \frac{Mus}{J \times g \times G} + \frac{Tull}{Fy \times \partial s} \right| = \ldots\ldots\ldots\ldots \mathbf{(3.18)}$$

Assume Ø = 16 mm used $B_{cr} = 0.75$

$$As = \frac{1}{0.75}\frac{521 \times 106}{0.347 \times 460 \times 360} + \frac{112.77 \times 10^3}{360 / 1.15}$$

As = 12 569.21 mm^2 / m = Ø 16 / m

Sec (2 - 2) water section

$M_{working}$ = 87.4 kN.m

$M_{working}$ = 49 kN.m b = 1000 mm

- All walls of the tank Rested & Underground Tank is being N.F. Generated within it is the weight and weights standing power and be compression .

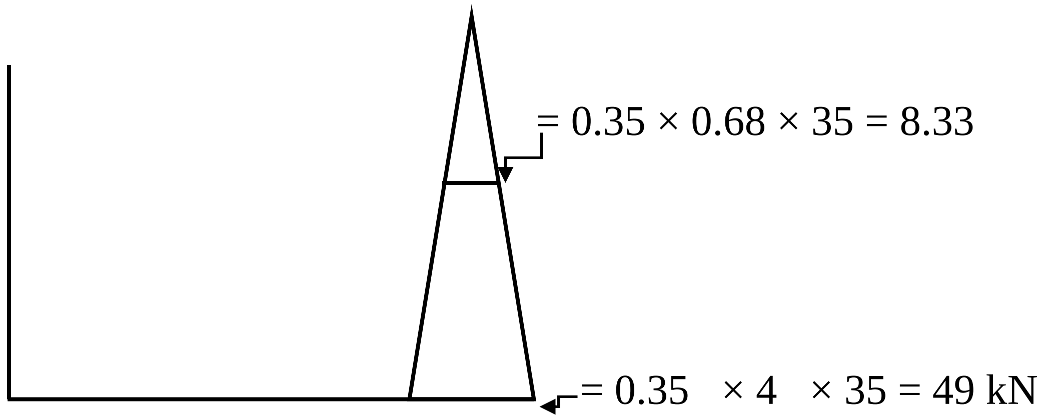


Figure (3.7): N.F

Sec (3 - 3) air section

$M_{working}$ = 2.67 kN.m T = 350 mm

$M_{working}$ = 8.33 kN

b = 1000 mm

As = 5 Ø 12 / m

Sec (4 - 4) water section

$M_{working}$ =106 kN.M b = 1000 mm

Sec (5 - 5) air section t = 0.35

M_w=106kN.M b = 1000 mm A_s = 5 Ø 12 / m2

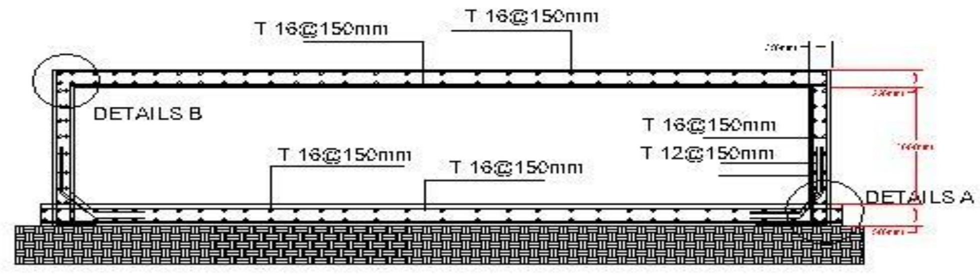


Figure (3.8) tank details

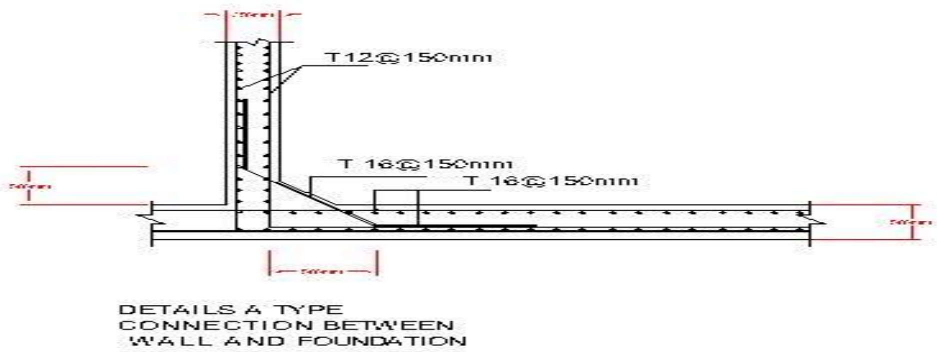


Figure (3.9) detail (A) type connection between

wall and foundation

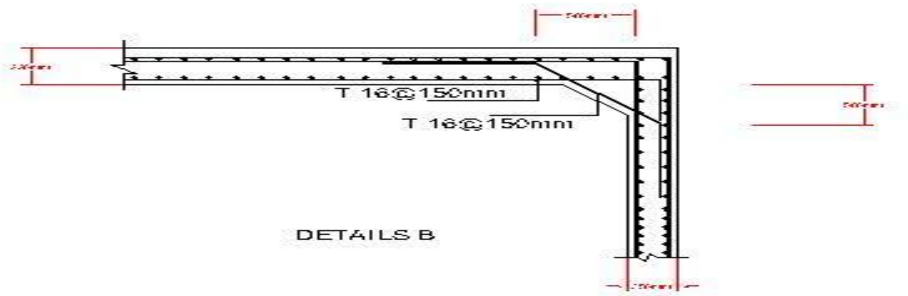


Figure (3.10) detail (b) type connection between wall and slab

3.3-Design of elevated steel water tank: -

Dimension of tank V = 4.2×4.2× 3.6 = 63.5m^3

No. of column = 4

Column dimension = 0.4 × 0.25 (m^2)

Bracing cross section area

Coefficient of rectangle shape = 0.5

Wind load pressure = 1.5 kN/m

Allowable stress of concrete p_y = 275kN/m^2

Allowable bending stress = p_{ys} = 275kN/m^2

Allowable stress for steal p_{st} = 275kN/m^2

Modulus ratio = n = 14

F_c^1 = 12.5 Mpa

γ steel = 7850 Kg / m ^{3} = 78.7 kN

Solution:

Wind load:

Wind load acting on the face of tank

W_1 = 1.5*area of tank **………………. (3.19)**

=1.5× 3.6 × 4.2 = 2 2.68kN

Wind load acting on tie and bracing

W_2 = 1.5*area =1.5× 0.4 × 4 = 2.4 kN

W_3 = W_4 = 2.4 kN

Moment at the base

$M1 = W_1 \times h1 + W_2 * h2 + W_3 \times h3 + W_4 \times h4$ **………………. (3.20)**

$M1 = W_1 \times 10.5 + W_2 * 8.7 + W_3\, 5.7 + W_4 \times 2.7$

$M1 = 22.68 \times 10.5 + 2.4\,(8.7 + 5.7 + 2.7)$

$M = 238.14 + 41.04 = 279.18\text{kN.m}$

$\sum M_t = (w_1 + w_2 + w_3 + w_4)\frac{\text{hcolmun}}{2}$ **……………. (3.21)**

$$M_t = (22.68 + 2.4 + 2.4 + 2.4) \times \frac{3}{2} = 44.82 \text{ kN.m}$$

Reaction due to wind load

$$V = \frac{m_1 - \sum mt}{2 \times 3 \times 2} \text{……………….} \ \mathbf{(3.22)}$$

$$= \frac{279.18 - 44.82}{12}$$

$$V = 19.53\text{kN}$$

V=Reaction due to wind load**.**

M_1=moment at the base.

$\sum mt$= total moment.

$$M = \frac{\sum mt}{4} = \frac{44.82}{4} = 11.205 \text{ kN.m}$$

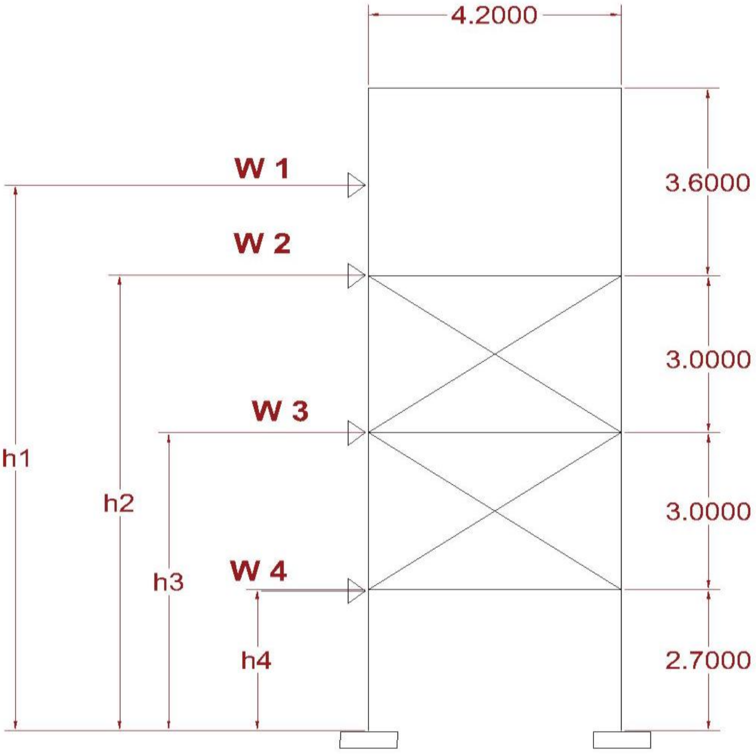


Figure 3.11Elevated water tank

Assume the thickness of water tank is

Base = 6mm

Wall= 5mm

Slab = 3mm

Vertical loads: -

(a) Weight of water =γ_w* volume

$\gamma_{w\,=}$ unite weight of water(kN/m^3)

Volume=volume of tank (m^3)

= 10× 4.2×3.6 × 4.2

= 635.04 kN

(b) Weight of column = γ_c*volume = 0.4 ×0.25 × 4× 8.7 * 24

= 83.52 kN

(b) Assume Thickness of Tank Wall and slab = 8mm = 0.08m

Weight of tank =volume of tank *γ_{steel}

= [4.2 × 4.2 * 2 + 3.6 × 4.2 × 4] * 0.08 * 78.7

= [35.28 + 60.48] ×0.08 × 78.7 = 602.9 kN

$\gamma_{Stainless\ steel}$=304 = 8030 Kg/$m^3$

γ_{steel} = 78.7 kN

Weight of bracing steel beam = 2.51 ×146 × 21 Kg UB

No of the beam = 2 × 4 = 16 ×3.3 = 52.8

52.8 × 31 = 1,636.8 Kg

Column = 381×152 × 52× 5/Kg UC

No of column = 4 length = 6 m , weight =g*L*NO= 4 × 6× 52 = 1,248 Kg

Angle = 76.2 × 63.5 × 7.9 Angle

No of Angle = 4 , Length = 6 m

weight =g*L*NO

4 × 6 × 7.9 = 189.6 Kg

Beam Angle 63.5×63.5 × 7.94

Diagonal members

No. of Diagonal members = 4 × 4 = 16

Length of = 4.7 m

weight =g*L*NO

16 × 4.7 × 7.9 = 594.0 Kg

Support of Tank = 251× 146 × 314Kg UB

No. ,, ,, = 6

Weight of support of Tank = 4.2 × 6 = 25.2

25.2 × 31 = 781.2 Kg

The Beam support of Tank = 4.2 × 6 = 25.2

152 × 76 × 17 = 86kg UC

No of Beam support of Tank. = 4 , Length = 3m

No of Beam support of Tank = 2 , Length = 4.2

weight =g*L*NO

4.2 × 4 × 17.86 + 2 × 5.9 × 17.86 = 510.8 Kg

Total load of the bridge

1636.8 + 1248 + 189.6 + 594.08 + 781 - 2 + 510.8 = 4,960.48 Kg

× 9.81 = 4866230.69 N = $\underline{\underline{48.66}}$kN

Total vertical load= 635.04 + 83.52 + 602.9 + 48.66 = 1370.12 kN

Load on column $= \frac{\text{totlal load}}{\text{no of column}} = \frac{1370.12}{4} = \underline{\underline{342.52}}$ kN

Total load on heavily loaded column

P_0=Total vertical load + Load on column = 342.52 + 234.36= $\underline{\underline{576.88\ \text{kN}}}$

Bracing moment = ∑Mt of columns

Above and below bracing:

M_{br} = 11.205 × 2 = 22.41 kN.m

Length of bracing = 3.3 m

Shear force on bracing: -

$$S = \frac{\text{Mbr}}{\frac{1}{2}\ \text{length of bracing}} = \text{……………….. } \textbf{(3.23)}$$

$$\frac{21.4}{3.3/2} = \underline{\underline{12.97}}\ \text{kN}$$

Column design: -

$$\mathbf{e = \frac{M}{P_o}} \quad \textbf{........................ (3.24)}$$

$$= \frac{11.205 \times 10^3}{576.88} = 19.42 < e_{min} = 25 \text{ mm}$$

$$P_c = \left(Ag + 0.45 \frac{Fcu}{P_y} Ac\right) P_c$$

Take P_y = 275 N

Fcu = 25 N

A_c = 500 × 500 = 250,000 mm^2

A_g = brow table section

A_g = From table p_y = 275

From table 22 BS 5950-:2000, G = 200

LE = 0.7 * L **.................. (3.24)**

LE= effective length of column (m)

L=length of column (m)

= 0.7 * 8.7

LE = 60.59 m

For cased section

r_y = 0.2 * 500 = 100

$\lambda = \frac{LE}{ry} = \frac{6090}{100}$ = 60.9 > 40

From table 24 BS 5950-:2000,

P_c = 238 N/ mm2

use 36 ×158UC

Ag = 20100N

$$Pc = (20100 + 10{,}227.3) \times \left(Ag * 10^2 * 0.45 \times \frac{25}{275} * 250.000\right)\frac{238}{10^3}$$

= 7218 N

This is not to exceed the short start capacity:

$$Pcs^2 = \left(Ag + 0.25 \times \frac{25 \times 250.000}{275}\right) \times \frac{338}{10^3} \text{.................. } \mathbf{(3.25)}$$

$$(20.100 \times 5{,}681.8) \times \frac{238}{1000} = 6136 \text{ N}$$

The compression resistance is

$P_c \leq P_{cs}$

$P_c = 7218$ N

$P_{cs} = 6136$ N

Use

Design of bracing: -

251 ×146 × 31 Kg UB

M = 22.49 kN.m

$V_{bracing} = 13.58$ kN

$Mc = P_{ys}$

$Mb = P_y s_x$

$$\frac{F_c}{AgPy} + \frac{Mp_s}{my^s{}_x} \leq 1$$

$P_y = 275$ kN

From table 16 of cod BS 5950-:2000

Use 250 × 31.04 UB

$A_g = 4010\ mm^2$

$S \times 397 \times\ 10^3\ \ mm^3$

$S =\ \ 94.2 \times\ 10^3\ mm^3$

UB 259×146 ×31

W = 31.1 kg/m

$A =\ \ 39.68\ cm^2$

S = 6.1 mm

$A_g =\ \ 34.1\ mm^2$

UB 259 ×146 × 31

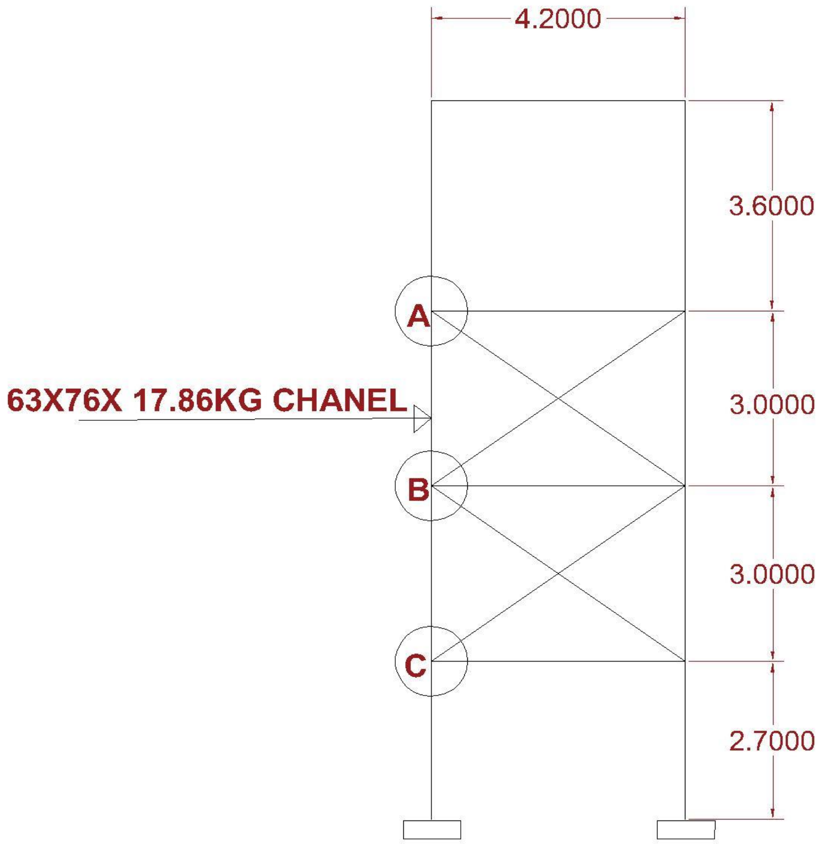


Figure 3.12elevated water tank details

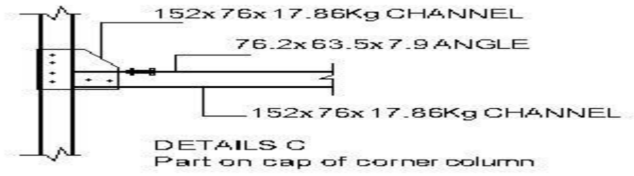


Figure (3.13) details C part on cap of corner column

Figure (3.14) detail A part side elevation @ head of tower

Chapter four

Conclusion &Recommendation

4.1- Conclusion

This research was study the water harvesting reservoir as underground water tank, elevated water tank and pipe diameter it can conclude that

1-the design of pipe diameter is safety and its equal 0.45m & 0.35m according to the velocity of water in the pipe that is conducted the friction and pressure loses along the pipe line.

2-in underground water tank the section thickness in all tanks is checked and equal (0.35m, 0.22m & 0.60m – wall, slab, foundation) for shear in deferent cases and it is adequate.

3-the elevated water tank is design the wall of tank column, bracing, diagonal member and it safety.

4.2 - Recommendation

The result of this research, the recommendations for this research are:

1- Design the pipe diameter by using the program design to compare the result between manual designs and programming design.
2- Redesign the underground water tank by using the program design and compare it's.
3- Design of underground water tank by workability limit State
4- Redesign the elevated water tank by using program design and compare it's.

5- **References: -**

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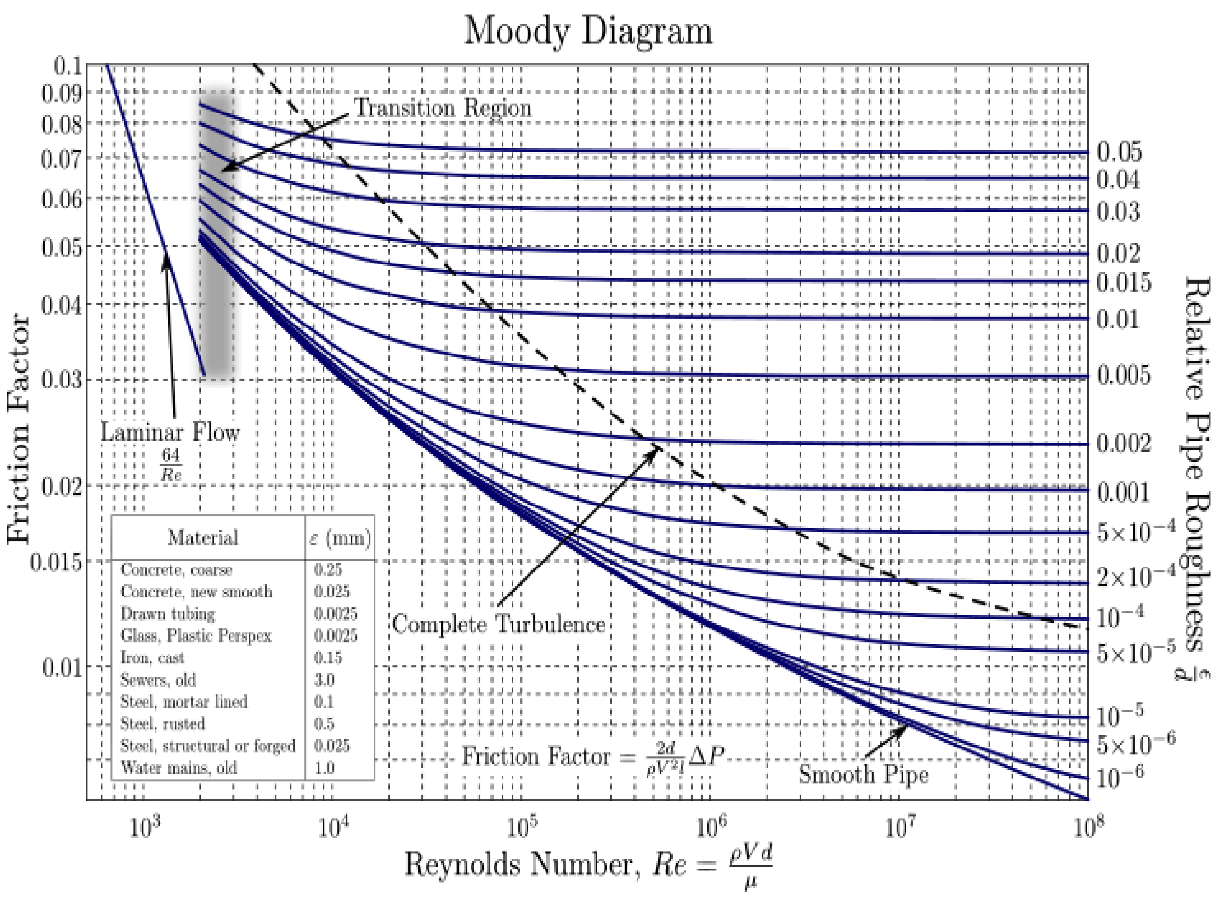
Append A

1-Moody diagram.



2-Basic conception: -

أسس التصميم :

١ – سرعة المياه فى مواسير المأخذ لا تقل عن ٦ر م/ث ولا تزيد عن ٣ م/ث

٢ – حساب الفواقد :

– الفاقد فى الضغط نتيجة الإحتكاك :

(يطبق معادلة (هازن وليم)

$$H = \frac{6.78\,L}{d^{1.165}} \left(\frac{V}{C}\right)^{1.85}$$

V.: سرعة المياه م / ث

d : قطر الماسورة م

C : معامل هازن وليم

L : طول الماسورة م

H : الفاقد فى الضغط م

– الفاقد فى الضغط للكيعان والمحابس

تطبق المعادلة الآتية :

$$H = K.\frac{V^2}{2g}$$

ويؤخذ K (معامل الفقد) حسب كل حالة

١-٢ - بيارة طلمبات المياه العكره :

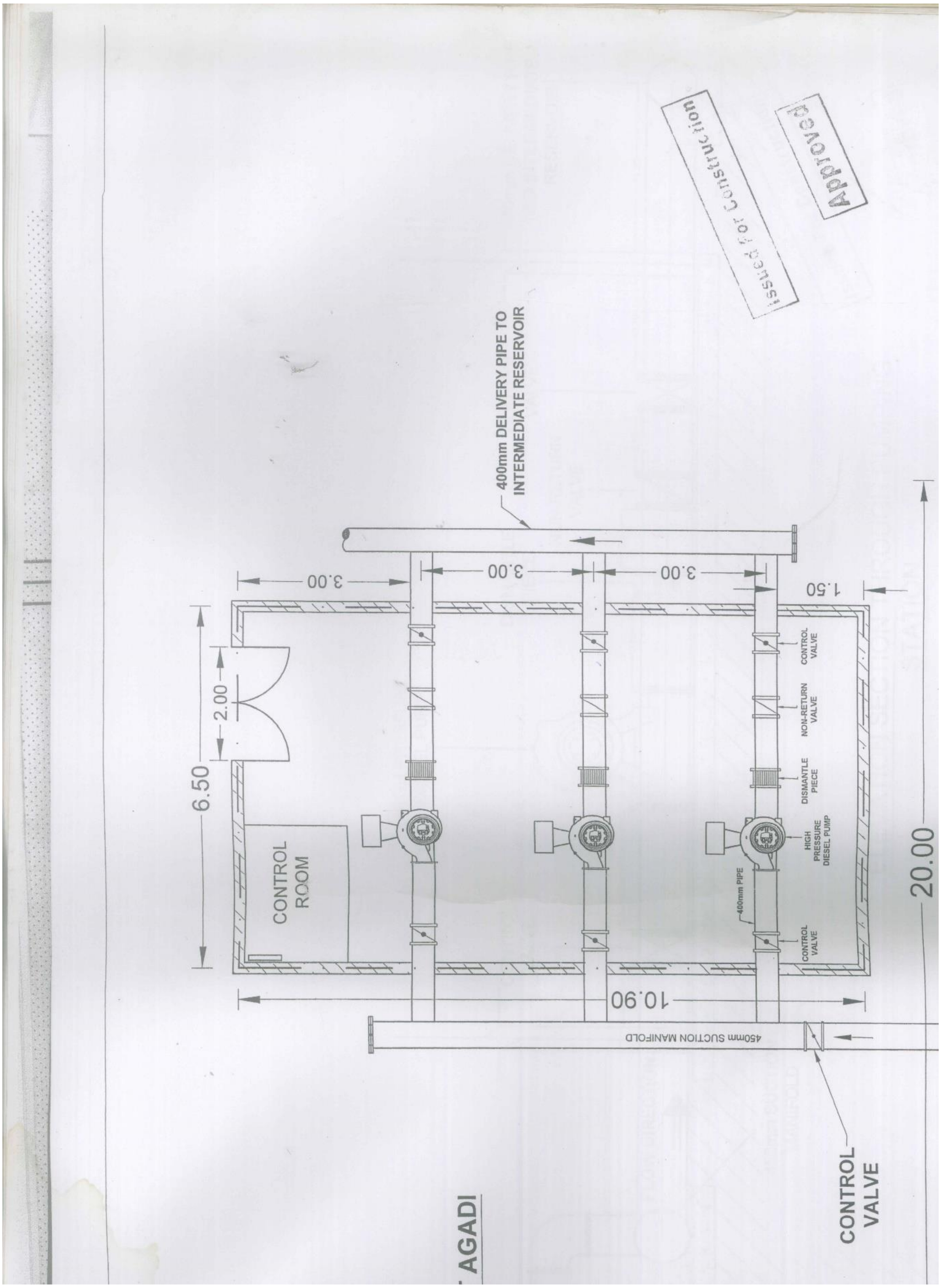
الغرض من الوحدة :

إستقبال المياه القادمة من المأخذ ومنه تسحب الطلمبات المياه لرفعها إلى وحدات التنقية . (بئر التوزيع)

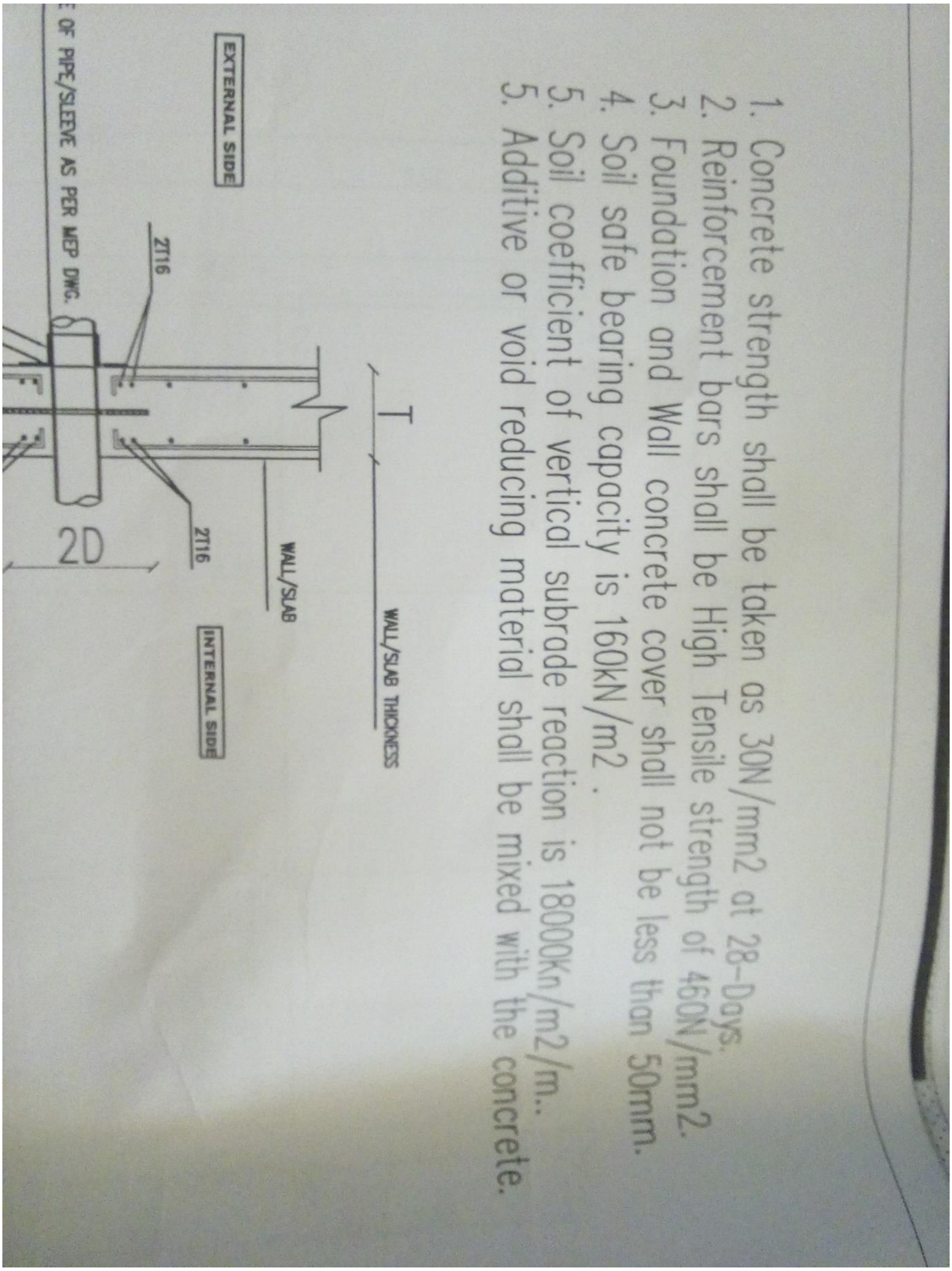
مكونات الوحدة :

تنشأ من الخرسانة المسلحة بحيث تكون مستطيلة أو دائرية الشكل وذلك حسب عدد طلمبات المياه العكره وطبيعة التربة .

3-Diameter of pipe.



4-Soil safe bearing capacity



5-Table 16 BS5950-1:2000

Table 16 — Bending strength p_b (N/mm²) for rolled sections

λ_{LT}	Steel grade and design strength p_y (N/mm²)														
	S 275					S 355					S 460				
	235	245	255	265	275	315	325	335	345	355	400	410	430	440	460
25	235	245	255	265	275	315	325	335	345	355	400	410	430	440	460
30	235	245	255	265	275	315	325	335	345	355	395	403	421	429	446
35	235	245	255	265	273	307	316	324	332	341	378	386	402	410	426
40	229	238	246	254	262	294	302	309	317	325	359	367	382	389	404
45	219	227	235	242	250	280	287	294	302	309	340	347	361	367	381
50	210	217	224	231	238	265	272	279	285	292	320	326	338	344	356
55	199	206	213	219	226	251	257	263	268	274	299	305	315	320	330
60	189	195	201	207	213	236	241	246	251	257	278	283	292	296	304
65	179	185	190	196	201	221	225	230	234	239	257	261	269	272	279
70	169	174	179	184	188	206	210	214	218	222	237	241	247	250	256
75	159	164	168	172	176	192	195	199	202	205	219	221	226	229	234
80	150	154	158	161	165	178	181	184	187	190	201	203	208	210	214
85	140	144	147	151	154	165	168	170	173	175	185	187	190	192	195
90	132	135	138	141	144	153	156	158	160	162	170	172	175	176	179
95	124	126	129	131	134	143	144	146	148	150	157	158	161	162	164
100	116	118	121	123	125	132	134	136	137	139	145	146	148	149	151
105	109	111	113	115	117	123	125	126	128	129	134	135	137	138	140
110	102	104	106	107	109	115	116	117	119	120	124	125	127	128	129
115	96	97	99	101	102	107	108	109	110	111	115	116	118	118	120
120	90	91	93	94	96	100	101	102	103	104	107	108	109	110	111
125	85	86	87	89	90	94	95	96	96	97	100	101	102	103	104
130	80	81	82	83	84	88	89	90	90	91	94	94	95	96	97
135	75	76	77	78	79	83	83	84	85	85	88	88	89	90	90
140	71	72	73	74	75	78	78	79	80	80	82	83	84	84	85
145	67	68	69	70	71	73	74	74	75	75	77	78	79	79	80
150	64	64	65	66	67	69	70	70	71	71	73	73	74	74	75
155	60	61	62	62	63	65	66	66	67	67	69	69	70	70	71
160	57	58	59	59	60	62	62	63	63	63	65	65	66	66	67
165	54	55	56	56	57	59	59	59	60	60	61	62	62	62	63
170	52	52	53	53	54	56	56	56	57	57	58	58	59	59	60
175	49	50	50	51	51	53	53	53	54	54	55	55	56	56	56
180	47	47	48	48	49	50	51	51	51	51	52	53	53	53	54
185	45	45	46	46	46	48	48	48	49	49	50	50	50	51	51
190	43	43	44	44	44	46	46	46	46	47	48	48	48	48	48
195	41	41	42	42	42	43	44	44	44	44	45	45	46	46	46
200	39	39	40	40	40	42	42	42	42	42	43	43	44	44	44
210	36	36	37	37	37	38	38	38	39	39	39	40	40	40	40
220	33	33	34	34	34	35	35	35	35	36	36	36	37	37	37
230	31	31	31	31	31	32	32	33	33	33	33	33	34	34	34
240	28	29	29	29	29	30	30	30	30	30	31	31	31	31	31
250	26	27	27	27	27	28	28	28	28	28	29	29	29	29	29
λ_{L0}	37.1	36.3	35.6	35.0	34.3	32.1	31.6	31.1	30.6	30.2	28.4	28.1	27.4	27.1	26.5

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6-Table 22 BS5950-1:2000

Bracing systems that supply positional restraint to more than one member should be designed to resist the sum of the restraint forces from each member that they restrain, reduced by the factor k_r obtained from:

$k_r = (0.2 + 1/N_r)^{0.5}$

in which N_r is the number of parallel members restrained.

4.7.2 Slenderness

The slenderness λ of a compression member should generally be taken as its effective length L_E divided by its radius of gyration r about the relevant axis, except as given in **4.7.9**, **4.7.10** or **4.7.13**.

In the case of a single-angle strut with lateral restraints to its two legs alternately, the slenderness for buckling about every axis should be increased by 20 %.

4.7.3 Effective lengths

Except for angles, channels or T-sections designed in accordance with **4.7.10** the effective length L_E of a compression member should be determined from the segment length L centre-to-centre of restraints or intersections with restraining members in the relevant plane as follows.

a) Generally, in accordance with Table 22, depending on the conditions of restraint in the relevant plane, members carrying more than 90 % of their reduced plastic moment capacity M_r in the presence of axial force (see **I.2**) being taken as incapable of providing directional restraint.

b) For continuous columns in multistorey buildings of simple design, in accordance with Table 22, depending on the conditions of restraint in the relevant plane, directional restraint being based on connection stiffness as well as member stiffness.

c) For compression members in trusses, lattice girders or bracing systems, in accordance with Table 22, depending on the conditions of restraint in the relevant plane.

d) For columns in single storey buildings of simple design, see **D.1**.

e) For columns supporting internal platform floors of simple design, see **D.2**.

f) For columns forming part of a continuous structure, see Annex E.

Table 22 — Nominal effective length L_E for a compression member[a]

a) non-sway mode			
Restraint (in the plane under consideration) by other parts of the structure			L_E
Effectively held in position at both ends	Effectively restrained in direction at both ends		$0.7L$
	Partially restrained in direction at both ends		$0.85L$
	Restrained in direction at one end		$0.85L$
	Not restrained in direction at either end		$1.0L$
b) sway mode			
One end	Other end		L_E
Effectively held in position and restrained in direction	Not held in position	Effectively restrained in direction	$1.2L$
		Partially restrained in direction	$1.5L$
		Not restrained in direction	$2.0L$
[a] Excluding angle, channel or T-section struts designed in accordance with **4.7.10**.			

4.7.4 Compression resistance

The compression resistance P_c of a member should be obtained from the following:

a) for class 1 plastic, class 2 compact or class 3 semi-compact cross-sections:

$P_c = A_g p_c$

b) for class 4 slender cross-sections:

$P_c = A_{eff} p_{cs}$

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7-Table 24 BS5950-1:2000

Table 24 — Compressive strength p_c (N/mm²) (*continued*)

6) Values of p_c (N/mm²) with $\lambda \geq 110$ for strut curve c															
λ	Steel grade and design strength p_y (N/mm²)														
	S 275					S 355					S 460				
	235	**245**	**255**	**265**	**275**	**315**	**325**	**335**	**345**	**355**	**400**	**410**	**430**	**440**	**460**
110	102	104	106	108	110	116	118	119	120	122	126	127	129	130	132
112	100	102	104	106	107	113	115	116	117	118	123	124	125	126	128
114	98	100	101	103	105	110	112	113	114	115	119	120	122	123	124
116	95	97	99	101	102	108	109	110	111	112	116	117	118	119	120
118	93	95	97	98	100	105	106	107	108	109	113	114	115	116	117
120	91	93	94	96	97	102	103	104	105	106	110	110	112	112	113
122	89	90	92	93	95	99	100	101	102	103	107	107	109	109	110
124	87	88	90	91	92	97	98	99	100	100	104	104	106	106	107
126	85	86	88	89	90	94	95	96	97	98	101	102	103	103	104
128	83	84	86	87	88	92	93	94	95	95	98	99	100	100	101
130	81	82	84	85	86	90	91	91	92	93	96	96	97	98	99
135	77	78	79	80	81	84	85	86	87	87	90	90	91	92	92
140	72	74	75	76	76	79	80	81	81	82	84	85	85	86	87
145	69	70	71	71	72	75	76	76	77	77	79	80	80	81	81
150	65	66	67	68	68	71	71	72	72	73	75	75	76	76	76
155	62	63	63	64	65	67	67	68	68	69	70	71	71	72	72
160	59	59	60	61	61	63	64	64	65	65	66	67	67	67	68
165	56	56	57	58	58	60	60	61	61	61	63	63	64	64	64
170	53	54	54	55	55	57	57	58	58	58	60	60	60	60	61
175	51	51	52	52	53	54	54	55	55	55	56	57	57	57	58
180	48	49	49	50	50	51	52	52	52	53	54	54	54	54	55
185	46	46	47	47	48	49	49	50	50	50	51	51	52	52	52
190	44	44	45	45	45	47	47	47	47	48	49	49	49	49	49
195	42	42	43	43	43	45	45	45	45	45	46	46	47	47	47
200	40	41	41	41	42	43	43	43	43	43	44	44	45	45	45
210	37	37	38	38	38	39	39	39	40	40	40	40	41	41	41
220	34	34	35	35	35	36	36	36	36	36	37	37	37	37	38
230	31	32	32	32	32	33	33	33	33	34	34	34	34	34	35
240	29	29	30	30	30	30	31	31	31	31	31	31	32	32	32
250	27	27	27	28	28	28	28	28	29	29	29	29	29	29	29
260	25	25	26	26	26	26	26	26	27	27	27	27	27	27	27
270	23	24	24	24	24	24	25	25	25	25	25	25	25	25	25
280	22	22	22	22	22	23	23	23	23	23	23	24	24	24	24
290	21	21	21	21	21	21	21	22	22	22	22	22	22	22	22
300	19	19	20	20	20	20	20	20	20	20	21	21	21	21	21
310	18	18	18	19	19	19	19	19	19	19	19	19	19	19	20
320	17	17	17	17	18	18	18	18	18	18	18	18	18	18	18
330	16	16	16	16	17	17	17	17	17	17	17	17	17	17	17
340	15	15	15	16	16	16	16	16	16	16	16	16	16	16	16
350	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15

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