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ANALYSIS AND DESIGN OF AN OPEN CHANNEL FLOW FLUME:

RESERVOIR SECTION

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EXAMINER APPROVAL DOCUMENT

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I hereby declare that the work in this report is my own, except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any other Degree and is not concurrently submitted for award of other degree.

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I hope this thesis can contribute in provide some information and knowledge to others. Thanks again to all parties who have help me in doing this thesis.

ABSTRACT

The facilities for testing hydro turbine is not many in Malaysia, hence flume project is initialize to overcome this problem. This study is about on choosing the best reservoir designs that need to be implement in flume project, to choose the best the design, there are analysis that need to be done, stress and strain analysis, CFD analysis and costing analysis also should be include. Throughout the analysis, the main parameter of choosing reservoir design can be recognize, in this study there are two main parameters for choosing the best tank design that is, pressure drop and costing. The need of reservoir generally in term of costing for the whole project is because a costly pipe material would be required to withstanding a very high pressure in a very long pipe system. Therefore using reservoir is more economical compare to costly pipeline material, but in term of reservoir costing only, the variable that we can change is the volume of material use and also price of material. The volume of material used is depends on the dimension of the design and the dimension is depends on the criteria that this project need for reservoir section, to reduce volume material used, a single, double, and triple design is rational to be proposed. Choosing a right material need several analysis to be done, firstly throughout the CFD analysis, the data for maximum total pressure across wall can be obtain and with this data, a stress and strain analysis will be perform using a different grade of concrete, in this project the material used is concrete because it cannot be corroded since the fluid medium will be water so corrosion aspect is important. With stress and strain analysis, the maximum deflection data for each design can be obtain, the maximum deflection is like the safety level for the material use, the less deflection the more level of safety of the material, hence an optimum material with less price but strong can be choose, in this study the most suitable material to be use is grade 10 ready mix concrete. For pressure drop factor, it is depends on the design, in this study the design that have been proposed is parshall design, rectangular design and circular design varied with single, double and triple tank. In conclusion the design that full fills this both parameters is double tank parshall design.

ABSTRAK

Kemudahan untuk menguji hidro turbin di Malaysia adalah tidak banyak, oleh sebab itu projek saluran air terbuka dijalankan bagi mengatasi masalah ini. Kajian ini adalah mengenai pemilihan reka bentuk takungan air yang terbaik untuk digunakan dalam projek saluran air terbuka, untuk memilih reka bentuk yang sesuai , terdapat beberapa analisis yang perlu dijalankan, seperti analisis tekanan dan bebanan, CFD analisis dan analisis harga. Melalui analisis, parameter yang utama dalam memilih reka bentuk yang sesuai dapat dikenal pasti, dalam kajian ini, terdapat dua parameter yang penting iaitu perbezaan tekanan dan harga. Keperluan takungan air secara asasnya dalam aspek kos untuk keseluruhan projek adalah disebabkan bahan yang digunakan oleh paip untuk mengatasi tekanan yang kuat dalam paip sistem yang panjang sangat mahal.Oleh sebab itu, menggunakan takungan air lebih murah berbanding paip yang mahal, tetapi dalam aspek kos takungan air itu sendiri, pemboleh ubah yang boleh diubah adalah isi padu bahan yang digunakan dan harga bahan yang digunakan. Isi padu bahan itu bergantung terhadap dimensi reka bentuk itu sendiri dan dimensi hendaklah mengikut kriteria yang ditetapkan oleh projek untuk seksyen takungan air, untuk mengurangkan isi padu bahan yang digunakan, reka bentuk satu tangki, dua tangki dan tiga tangki adalah rasional untuk dicadangkan. Memilih bahan yang sesuai memerlukan beberapa analisis untuk dijalankan, yang pertama adalah melalui analisis CFD, data yang diperolehi untuk keseluruhan tekanan pada dinding tangki akan digunakan untuk analisis tekanan dan bebanan dengan menggunakan gred konkrit yang berlainan, dalam projek ini bahan yang digunakan adalah konkrit disebabkan ia tidak boleh terhakis kerana bendalir yang digunakan adalah air, oleh itu aspek hakisan sememangnya penting. Dengan analisis tekanan dan bebanan, data pemesongan maksima untuk setiap reka bentuk mampu diperolehi, faktor pemesongan yang maksima adalah penting untuk menunjukkan level keselamatan sesebuah bahan, disebabkan itu bahan yang sesuai dengan harga yang kos yang sesuai tetapi kuat boleh dipilih, dalam kajian ini bahan yang sesuai adalah konrit gred 10. Untuk faktor perbezaan tekanan, ianya bergantung terhadap reka bentuk, dalam kajian ini, reka bentuk yang dicadangkan adalah reka bentuk parshall, reka bentuk empat segi dan reka bentuk bulatan menyebar divariasikan dengan satu tangki, dua tangki dan

tiga tangki. Kesimpulannya, reka bentuk yang memenuhi kehendak kedua – dua parameter adalah reka bentuk parshall dengan dua tangki.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

Human depends too much on fossil in gaining the energy to power up machine for daily needs, this situation resulting on decreasing of fossil fuel in earth as it closer to its extinction. A new source should be provided and developed to replace the current energy, initiative plan should be done and to have knowledge on other source of renewable energy, more experiment and analysis must be done. Hydroelectric energy is nowadays one of the developing source energy because of its friendly environment compare to other type of energy and more over it is renewable energy so it will not depleted.

Hydroelectric energy comes from the flow of water, it is a motion of water that cause from the effect of gravitational force. So in order to produce electricity, water should be in motion and when it goes through the blade of a turbine, the blade will turn and the rotor in the generator will convert it to electricity. From this fundamental of sequence it is shown that, the energy is not destroyed, it’s only converting or changing from kinetic to mechanical and lastly electricity.

1.2 PROBLEM STATEMENT

The hydroelectric energy is different as its only use water motion but not use the waters to produce electrical energy. The distribution of this electrical energy mainly on city area because the geographical of the place and more demand compared to rural area. The rural citizen will have difficulties in obtaining electric supplies to power up their home, so the microhydro turbine is use to be an option for producing electricity as it is suitable in small river that located in rural part, but to install the turbine, it need to have a demonstration of the hydroturbine using a flume that have same specification in flow velocity, mass and volume flow rate of the river in rural area, and UMP don’t have this flume test as the medium of river flow experiment on micro hydro turbine. In order to have a flume designed according to river behaviour, a reservoir playing a main part on storing the main resource of hydroelectric energy that is water.

1.3 OBJECTIVE

The main objective of the study is:

i. To design and evaluate the reservoir of a proposed flume design.
ii. To design and analysis the support structure for reservoir of flume project.
iii. To choose the best reservoir design.

1.4 SCOPE OF STUDY

i. Analysis of Pressure distribution on reservoir wall
ii. Structural analysis of reservoir of a flume.
iii. CFD simulation using ANSYS and Stress analysis using ALGOR or AUTODESK.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will give an overview of a flume, reservoir, support structure for reservoir, pressure exerted on the wall and price.

2.2 FLUME

Flume is an artificial water channel in the form of gravity chute that leads water from an inlet to an outlet and circulate the flow. A flume water channel direct water from water source to specified destination. The history of a flume was, at first a flume is structured elevated wooden box that will follow the geographical condition of the earth. These method of directing the water from its source have been used widely in the mining industries to deposits useful mineral such as gold, tin other heavy minerals. In the other cases, in the early years of flume creation, flumes were used to transport logs in the logging industry, to generate electric power and to power various waterwheels. In the modern years and ages, flumes were optimized for various applications. The examples of flumes widely used today are Venturi Flumes and Parshall Flumes. The two examples named are used to evaluate the flow rate of water (or other liquid).

The flumes to be studied a design in the scope of the project is flumes designed for flow rate evaluation. The flume will be consisting of a water channel which will be consisting the main test section of water in it. The other components which will be completing a flume are water pumps, convergent inlet, divergent outlet, pumps, water reservoirs and piping system. This complete combination of a flume will be important in simulating the real condition of water in river. To design and establish a flume, the properties of a flume is very important. This will be involving the width of the flume, the length of the flume, material used, the specified depth, and the pump specification used. This will be affecting the properties of water such as the volume flow rate of water, mass flow rate of water, Froude number of water, Reynolds number of water and velocity of water. The listed affecting parameters are very important in simulating the real condition of the real water properties in the river. The flow condition may not be the same, but at least will be almost the same with the study case.

Parallel with the objectives of the project, the flume will be used of testing the apparatus or machines for the real objectives of flumes being constructed which is as a testing utility to evaluate and test the potential of hydro turbines and micro hydro turbines to generate electricity. The hydro turbine will be located in the water channel effective location which is having effective length from all over length of the water channel (called the test section) and at an effective depth. From specified properties of water flow that is suitable with the flow of the river, the hydro turbine will be tested. The result obtained from the test, will be depicting almost the real result in the real condition of the river. This will be making the testing process of useful apparatus made easy.

2.3 RESERVOIR (SURGE TANK)

According to J. Thornton (UNESCO,1992)**,** reservoirs are those water bodies formed or modified by human activity for specific purpose, in order to provide a reliable and controllable resource. Surge tank are a form of reservoir but it is also act as a place for pressure release from the pipeline system effect from the water hammer that happen when closuring the valve.

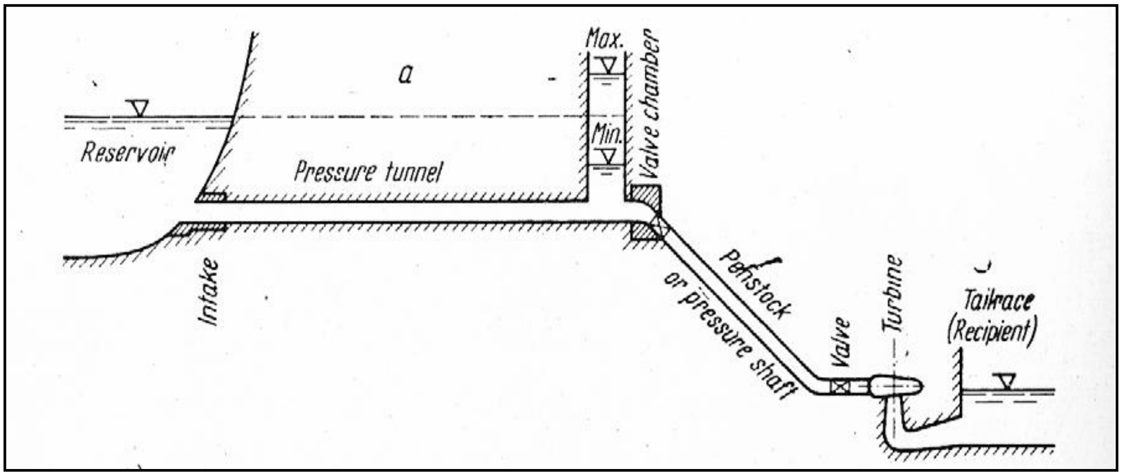

Figure 2.1: Simple surge tank system.

M. Azhadhary(2003)

Previous study conducted by M. Azhadhary (2003) stated that, in hydroelectric plant, this surge tank can be concluded as three main purposes:

i. The turbines to the reservoir are practically interrupted by the surge tank to prevent the pressure wave due to the water hammer at the free water surface and to free the pressure tunnel from excessive pressures.

ii. The surge provides protection to the penstock against damage of water hammer. The overpressure depends upon the length of the penstock (the closed conduit). The surge tank, by interrupting the closed system of the penstock and of the pressure tunnel, reduces the overpressure due to water hammer.

iii. The third purpose of the surge tank is to provide water supply to the turbines in case of starting up. The amount of water required during these changes in operating conditions is supplied by the surge tank installed in the conduit. The capacity thereof should be selected to ensure the required water supply during the most unfavorable increase in demand, until the water mass in the tunnel has attained the necessary velocity. Air should be prevented from entering the penstock even in case of the deepest down surge in the chamber.

Water hammer is the consequence from the conversion of kinetic energy into elastic energy, but only rapid change of the flow velocity will produce this effect, such as sudden closure of a gate valve or the sudden failure of a pump. Due to the inertia of the fluid, the flow velocity of the liquid column as a whole is no longer capable of adjusting to the new situation. The fluid is deformed, with pressure transients accompanying the deformation process. The reason why surge pressure is so dangerous is that it travels at the almost undiminished speed of sound (roughly 1000 m/s for a large number of pipe materials) and causes destruction in every part of the piping system it reaches (Hoarst Joachim, 2006).

In parallel with the project, flume design, the concept of surge tank can be use as it contributes on lowering the pressure in pipe system and in the same time can act as water storage; there is several type of surge tank that can be use:

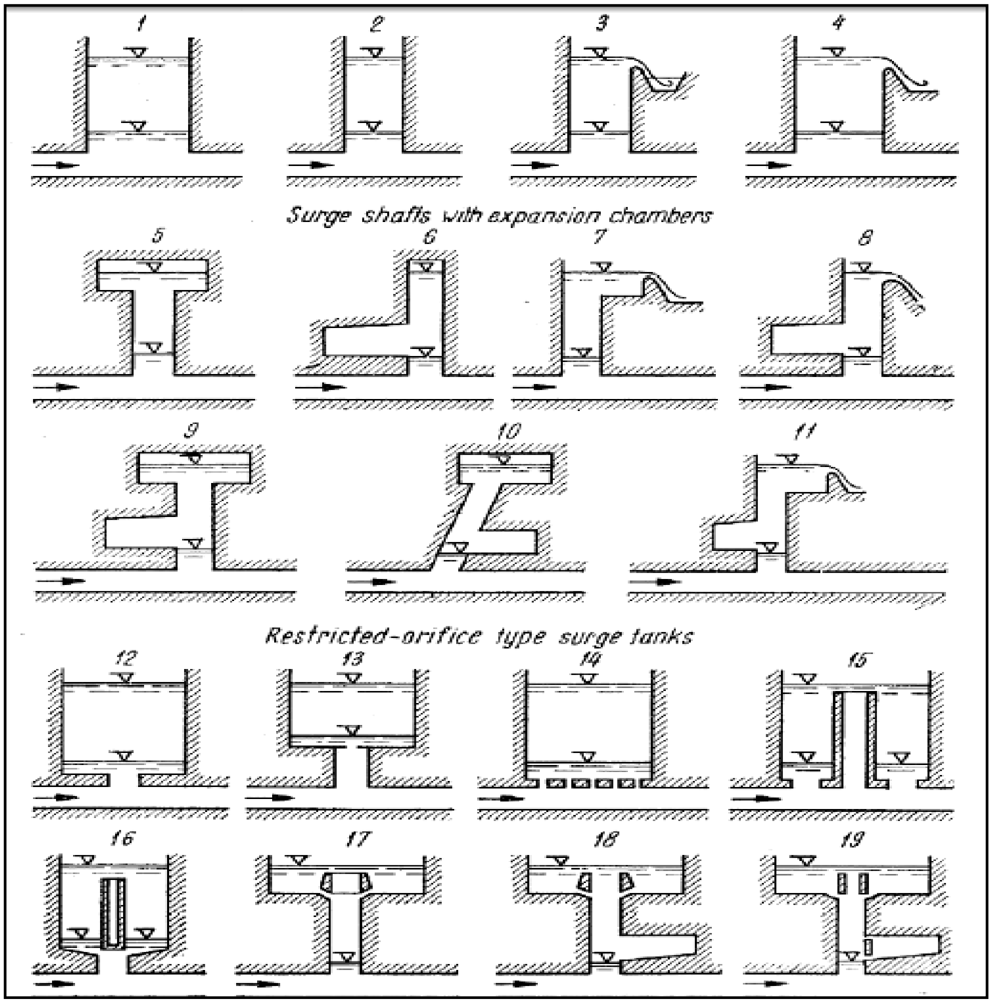

Figure 2.2: Type of surge tank.

Source : Atil BULU (2006)

According to Figure 2.2, the name for each type of surge tank is mention as below by referring to the number shown in the figure.

1) Simple tank
2) Simple shaft
3) Spilling shaft
4) Overflow type tank
5) Shaft with expansion chamber
6) Shaft with lower chamber

7) Shaft with over flow type upper chamber
8) Overflow type shaft with lower chamber
9) Shaft with two chambers
10) Inclined shaft with two chamber
11) Overflow type tank with two chambers
12) Simple restricted orifice type tank
13) Simple restricted orifice type tank
14) Tank with grate type throttling
15) Differential (Johnson type) tanks
16) Differential (Johnson type) tanks
17) Differential tank with upper chamber
18) Double chamber differential tank
19) Double chamber differential tank with throttled lower chamber

With this multiple type of choice of surge tank, selecting the simple surge tank is enough as it not complex and save cost, more over it will be easy on analysing the effect of surge tank size on pressure distribute from pipe system.

2.4 COUNTERFORT WALL

A retaining wall is defined as a structure whose primary purpose is to provide lateral support for soil or rock. In some cases, the retaining wall may also support vertical loads. Examples include basement walls and certain types of bridge abutments. Some of the more common types of retaining walls are gravity walls, counterfort walls, cantilevered walls, and crib walls. Gravity retaining walls are routinely built of plane concrete or stone and the wall depends primarily on its massive weight to resist failure from overturning and sliding. Counterfort walls consist of a footing, a wall stem, and intermittent vertical ribs (called counterforts) that tie the footing and wall stem together. Crib walls consist of interlocking concrete members that form cells, which are then filled with compacted soil.

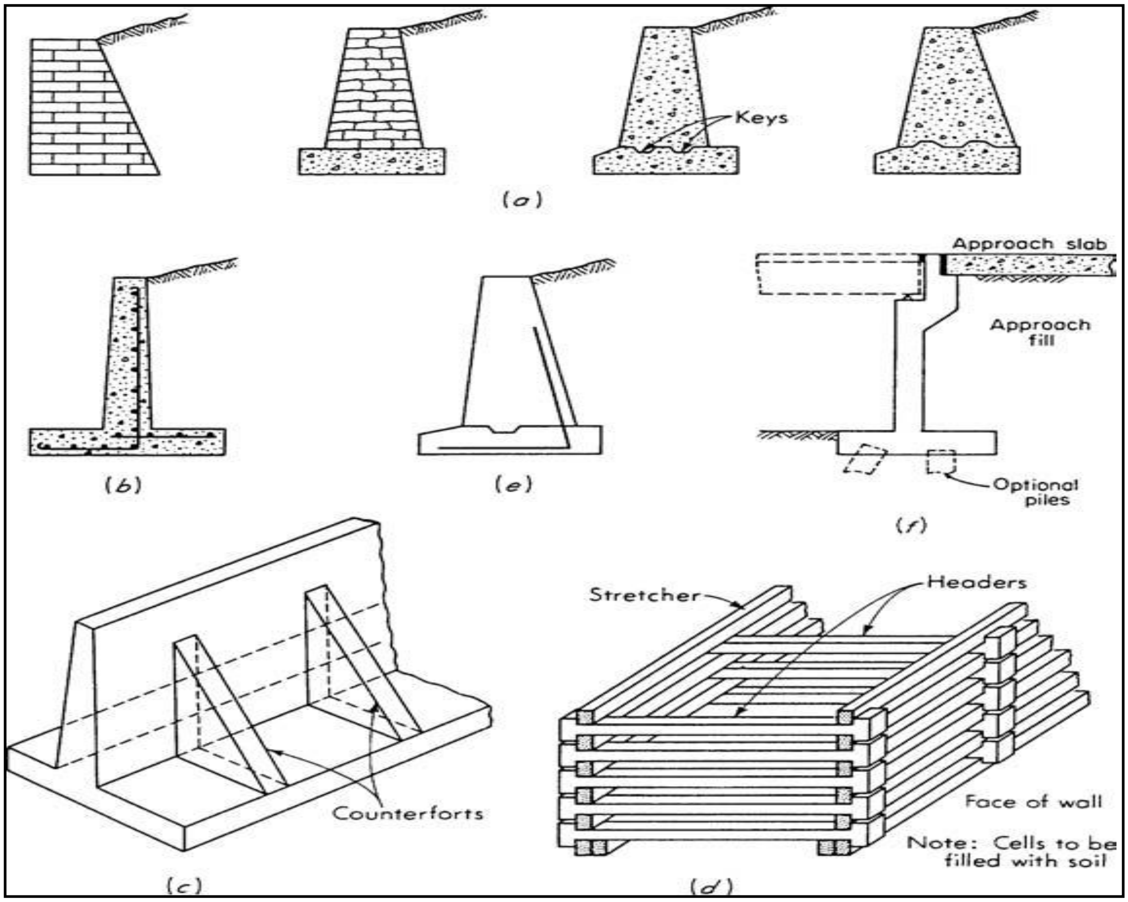

Figure 2.3: Different type of concrete wall.

Source: M Ghazavi (2003)

Figure 2.3, shows a multiple type of concrete wall that can be apply in this flume project, each wall type description and name is explain as follow:

a) Gravity walls of stone, brick, or plain concrete. Weight provides overturning and sliding stability.
b) Cantilevered wall.
c) Counter fort retaining wall or buttressed retaining wall. If backfill covers counterforts, the wall is termed a counterfort retaining wall.
d) Crib wall.
e) Semi gravity wall (often steel reinforcement is used).
f) Bridge abutment.

In parallel with the project, the counter fort is chose as the support structure for reservoir and flume section because first it is made of concrete that have strong structure and it will not corroded as we use water as a medium in this flume, secondly it did not have a backfill for active earth pressure as the counter force at the back of the wall so the total area use will be small, and lastly the wall did not only use weight of the wall as the main factor for stability but it also has a counterfort that support the wall structure to overcome the hydrostatic force that exert by the water in the reservoir.

According to M. Ghazavi (2003), the design variables for counter fort retaining wall also applicable to counter fort wall, base width (X1), thickness of heel and toe (X2), bottom thickness of stem (X3), top thickness of stem (X4), heel width (X5), toe width (X6), counterfort thickness (X7), distance between counterforts (X8), amount of main steel rebar on the top of heel and in x direction (X9), amount of main steel rebar on the bottom of heel and in x direction (X10), amount of main steel rebar on the top of heel and in y direction (X11), amount of main steel rebar on the bottom of heel and in y direction (X12), amount of main rebar on the top of toe and in x direction (X13), amount of main rebar on the bottom of toe and in x direction (X14), amount of main rebar on the top of toe and in y direction (X15), amount of main rebar on the bottom of toe and in y direction (X16), quantity of main rebar in the front of stem and in z direction(X17),quantity of main rebar in the back of stem and in z direction (X18), quantity of main rebar in the front of stem and in y direction (X19), quantity of main rebar in the back of stem and in y direction (X20), quantity of inclined rebar of counterfort (X21), and shear rebar of counterfort (X22).Since this study is only for early design, so the only variable that will be consider is X4, X5, X7 and X8.

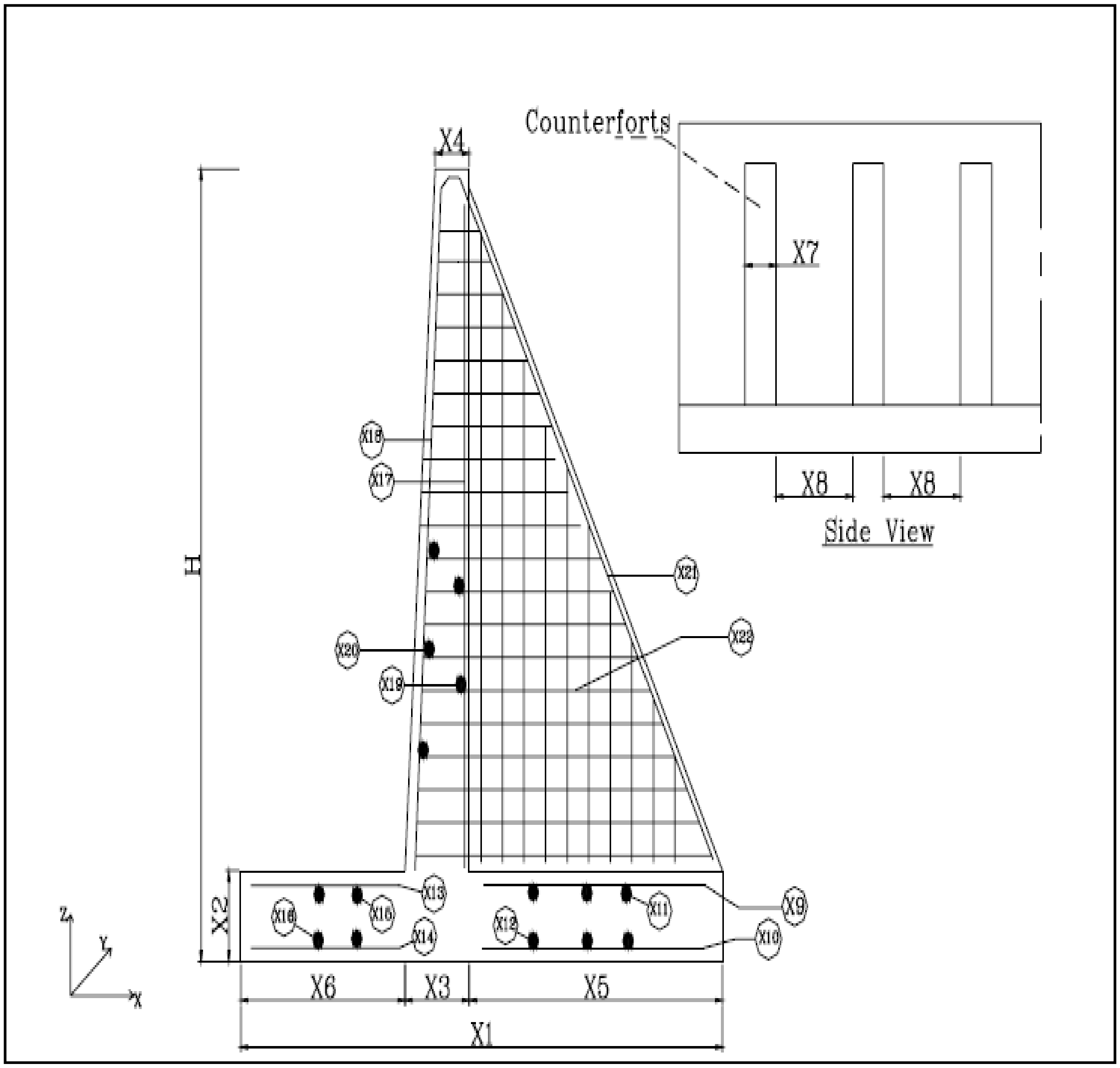

Figure 2.4: Design variable for counterfort wall.

Source: M Ghazavi (2003)

Table 2.1: List of lower and upper bound for counterfort wall design variable.

Lower Bound	Upper Bound
X_{1}min=0.3H	X_{1}max= 3H
X_{2}min=H/10	X_{2}max= H/8.5
X_{3}min=H/10	X_{3}max= H/8.5
X_{4}min=20 cm	X_{4}max= 30 cm
X_{5}min= 0.1H	X_{5}max= 2H
X_{6}min= 0.1H	X_{6}max= H
X_{7}min= 20 cm	X_{7}max= 50 cm
X_{8}min= 0.3H	X_{8}max= 0.7H
X_{9}min= minimum of shrinkage and temperature rebar at heel in x direction	X_{9}min= maximum of shrinkage and temperature rebar at heel in x direction
X_{10}min= minimum of shrinkage and temperature rebar at heel in x direction	X_{10}min= maximum of shrinkage and temperature rebar at heel in x direction
X_{11}min= minimum of shrinkage and temperature rebar at heel in y direction	X_{11}min= maximum of shrinkage and temperature rebar at heel in y direction
X_{12}min= minimum of shrinkage and temperature rebar at heel in y direction	X_{12}min= maximum of shrinkage and temperature rebar at heel in y direction
X_{13}min= minimum of shrinkage and temperature rebar at toe in x direction	X_{13}min= maximum of shrinkage and temperature rebar at toe in x direction
X_{14}min= minimum of shrinkage and temperature rebar at toe in x direction	X_{14}min= minimum of shrinkage and temperature rebar at toe in x direction
X_{15}min= minimum of shrinkage and temperature rebar at toe in y direction.	X_{15}min= maximum of shrinkage and temperature rebar at toe in y direction.
X_{16}min= minimum of shrinkage and temperature rebar at toe in y direction	X_{16}min= maximum of shrinkage and temperature rebar at toe in y direction
X_{17}min= minimum of shrinkage and temperature rebar at stem in z direction	X_{17}min= maximum of shrinkage and temperature rebar at stem in z direction
X_{18}min= minimum of shrinkage and temperature rebar at stem in z direction.	X_{18}min= maximum of shrinkage and temperature rebar at stem in z direction.
X_{19}min= minimum of shrinkage and temperature rebar at stem in y direction	X_{19}min= maximum of shrinkage and temperature rebar at stem in y direction
X_{20}min= minimum of shrinkage and temperature rebar at stem in y direction	X_{20}min= maximum of shrinkage and temperature rebar at stem in y direction
X_{21}min= minimum of inclined rebar at counterfort	X_{21}min= maximum of inclined rebar at counterfort
X_{22}min= minimum of shear rebar at counterfort	X_{22}min= maximum of shear rebar at counterfort

Source: M Ghazavi (2003)

Figure 2.4 shows the location for each variable design apply and Table 2.1 are the list of lower and upper bound of design variable according to previous study of M. Ghazavi (2003), so the wall design must in range of this boundary given.

2.5 FLUID STATICS

Fluid statics is generally referred to as hydrostatics when the fluid is a liquid and as aerostatics when the fluid is a liquid and as aerostatics when the fluid is a gas. The only stress that needs to be deal with in fluid statics is the normal stress, which is the pressure, and the variation of pressure is due only to the weight of the fluid. Pressure in a fluid increase with depth because more fluid rest on deeper layer and the effect of this extra weight on a deeper layer is balance by an increase in pressure, this phenomenon is called variation of pressure with depth, John M. Cimbala (2006).

The absolute pressure above the liquid is P_o, which is the local atmospheric pressure if the liquid is open to atmosphere. Hence the absolute pressure at any point on the reservoir is $P = P_o + \rho gh$, where h is the distance of the point from the free surface. The resultant force can be determined as $F_R = P_{avg}A$, Where A is the surface area. According to Yunus A. Cengel (2003), the resultant force must pass through the centroid of pressure prism and the centroid is located at h/3 above the base along the vertical axis.

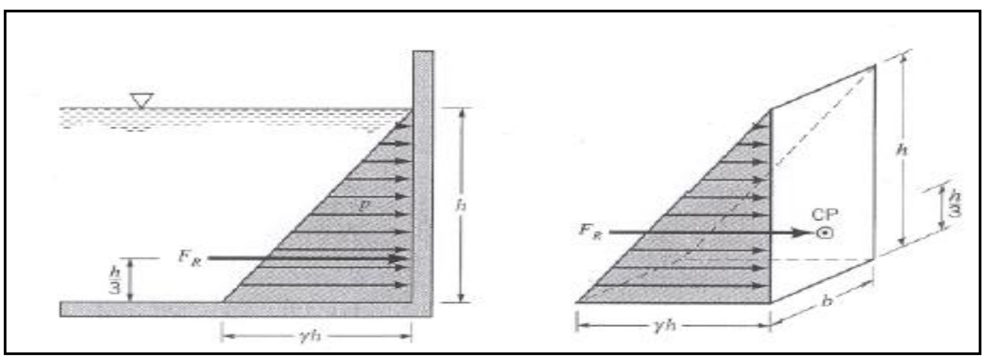

Figure 2.5: Location of pressure prism centroid.

Source: Yunus A.Cengel (2003)

Like what have been shows in the Figure 2.5, the resultant force is located at the h/3 of the depth height, hence it can be consider that the maximum pressure of static pressure is located at this point

However, if the reservoir wall are going to include the effect of atmospheric pressure on one side of the wall, must realize that this same pressure acts on the outside surface (assuming it is exposed to the atmosphere), so that an equal and opposite force will be developed as illustrated in the figure. By referring to Figure 2.6, it can be conclude that the resultant fluid force on the surface is that due only to the gage pressure contribution of the liquid in contact with the surface-the atmospheric pressure does not contribute to this resultant.

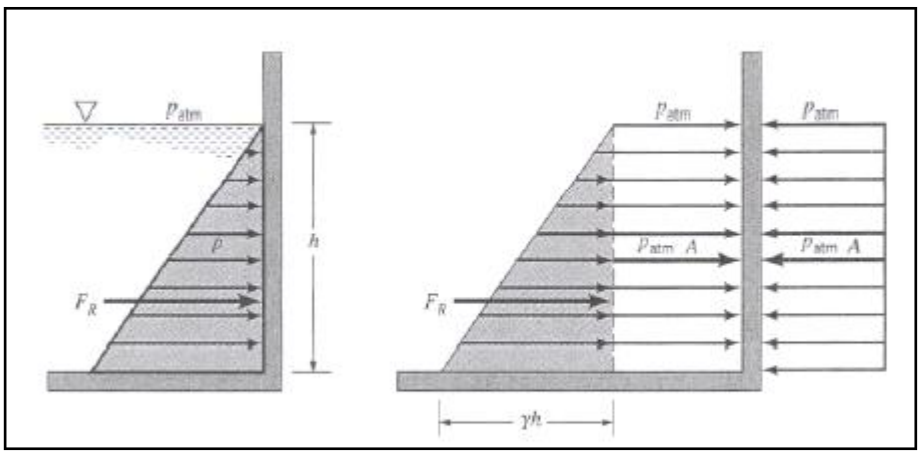

Figure 2.6: Effect of atmospheric pressure on reservoir wall.

Source: Yunus A.Cengel (2003)

2.6 BERNOULLI EQUATION

The Bernoulli equation states that the sum of the flow, kinetic, and potential energies of a fluid particle along a streamline is constant. Therefore, the kinetic and potential energies of the fluid can be converted to flow energy (and vice versa) during flow, causing the pressure to change.

$$P_1 + \frac{1}{2}\rho v^2 + \rho gh = \text{constant (along a streamline)} \quad (2.1)$$

Each term in this equation has pressure unit, and thus each term represent some kind of pressure:

- P is the static pressure; it represents the actual thermodynamic pressure of the fluid.
- $\frac{1}{2}\rho v^2$ is the dynamic pressure; it represents the pressure rise when the fluid in motion is brought to stop isentropically.
- ρgh is the hydrostatic pressure, which is not pressure in real sense since its value depends on the reference level selected; it accounts for the elevation effects of fluid weight on pressure.

The sum of the static, dynamic and hydrostatic pressure is called the total pressure. Therefore, the Bernoulli equation states that the total pressure along streamline is constant. The sum of the static and dynamic pressure is called the stagnation pressure, and it is expressed as

$$P + \frac{1}{2}\rho v^2 = P_{stag} \quad (2.2)$$

According to Yunus A. Cengel, the stagnation pressure represents the pressure at a point where the fluid is brought to a complete stop, this idea is visualize on Figure 2.7. In parallel with the project, stagnation occurs at the surface of the reservoir wall.

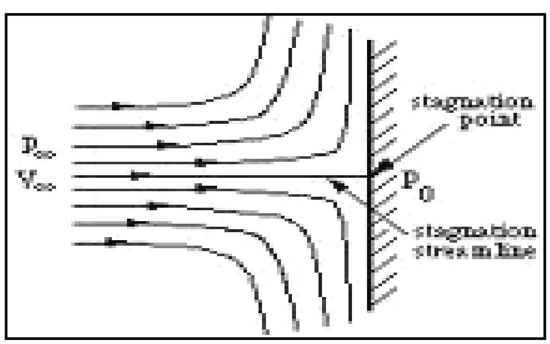

Figure 2.7: An illustration of stagnation pressure.

Source: E.J Finnemore (2002)

2.7 CONTROL VOLUME

During the water circulating process through the whole section in flume project, the depth in reservoir is maintain at 1.5 m depth, this scenario is called steady flow process, means that there is no change occur within the control volume with time. According to Yunus A. Cengel (2003), for a general steady flow system with multiple inlet or outlet, it can be expressed in rate form as

Mass flow rate in = mass flow rate out

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2 \qquad (2.3)$$

It states that the total rate of mass entering a control volume is equal to the total rate of mass leaving it. Since only water flow in and out from the reservoir, hence the density is constant, so the equation can be simplify into volume flowrate.

$$A_1 v_1 = A_2 v_2 \qquad (2.4)$$

2.8 CONCLUSION

In general, the literature review demonstrate the use of reservoir in helping the project, the purpose of existence of the reservoir is to reduce water hammer pressure that come from the inertia of water in the pipe after suddenly closed of pump and to reduce the head loss in pipe system, since reservoir can save the length of pipe use, with this fundamentals, certain design can be proposed but in the mean time the design should be low cost and also strong. In term of strength, they are certain pressure that needs to be considered, using the principle of Bernoulli, it can be conclude that the reservoir wall must withstand the dynamic and static pressure across the reservoir section. In aspect of design analysis, to have a low cost design, the tank can be separated to save the material cost, hence the idea of dividing tank into 2 or 3 small tank is rational .So basically, the design analysis is a try an error method in order to achieve the strong and economical cost design.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter presents the methodology involved in this study. The methodology flow is conducted as shown in Figure 3.1 and the detail of each stage is explained in the following sub-chapter.

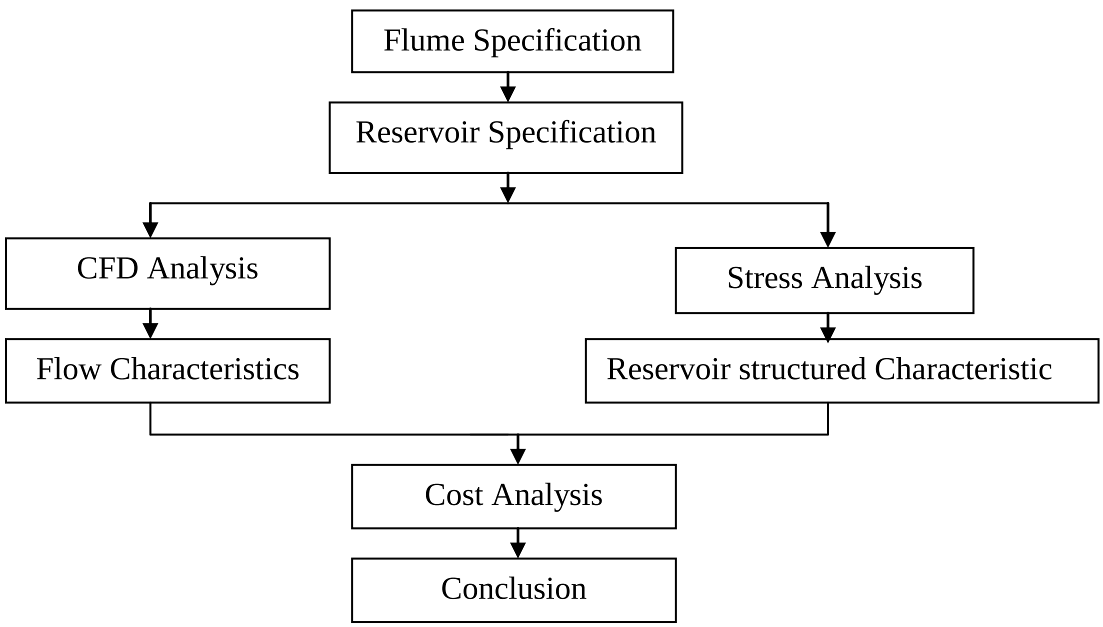

Figure 3.1: Flow Chart

3.2 FLUME SPECIFICATION

There are some theory considerations that need to be made before designing a reservoir, to maintain the depth in the reservoir, the volume flowrate of the inlet must be equal to the outlet. The volume flowrate that needed to be maintained is 9 m^3/s because the velocity that we want in the flume is 3 m/s with depth of water 1.5 m. The flume specification was set to be 2 meter width, 2 meters height and 30 meters length using the equation 2.4, the volume flowrate will be 9 m^3/s.

The outlet of reservoir can be assumed as fix at 9 m^3/s because the water is suck using pump, and at the inlet, the velocity is 11 m/s with pipe diameter of 0.8 m (value taken from outlet flume section), using equation 2.1 the volume flow rate is equal to 5.5 m^3/s, so the tank will have shortage of 3.5 m^3 of water, so the depth of water will be decreasing. Table below shows the depth of water decrease according to number of tank.

Table 3.1: List of water depth height decreases with number of tank.

Number of Tank	**Height of water Depth Decrease (m)**
Single	0.13
Double	0.3
Triple	0.4

By referring to the data obtained, the outlet pipe section should be located below than 1.1 meter height of the water depth in order to synchronize with the flume section. In case of double and triple tank, the shortage of water will only occur at the outlet tank only. The height of water depth decreased were analyse using the fix parameter that will be explain in design justification.

3.3 RESEVOIR SPECIFICATION

There are two parts in the study; 1) Computational Fluid Dynamic Simulation and 2) Stress Analysis. In this study, simulation will be performed to verify the pressure exerted on the wall of reservoir and the maximum deflection that will occur by using different type of concrete grade. Both simulation will be done on each propose design of reservoir. The proposed design will be exaggerated in design justification.

3.3.1 Proposed Design Justification

There are three type of reservoir that has been proposed:

i. Rectangular Design
ii. Parshall Design
iii. Circular Diffuser Design

Each design will be varied into three which are , single tank, double tank and triple tank. The designing of reservoir wall will be base on the method developed by M. Ghazavi (2003), but before that, there are several fix parameters that need to be set, the fix parameter of the design is:

i. The length for reservoir section is 15m, the location of this section can be refer at figure 3.3.It was located just before pump section because according to M.Azhdary (2003), the reservoir should be located as close to the power or pumping plant as possible in order to reduce effect of water hammer
ii. Reservoir must have eight outlet because there will be eight pump needed to maintain the volume flow rate through the section, the diameter of pipe for each pump is 40 cm.
iii. For single tank, the length of tank is 15 meter.
iv. For double tank, the length of each tank is 6 meters and the connecting pipe between two tanks is 3 meters.

v. For triple tank design, length on each tank is 4 meters and the connecting pipe will be 1.5 meters.

vi. The inlet pipe diameter is 80 cm as it referring to outlet pipe from the flume section.

vii. The connecting pipe diameter for double and triple tank is 80 cm.

viii. The location of inlet, outlet and connecting pipe also set in fix location for every design. The location for outlet and connecting pipe is located 0.1 m from the reservoir base surface on vertical axis, while the inlet pipe is located 0.35 m from the reservoir base surface on vertical axis.

The thickness of wall was design base on the figure 2.4 and table 2.1. From the table, the only design variable that will be referred is top thickness of stem X4, heel width (counterfort wall length) X5, counterfort thickness X7 and distance between counterfort X8. Although the journal include the backfill inclination, still the design is strong and can deal with the hydrostatic pressure exerted to the wall and thus this variable of design is still applicable to be the guideline on designing the reservoir wall. Except the variable of counterfort wall length, the other design variable will be at fix dimension. The dimension can be referred at t table 3.2 below.

Table 3.2: List of design variable with fix dimension.

Design Variable	**Dimension (m)**
Counterfort thickness	0.3
Distance between counterfort	Single – 1.33
	Double – 1
	Triple – 0.8
Top thickness of stem	0.2

The distance between counterfort is varied from single tank to triple tank, this is because to design a counterfort wall that is fit with the length of tanks but the value still must be in range of lower and upper bound. Using this fix dimension in each design, the only thing that will be change is the length of counterfort wall (shown in figure 3.2) and the optimum length that can be achieve through stress analysis.

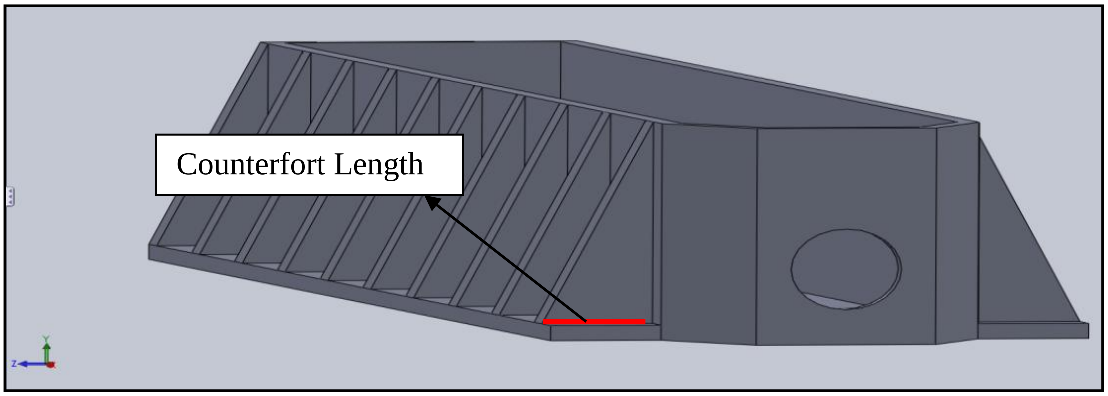

Figure 3.2: Counterfort length

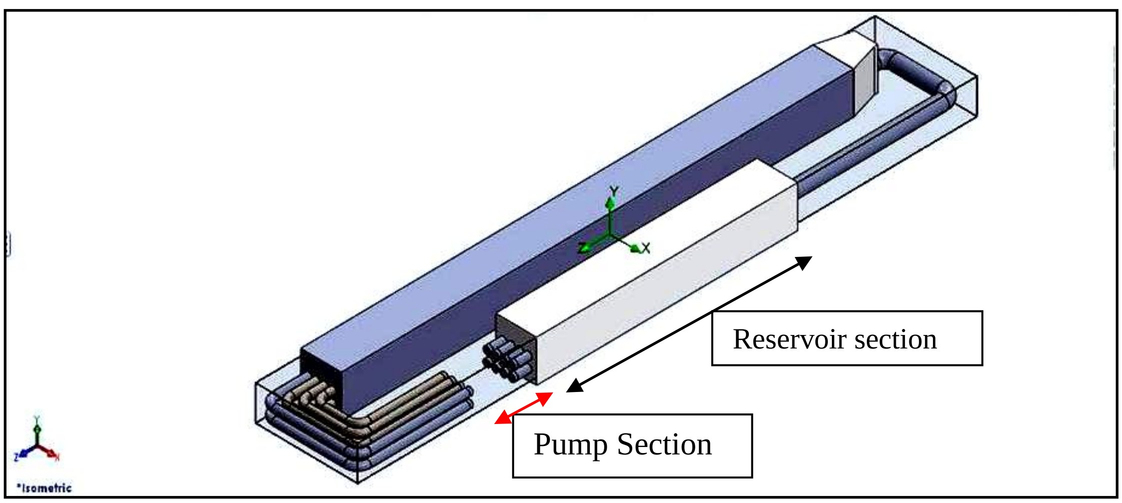

Figure 3.3: Location of reservoir and pump section from the whole system.

3.3.2 Final Design

Final design on each type of reservoir that has been proposed is done by using the optimum length of counterfort wall. Table 3.3 shows the optimum length of counterfort wall length for each design in each tank.

Table 3.3: Table of counterfort length on each design varied with number of tank.

		COUNTER FORT WALL LENGTH (m)		
		RECTANGULAR DESIGN	**PARSHALL DESIGN**	**CIRCULAR DIFFUSER DESIGN**
Single Tank	Tank 1	0.8	0.8	0.8
Double Tank	Tank 1	0.9	0.8	0.7
	Tank 2	0.8	0.4	0.7
Triple Tank	Tank 1	1	0.8	0.7
	Tank 2	0.9	0.8	0.7
	Tank 3	0.8	0.3	0.5

There are several changes that have been done on the dimension for each design of tank because of the difficulties on geometry and symmetry factor. The difficulties on geometry is more likely happen on the parshall and circular diffuser design, for example thickness of diffuser , length of circular and parshall diffuser so there will be a small change in term of tank length. Figure 3.4 to 3.30 shows the 2D and 3D view of each design for single, double and triple tank.

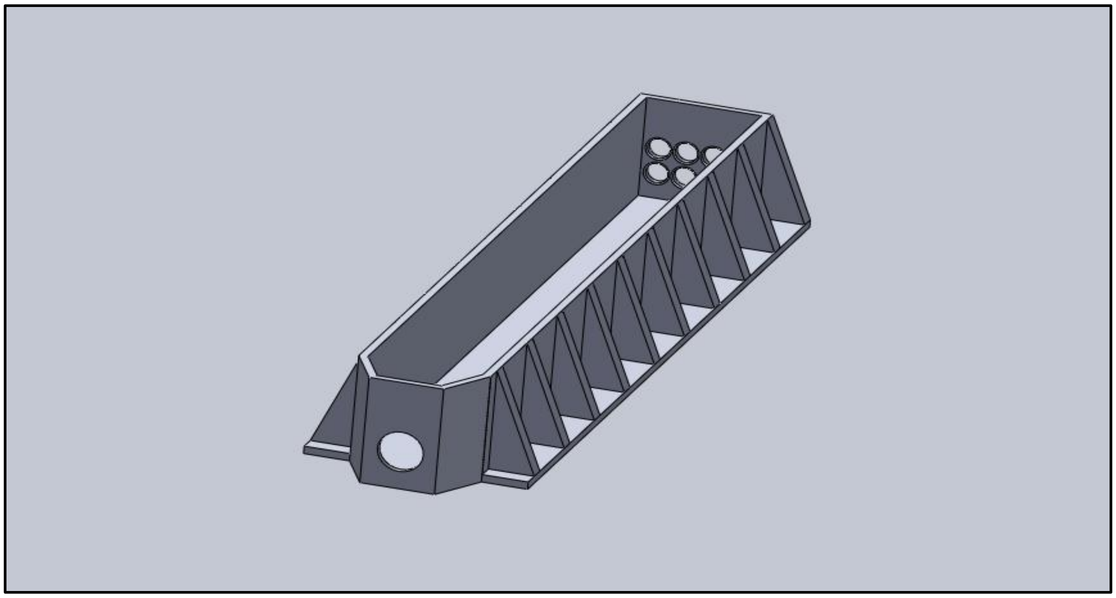

Figure 3.4: Single Tank Parshal Design 3D view.

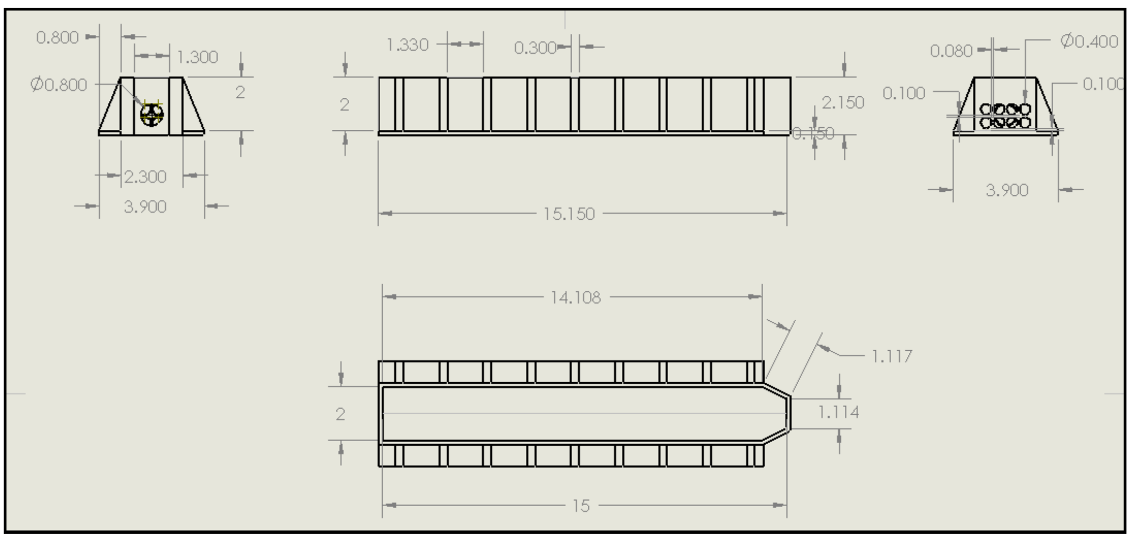

Figure 3.5: Single Tank Parshall Design 2D view.

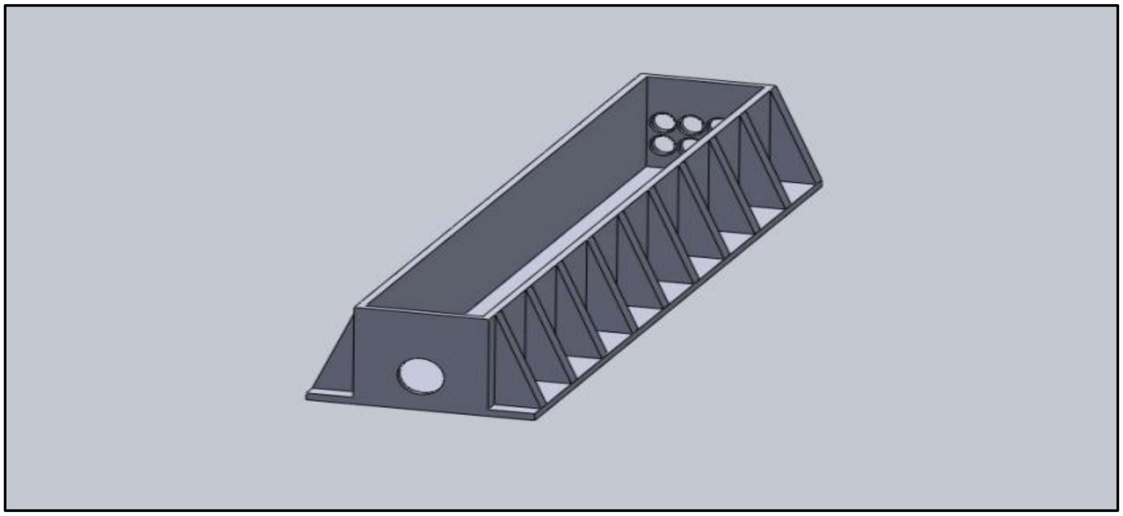

Figure 3.6: Single Tank Rectangular Design 3D view.

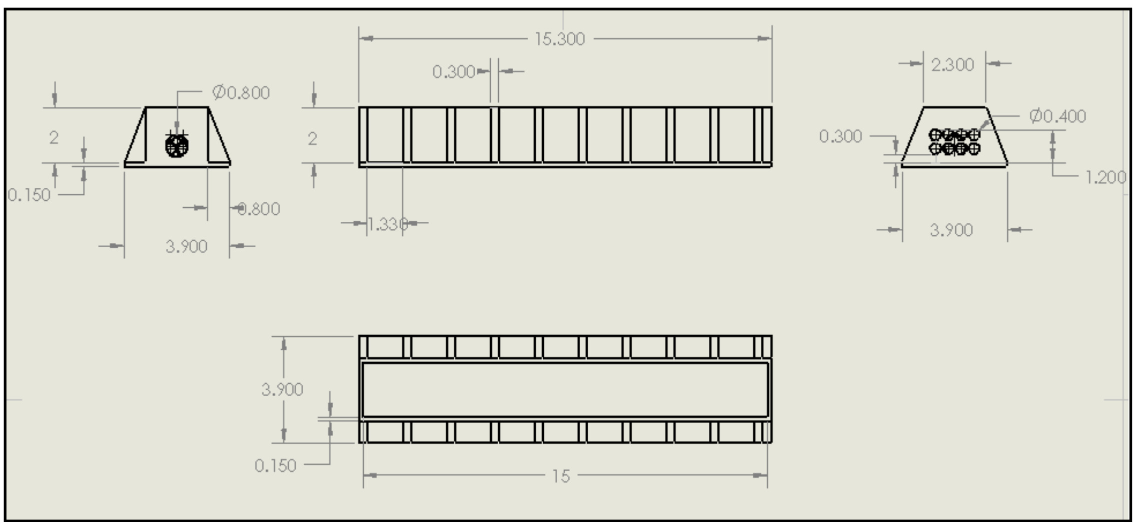

Figure 3.7: Single Tank Rectangular Design 2D view

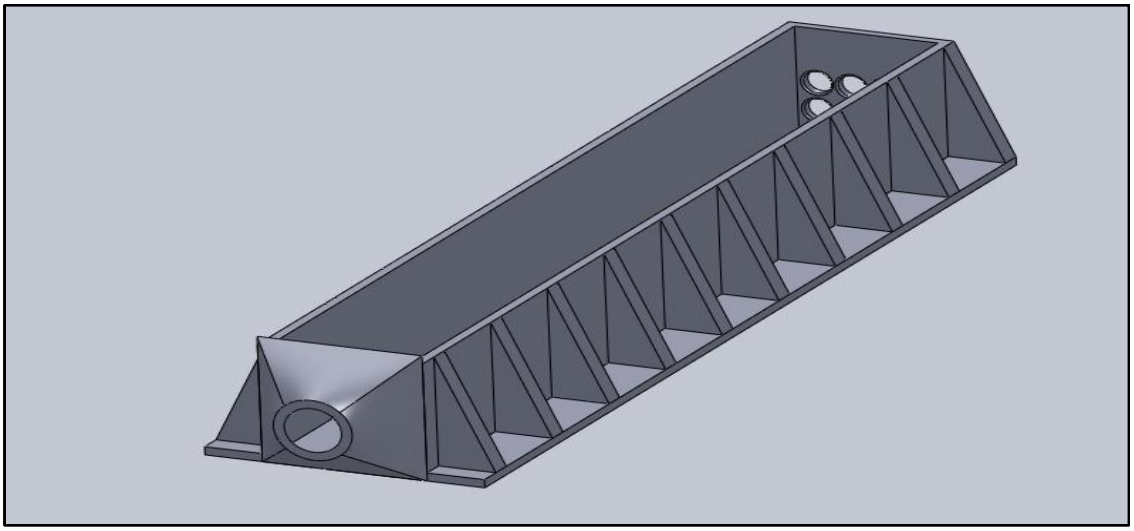

Figure 3.8: Single Tank Circular Diffuser Design 3D view

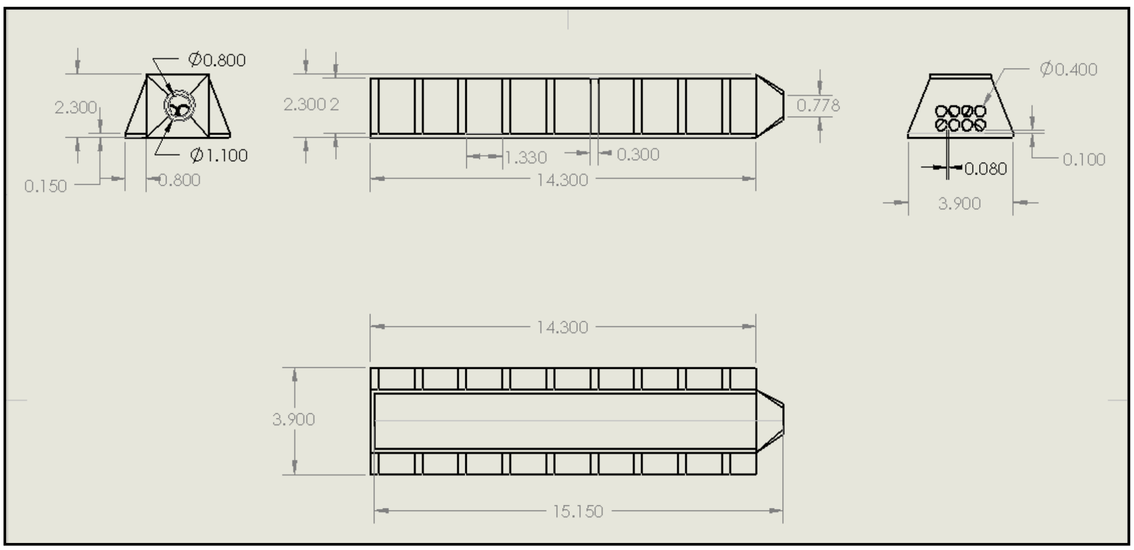

Figure 3.9: Single Tank Circular Diffuser Design 2D view

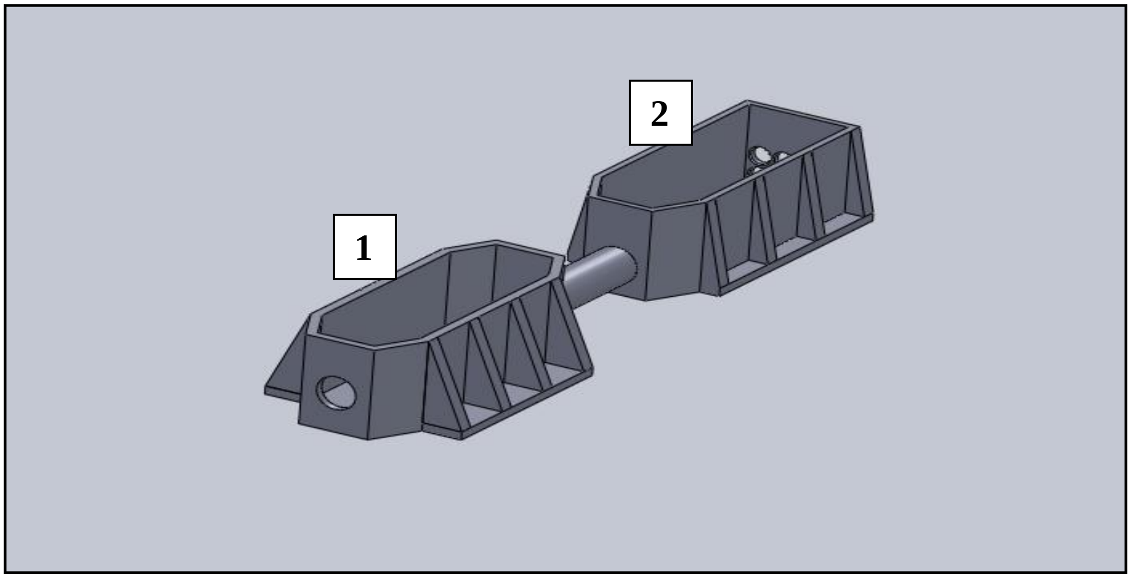

Figure 3.10: Double Tank Parshall Design 3D view

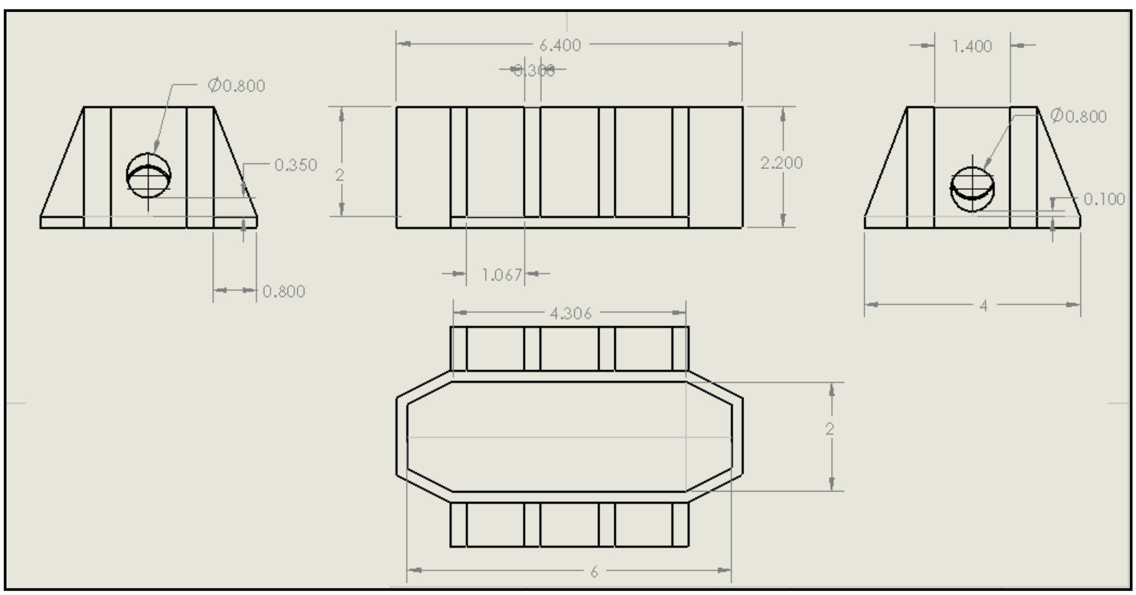

Figure 3.11: Double Tank Parshall Design 2D view (Tank 1)

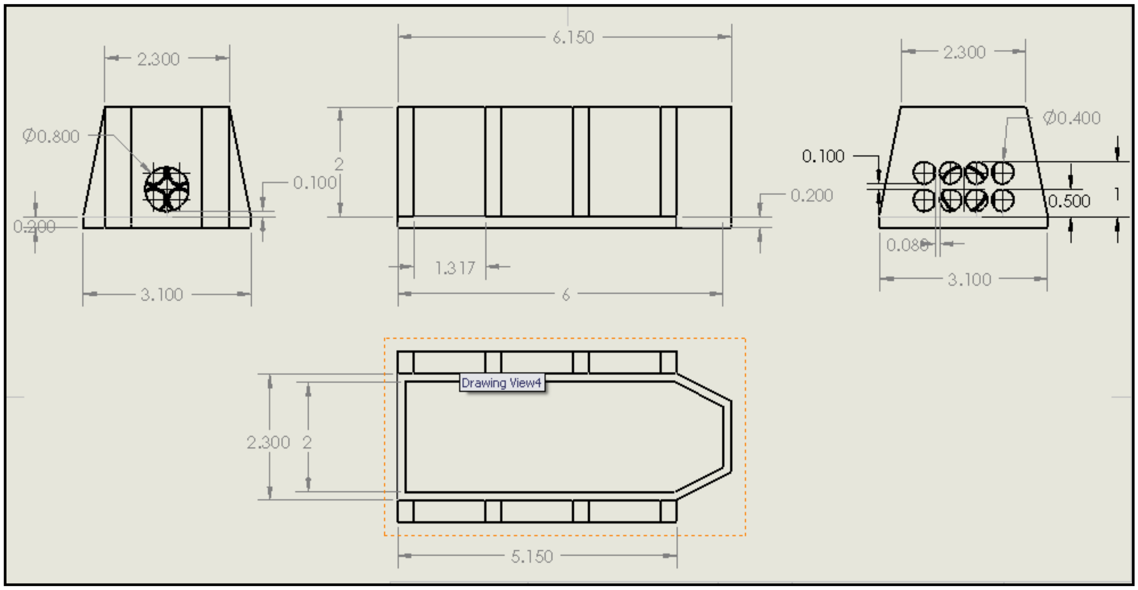

Figure 3.12: Double Tank Parshall Design 2D view (Tank 2)

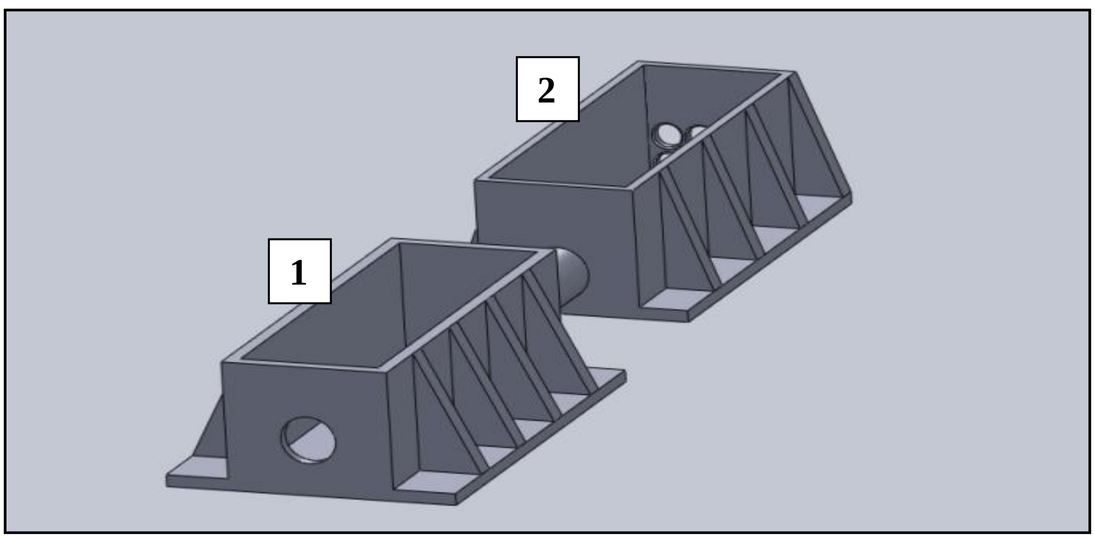

Figure 3.13: Double Tank Rectangular Design 3D view

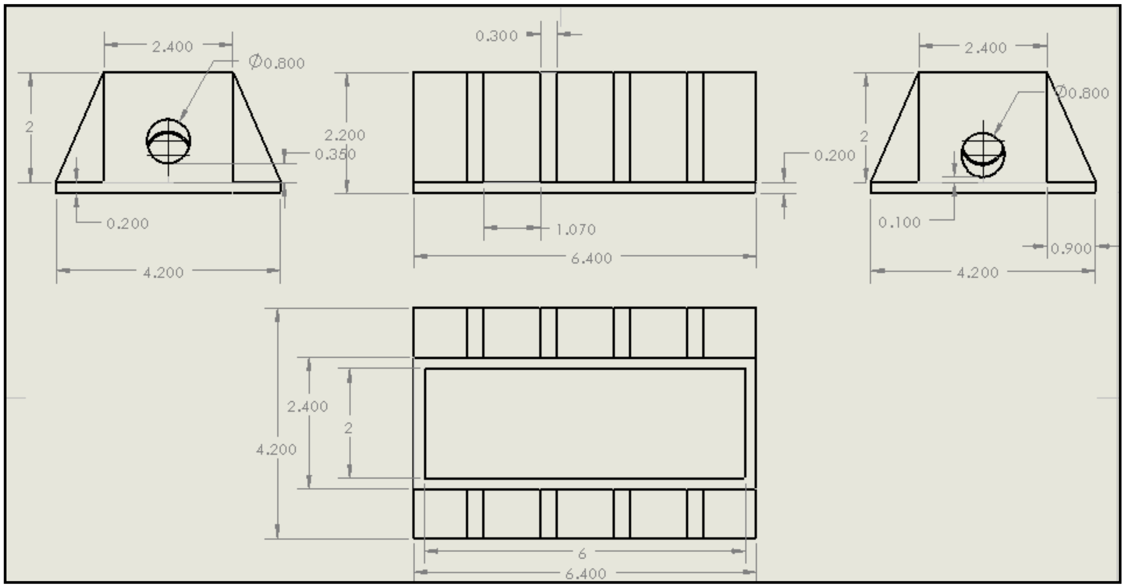

Figure 3.14: Double Tank Rectangular Design 2D view (Tank 1)

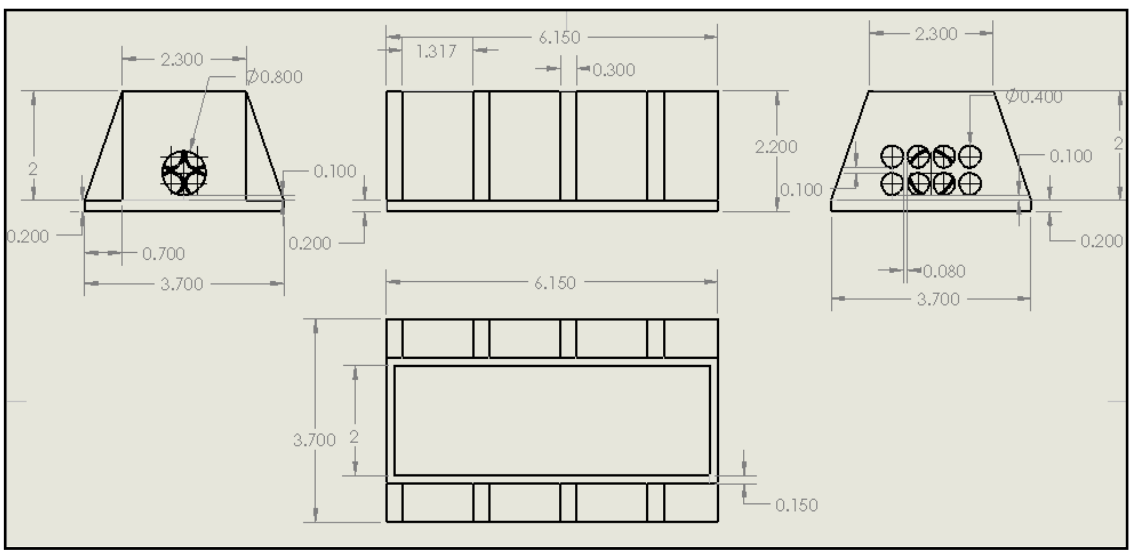

Figure 3.15: Double Tank Rectangular Design 2D view (Tank 2)

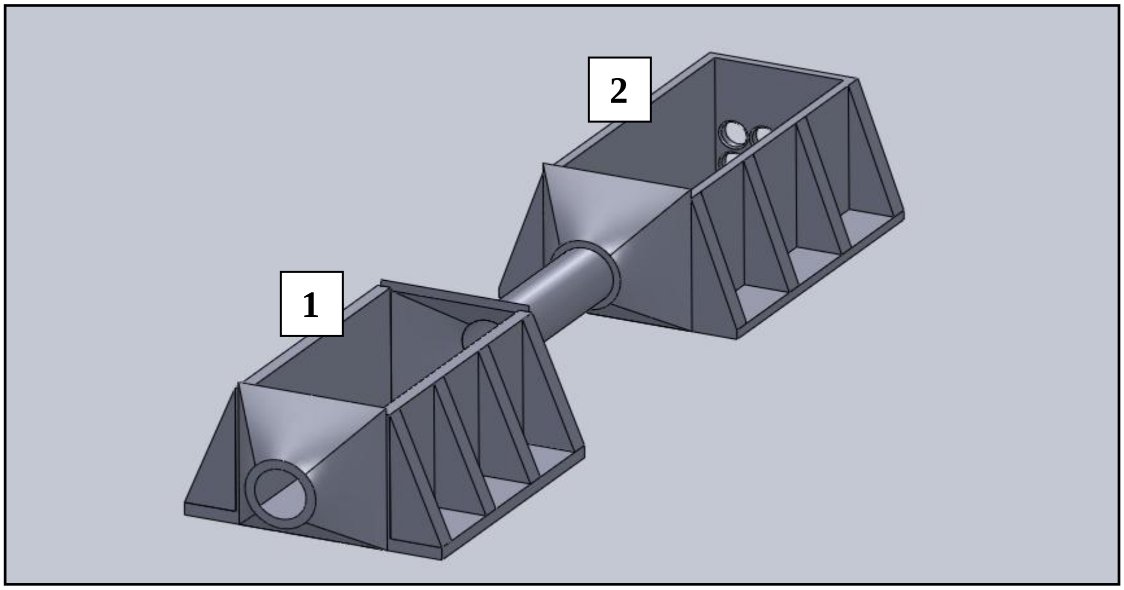

Figure 3.16: Double Tank Circular Diffuser Design 3D view

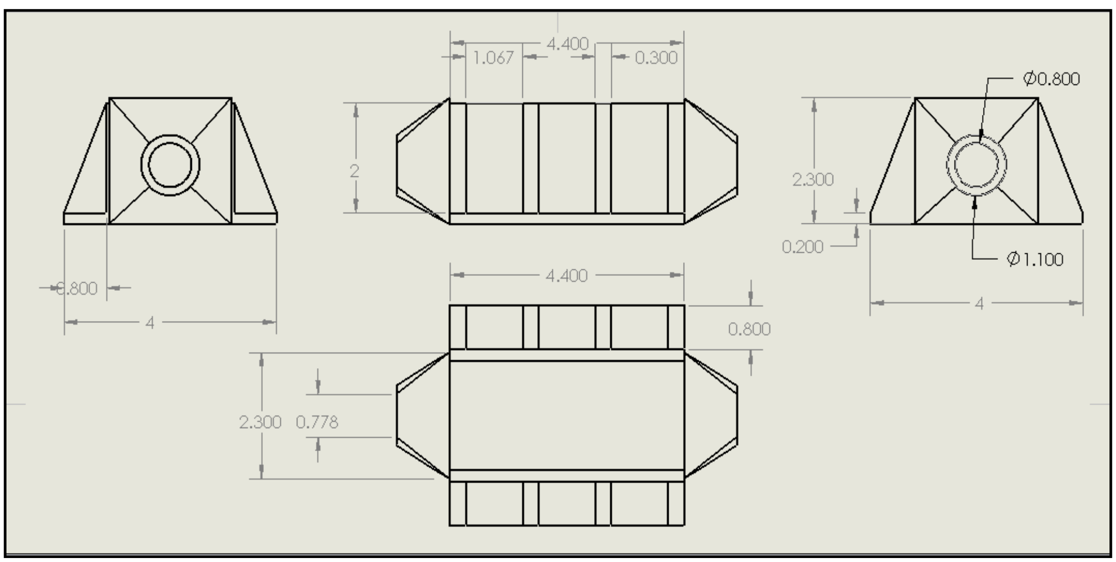

Figure 3.17: Double Tank Circular Diffuser Design 2D view (Tank 1)

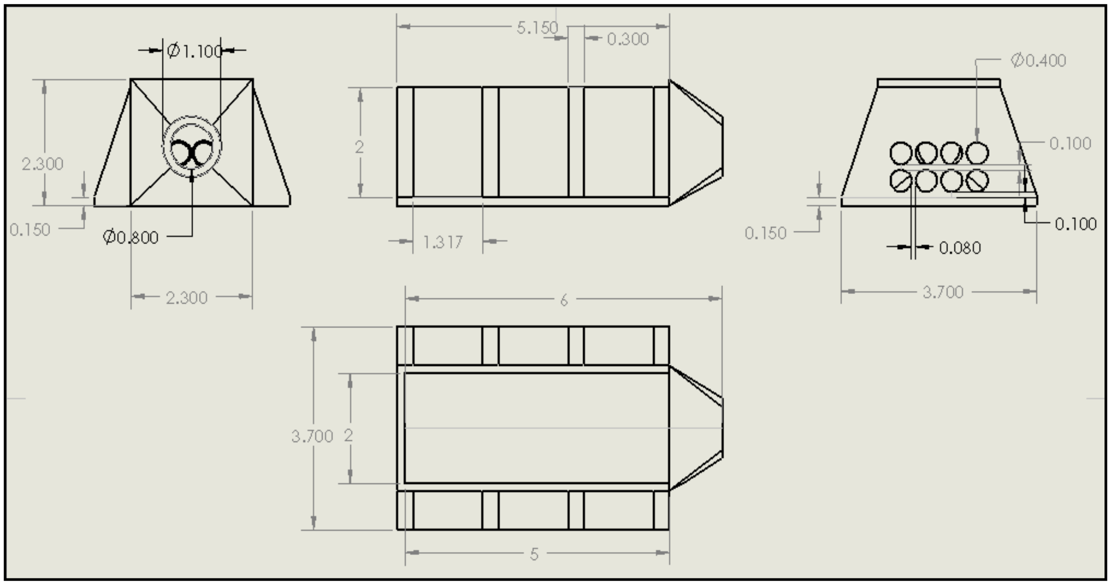

Figure 3.18: Double Tank Circular Diffuser Design 2D view (Tank 2)

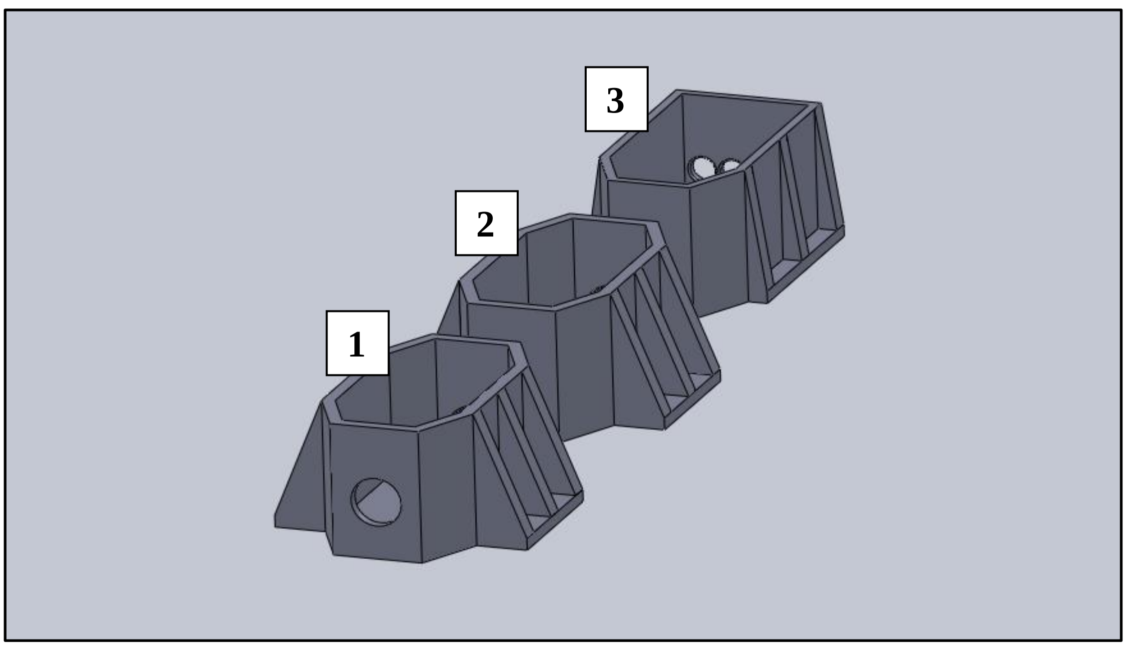

Figure 3.19: Triple Tank Parshall Design 3D view

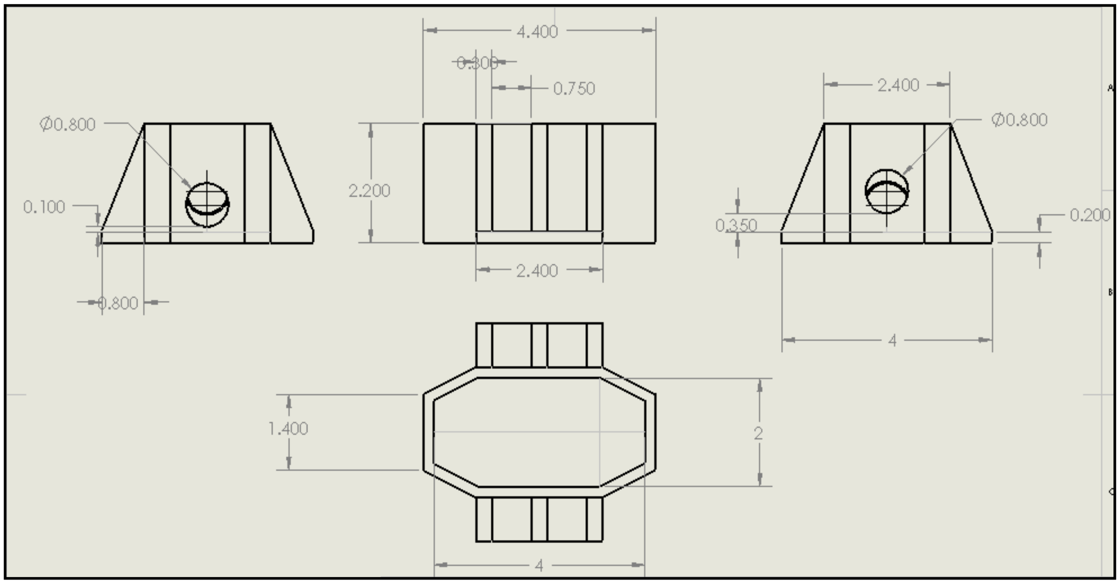

Figure 3.20: Triple Tank Parshall Design 3D view (Tank 1)

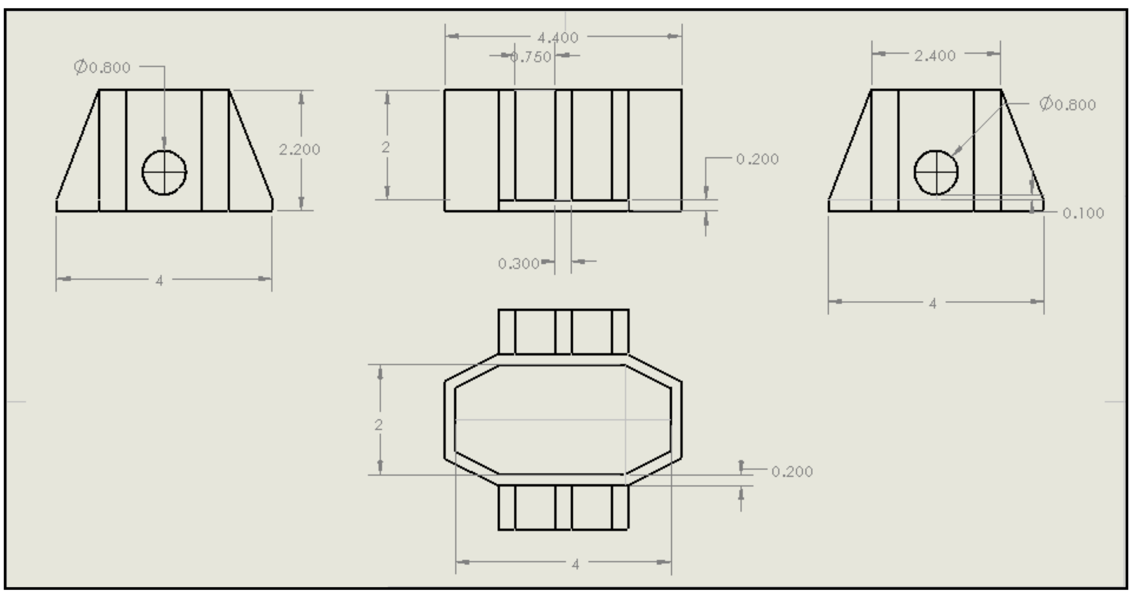

Figure 3.21: Triple Tank Parshall Design 3D view (Tank 2)

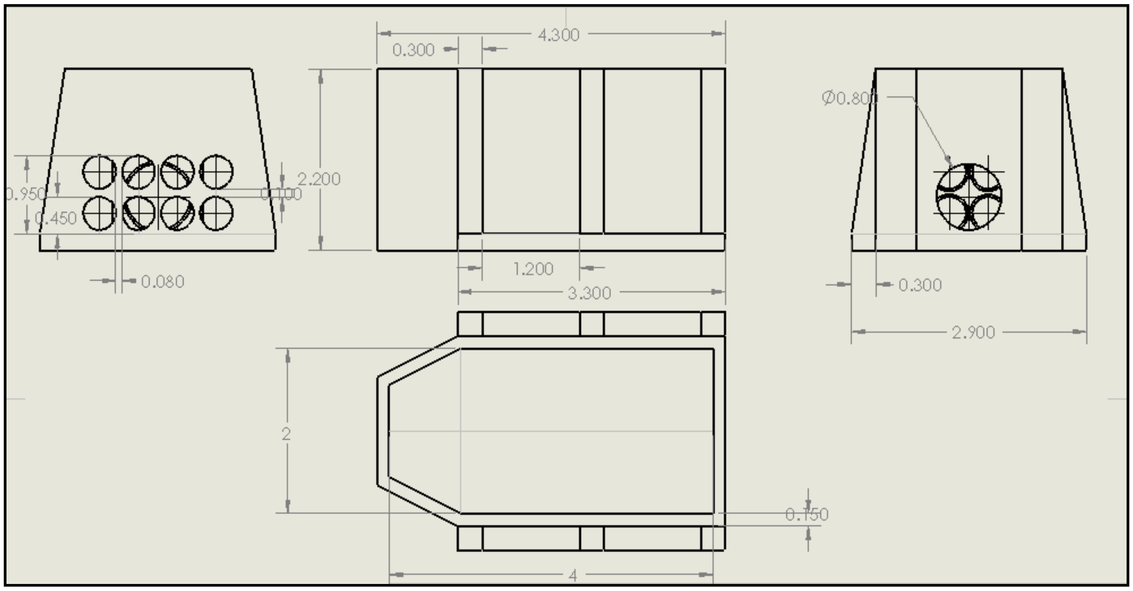

Figure 3.22: Triple Tank Parshall Design 3D view (Tank 3)

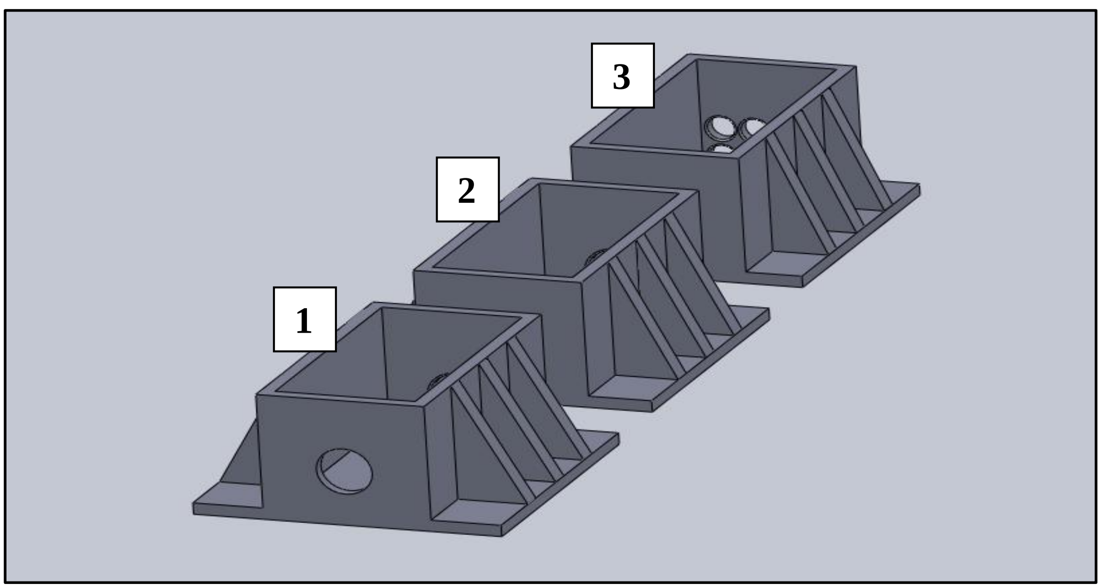

Figure 3.23: Triple Tank Rectangular Design 3D view

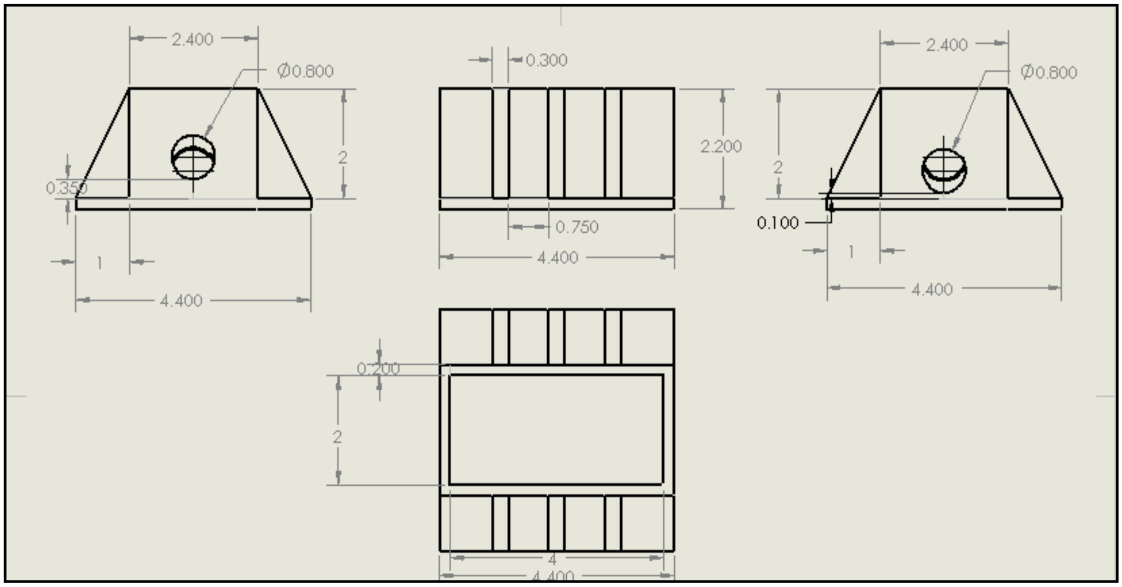

Figure 3.24: Triple Tank Rectangular Design 2D view (Tank 1)

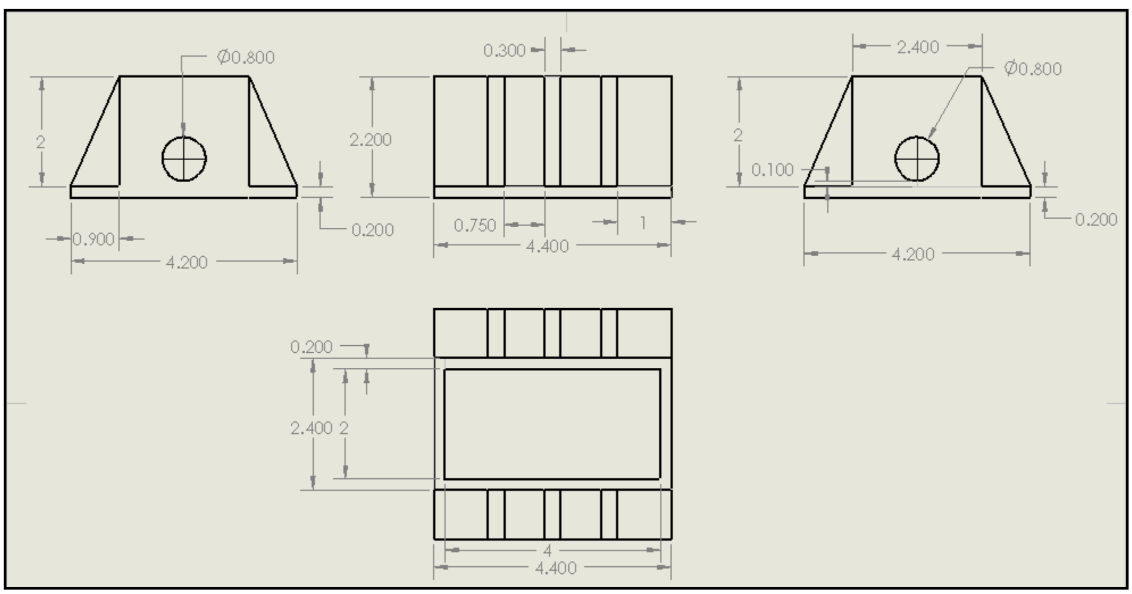

Figure 3.25: Triple Tank Rectangular Design 2D view (Tank 2)

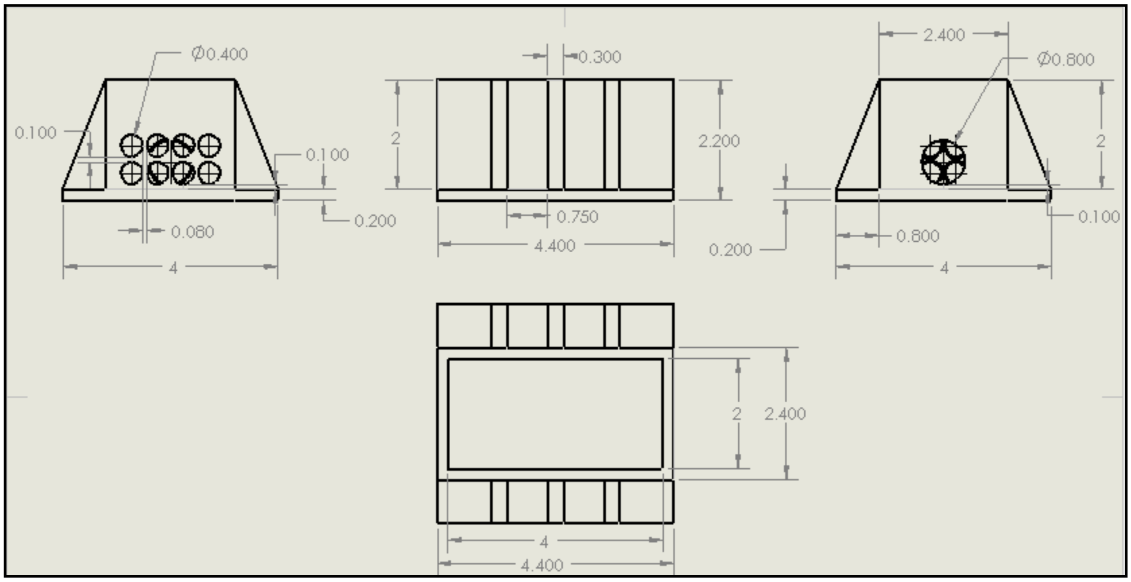

Figure 3.26: Triple Tank Rectangular Design 2D view (Tank 3)

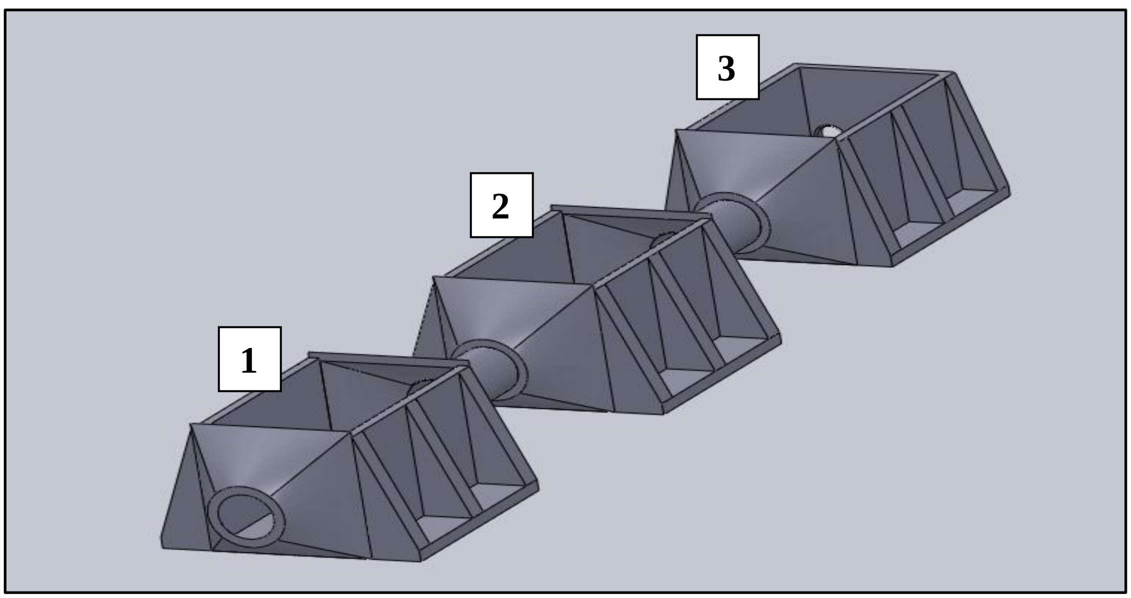

Figure 3.27: Triple Tank Circular Diffuser Design 3D view

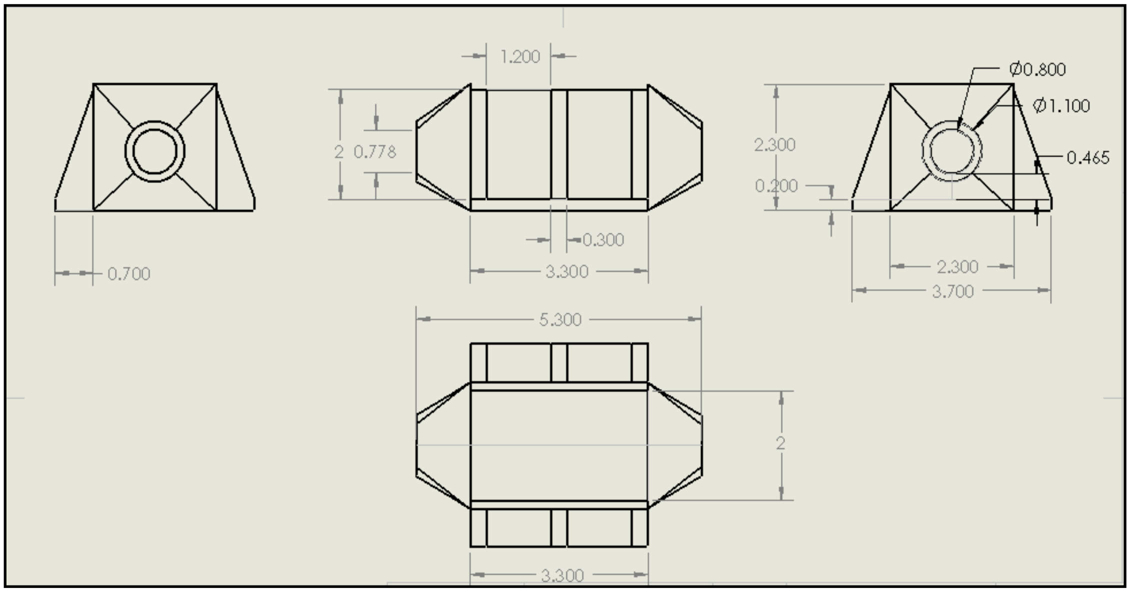

Figure 3.28: Triple Tank Circular Diffuser Design 2D view (Tank 1)

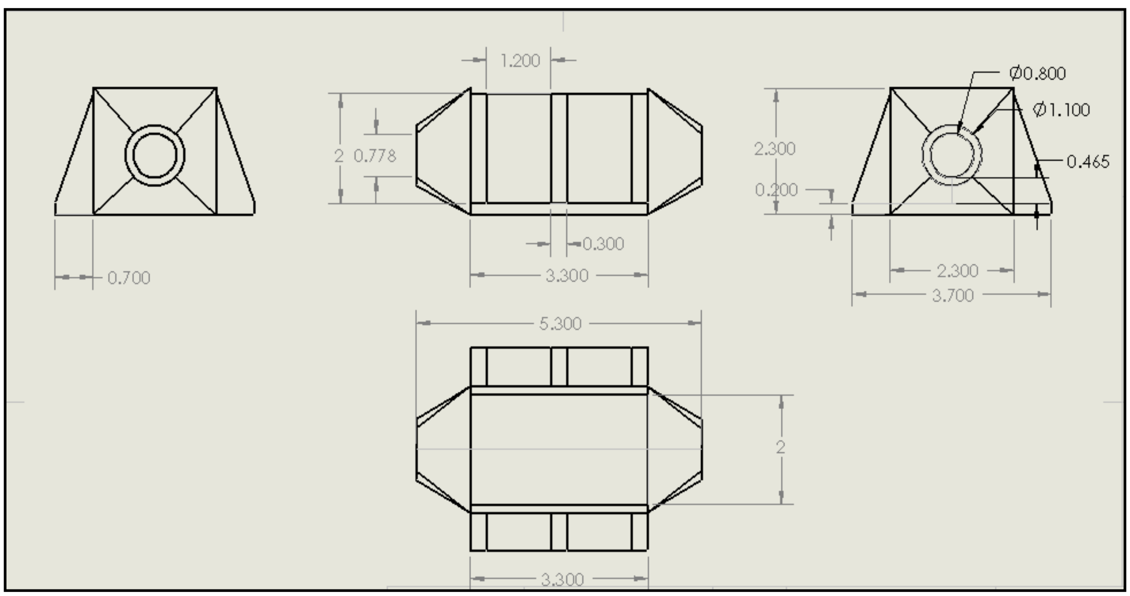

Figure 3.29: Triple Tank Circular Diffuser Design 2D view (Tank 2)

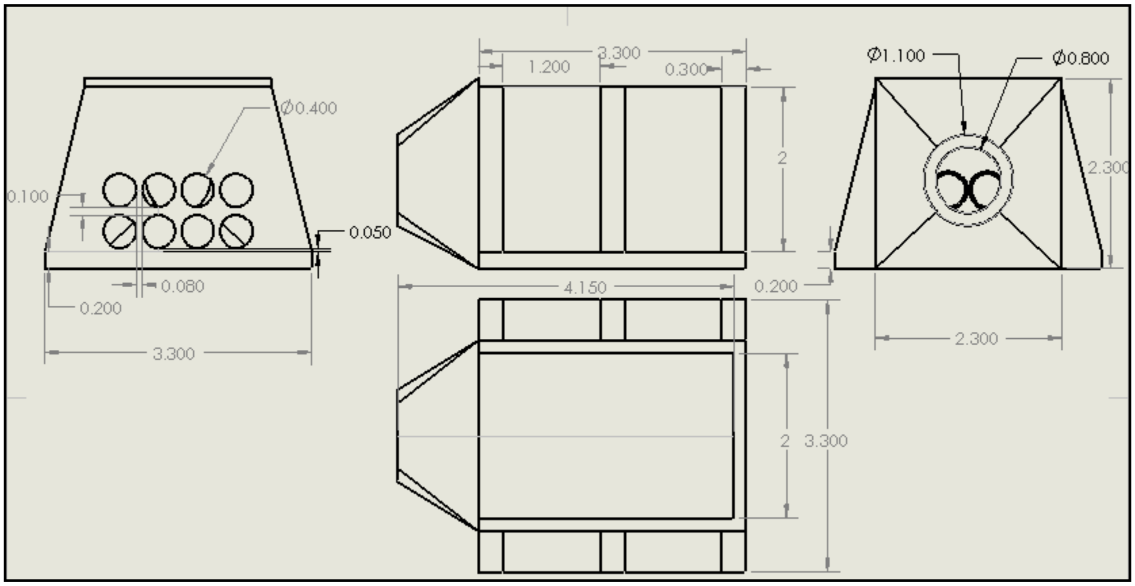

Figure 3.30: Triple Tank Circular Diffuser Design 2D view (Tank 3)

3.4 COMPUTATIONAL FLUID DYNAMIC ANALYSIS

CFD simulation will be performs using ANSYS CFX software, this software is basically a fluid base software that is specialized for fluid in motion. In parallel with the project, fluid in reservoir will be move as the circulation of water from flume to reservoir will continuously occur. The design of each reservoir will be expose to atmosphere thus it can be consider as an open channel flow, so the set up on this software must be set as an open flow condition.

There are several parameters that need to be set in order to have the same condition as an open channel flow, Table 3.3 shows the boundary condition on each parameters.

Table 3.4: List of Boundary condition.

Geometry Face	**Boundary Condition**
Inlet	Velocity = 11 m/s
Outlet	Static Pressure = 0 Pa
Opening	Free Slip Wall
Wall	Non – Slip Wall

The simulation use water at 25ºC as the type of fluid, acceleration on y axis with value -9.81 m/s² to enable the gravitational force and reference pressure at 1 atm to indicate that, at t = 0 there are atmospheric pressure exert on reservoir wall. To get an accurate result, the meshing is using a fine type meshing and the max iteration was set 150, also the residual mass value was set to 1e-4. Residual mass value is important to indicate the accuracy of result, the value shows the correction or error value, so the closer the value to zero the more accurate our result will be, to achieve this value, the number of maximum iteration plays it role since the convergence will occur at unknown number of iteration, so it is better to have a large value of number of iteration in order to have the converging phenomenon.

On the inlet boundary, the velocity of water from the pipe to reservoir is 11 m/s, this value was taken from the simulation result of flume section. On the outlet boundary, the static pressure was set to 0 Pa to ensure that the fluid in this stage move to outlet. The opening boundary is important to define the simulation was a free surface model, thus the boundary condition was set to be free slip wall in order to get the same velocity profile of an open channel flow.

On result stage of ANSYS CFX software, to get the total pressure exerted on the side wall, a line was been place at 0.5 m from the ground because this height is the centre point for resultant hydrostatic force. For pressure drop, the data for total pressure was gained from the simulation by locating the line at the middle of the tank, so basically the line will only indicate the pressure that produce from the water flow from inlet to outlet and this is suitable for the structure analysis on the inlet and outlet wall. Also from the simulation, it can determine the flow characteristic for each design in each tank.

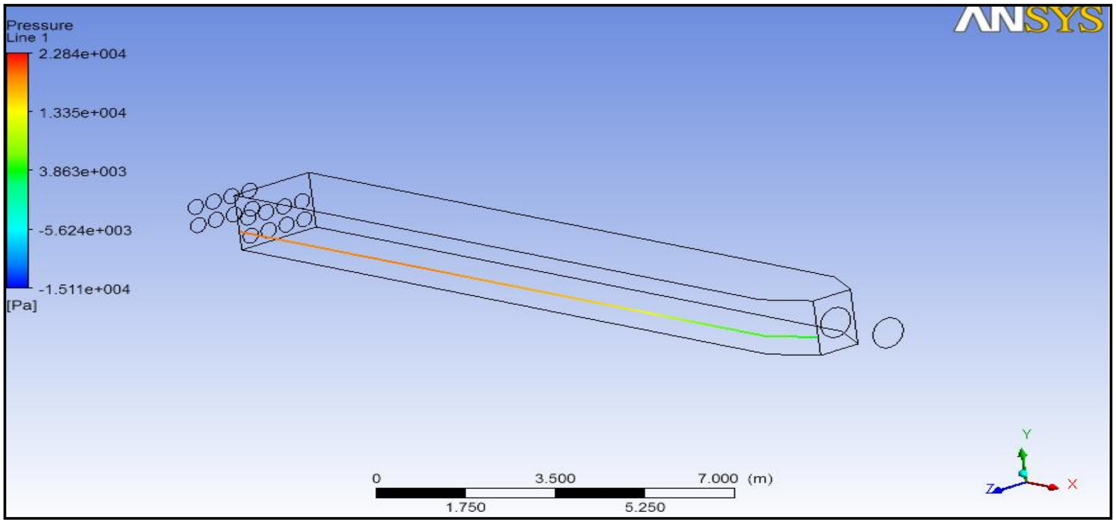

Figure 3.31: Total pressure line on reservoir wall.

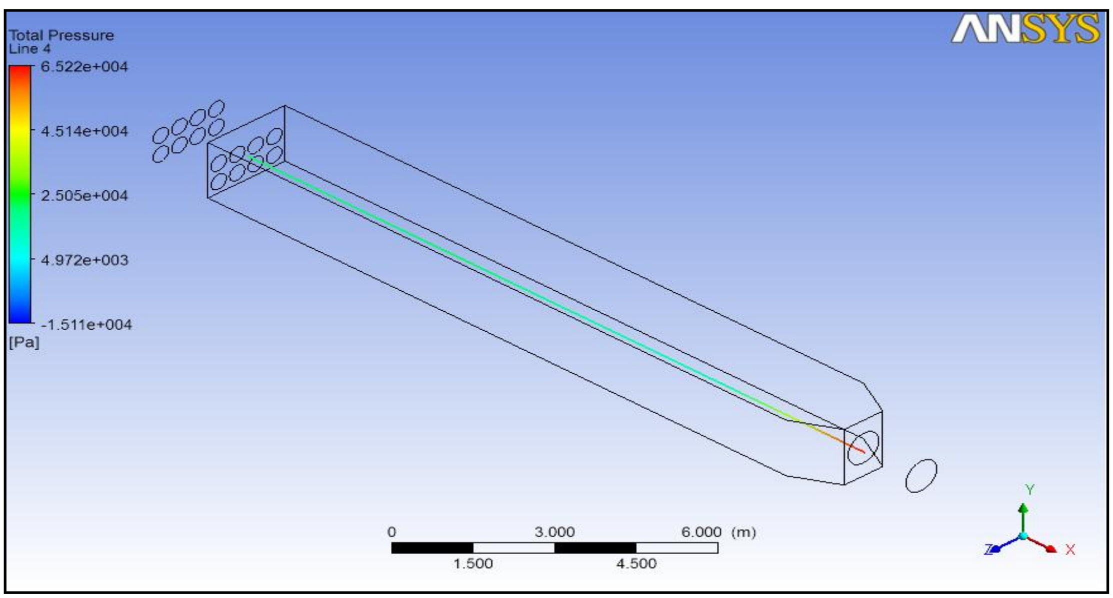

Figure 3.32: Total pressure line at the middle of the tank.

3.5 STRESS AND STRAIN ANALYSIS

This analysis is important to decide the optimum length of counterfort retaining wall and material used. From the simulation using ALGOR Software we can know the maximum deflection at certain length of counterfort retaining wall, using a fix range value of maximum deflection from 0.4 mm – 0.6 mm we can get the optimum length of the wall on each design of tank but the material use are fix on every design that is high strength concrete, an optimum length of counterfort is important to reduce the volume of material use because as mention before, for this study it has been decided to make this length as the variable for each design while the other dimension is fix. High strength concrete was used because it is suitable for the design to have the strongest possible design. Using this optimum length, another stress analysis was done using a different grade of ready mix concrete in order to choose the most suitable grade. Different grade of concrete has a different price, as the grade decreasing, the price will be cheaper and also the strength of the material is lower, so to ensure that the material is safe to use in all design, a maximum deflection analysis must be done to avoid the worst case scenario that might be happen at the reservoir section since the reservoir will be dealing with 30 – 50 tonnes of water (ground level).Also with this simulation, comparison of von mises stress with the yield strength can be done, in order to determine that whether the stress exceeding the yield stress of the material or not, this is to ensure that the material can overcome the stress exert on it.

Using ALGOR software the base surface of the reservoir on each design was set as fix pinned and the pressure were set on the surface of the reservoir wall using the highest value of total pressure exerted on the wall. The value of total pressure was taken from the result of CFD simulation. For material in deciding the counterfort wall length, the material used was high strength concrete and for the analysis of choosing the best concrete grade, new material need to be added, because the software did not have concrete properties according to its grade, the properties of the concrete on each grade can be refer to the table below:

Table 3.5: Table of material properties for each concrete grade.

Ready Mix Concrete Grade	**M10**	**M15**	**M20**	**M25**	**M30**	**M35**	**M40**
Tensile strength (Mpa)	1.6	1.9	2.2	2.6	2.9	3.2	3.5
Modulus of elasticity (Gpa)	27	29	30	31	32	34	35
Coefficient of thermal expansion	1e-4	1e-4	1e-4	1e-4	1e-4	1e-4	1e-4
Poisson ratio	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Yield Stress (Mpa)	10	15	20	25	30	35	40

Source: ERMCO (European Ready Mix Concrete Organization)

In conclusion, this analysis is to choose an optimum length of counterfort wall and the lowest grade of ready mix concrete in order to reduce the cost but at the same time the value of maximum deflection still can be considered as safe.

3.6 COSTING ANALYSIS

The main parameter on estimated cost is the volume of material use on each design and the volume on each design was directly calculated from Solidwork software. The price value of each grade ready mix concrete was taken from Constructional Industry Development Board of Malaysia, CIDB Malaysia monthly report on building material price. The price for Pahang district can be refer in Table 3.5.

Table 3.6: List of price for each ready mix concrete.

No	**Ready Mix Concrete - Granite**	**Unit**	**Dec - 2012 (RM)**
1	Ready Mix Concrete - Normal Mix - Grade 10, Granite	m^3	175.97
2	Ready Mix Concrete - Normal Mix - Grade 15, Granite	m^3	181.47
3	Ready Mix Concrete - Normal Mix - Grade 20, Granite	m^3	188.6
4	Ready Mix Concrete - Normal Mix - Grade 25, Granite	m^3	194.2
5	Ready Mix Concrete - Normal Mix - Grade 30, Granite	m^3	206.53
6	Ready Mix Concrete - Normal Mix - Grade 35, Granite	m^3	213.8
7	Ready Mix Concrete - Normal Mix - Grade 40, Granite	m^3	230.17

Source: Constructional Industry Development Board Malaysia

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

Based on simulation data, final length of counterfort wall on each type of reservoir, the pressure drop across reservoir, maximum total pressure exerted on the wall, maximum deflection on different grade of concrete and cost on each design of reservoir are presented in a graphical diagram. These data are used as the guideline in choosing the best reservoir design.

4.2 PRESSURE DROP

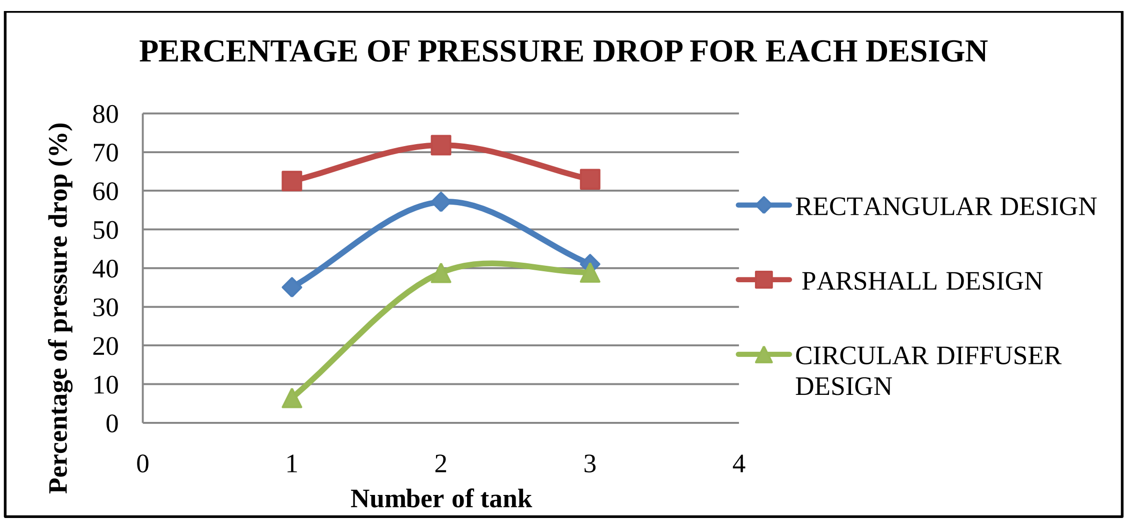

Figure 4.1: Percentage of pressure drop for variation number of tank.

Figure 4.1 shows the percentage of pressure drop across the reservoir for each design with different number of tank. As shown in the figure 4.7, for single tank the highest percentage of pressure drop by comparing these three designs is parshall design with 62.5 % and the lowest is circular diffuser design with 7%. For double tank, the highest percentage of pressure drop is parshall design with 72% and the lowest is circular design 38%, the pattern of highest and lowest was similar with the single tank. In triple tank there are decreasing in percentage of pressure drop for all reservoir design but still the highest percentage is parshall design with 63% and the lowest is circular design with 38% .

From the graph, it shows that there was an increasing stage from single tank to the double tank, the increasing of pressure drop percentage is because in double tank, tank 1 basically receive a high pressure and then in tank 2, the pressure is reduce to smaller value, this is the effect from the length of tank in double tank is smaller than single tank and they were a water swirling scenario occur in tank 1. In tank 2 the swirling of water is less than tank 1 because it has eight outlets. In single tank they were less swirling effect and the tank is long, hence the pressure decrease gradually with the length without any outside disturbance.

The decreasing of pressure drop across triple tank for each design is because all tank was defined in the same ground level hence the water velocity in connecting pipe is the same as the inlet pipe that is 11 m/s, this is by referring to the simulation. Since the water in the connecting pipe has a high velocity thus the pressure is still high on the last tank, so it will give a lesser pressure drop and furthermore the length for each tank is short, thus they are swirling of water phenomenon occur in each tank, so that also can be a factor of decreasing in pressure drop for triple tank. According to Tae Hyun Chang (2013), the velocity vector is weak as the swirling intensity decreases because of the length increases, in vice versa situation, the velocity will be increase as the length of tank decrease so this will be resulting in high intensity of water swirling, the swirling of water phenomenon is shown on Figure 4.2 to 4.10, this figure are the simulation result using ANSYS cfx. Velocity influence the dynamic pressure, as the velocity increase, the pressure also will increase. Comparing with the double tank, the pressure drop is higher than triple tank because the length of the tank is more than the tank in triple tank, so the length for the water to settle down is longer and this will reduce the pressure on the outlet of the reservoir as the water velocity approaching 0 m/s.

The efficiency of reservoir design is high when the pressure drop is lesser since the energy along the water flow in reservoir is conserve and can contribute to pump system, hence the pump will need a less power to suck water from reservoir. By referring to the simulation result shown in figure 4.1 to 4.10, it shows that the design with longer tank and high intensity of water swirling (turbulence) will have a lesser pressure drop because high swirling intensity will increase the velocity vector, thus the energy will conserve in the flow (dynamic flow), the design that have more swirling intensity and longer is single tank circular diffuser design. Basically swirling of water gives more pressure exerted on the reservoir wall but in term of efficiency it can maintain the energy in the water flow, so it has it pros and cons. In this flume project, the efficiency of the design is more preferable than the pressure factor because it can contribute in pump efficiency.

The conclusion that can be made by referring the data, single tank for circular diffuser design is suitable to be applied in the project because it has the least percentage of pressure drop compared to other design.

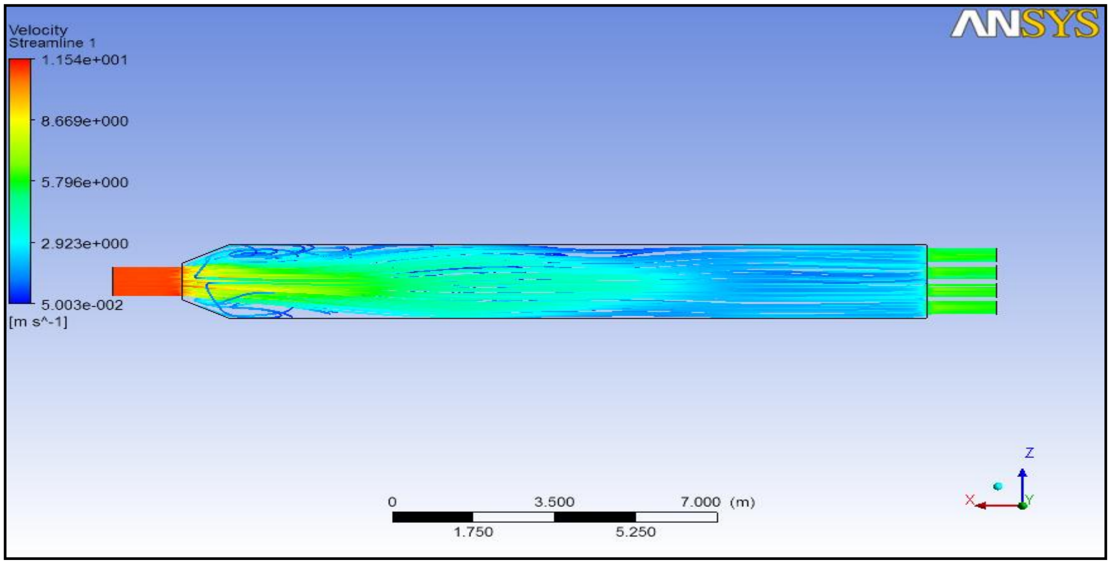

Figure 4.2: Water velocity streamline in single tank parshall design.

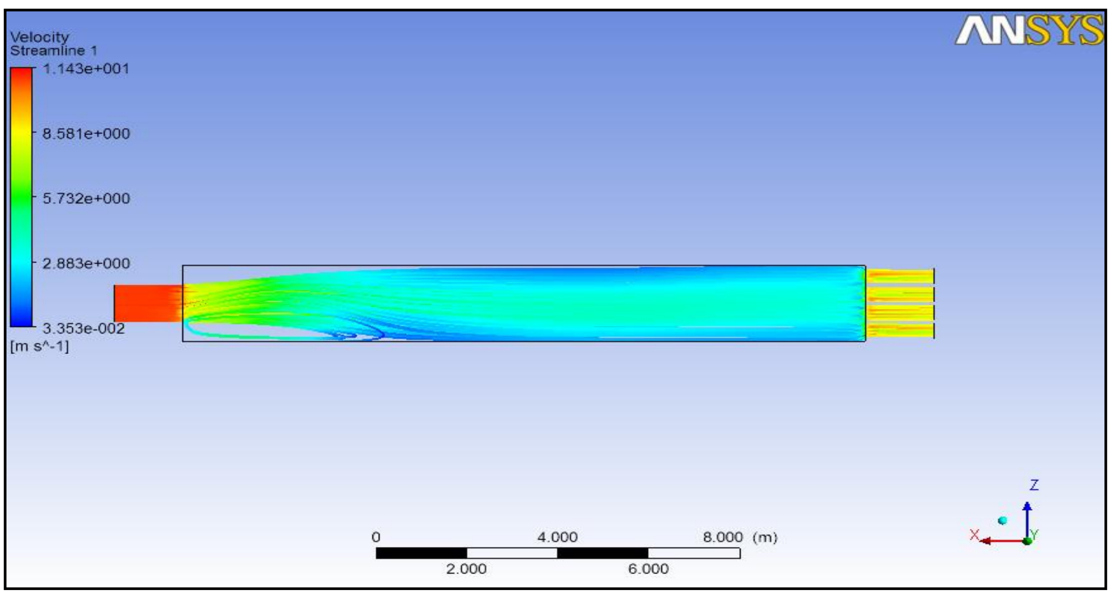

Figure 4.3: Water velocity streamline in single tank rectangular design.

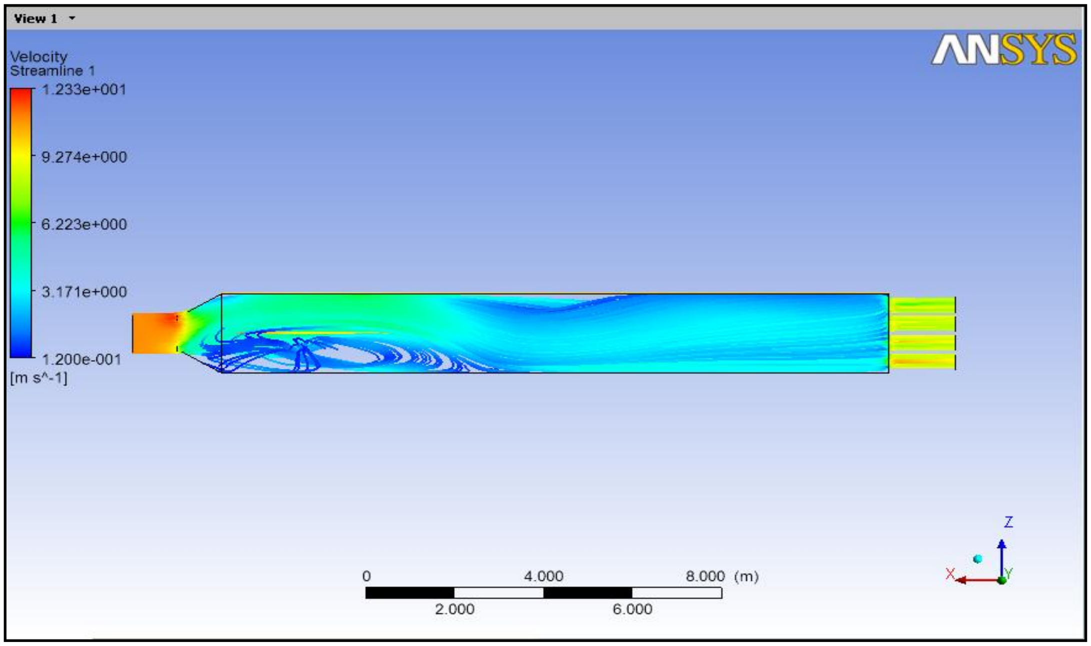

Figure 4.4: Water velocity streamline in single tank circular diffuser design.

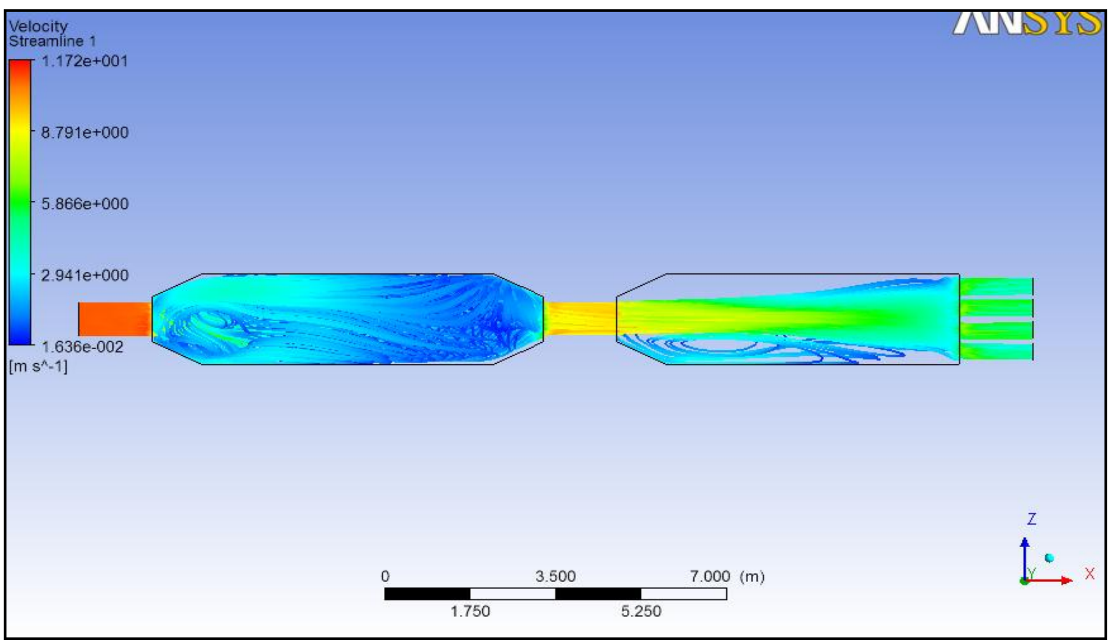

Figure 4.5: Water velocity streamline in double tank parshall design.

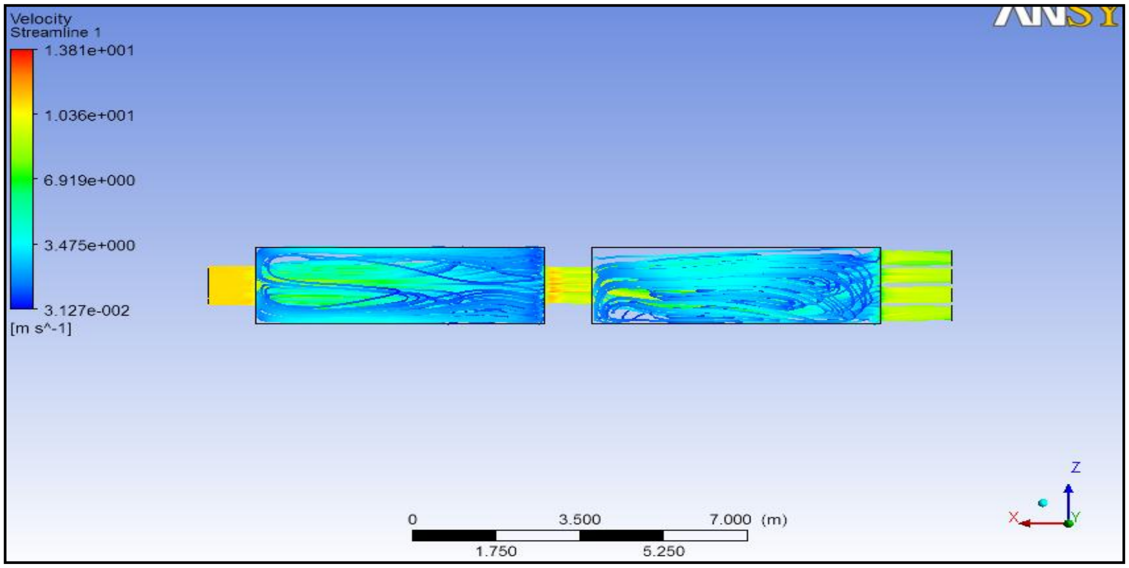

Figure 4.6: Water velocity streamline in double tank rectangular design.

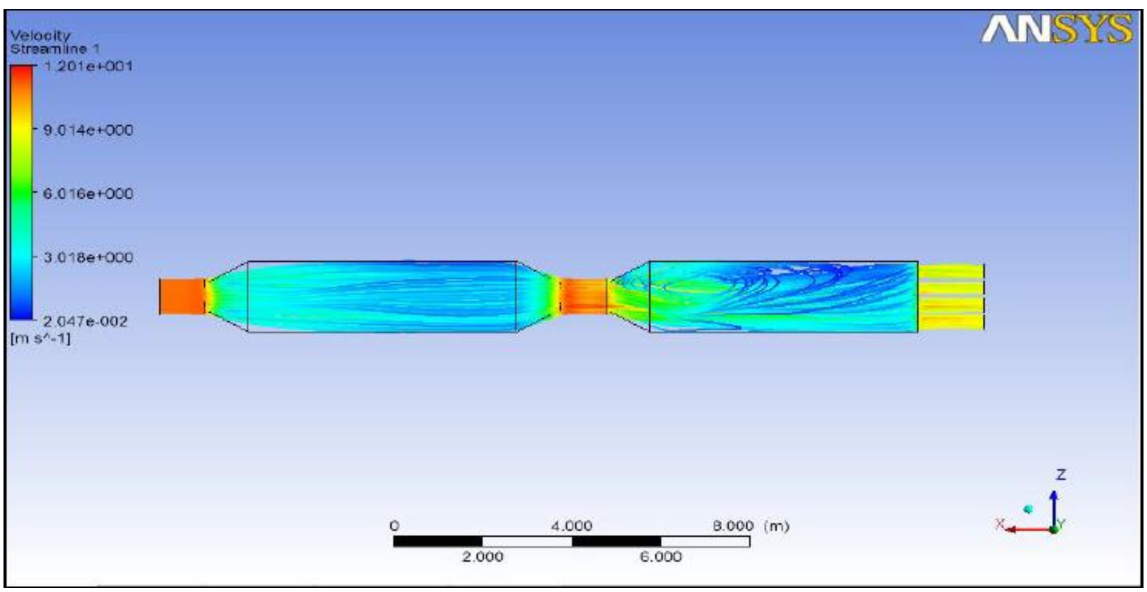

Figure 4.7: Water velocity streamline in double tank Circular Diffuser design.

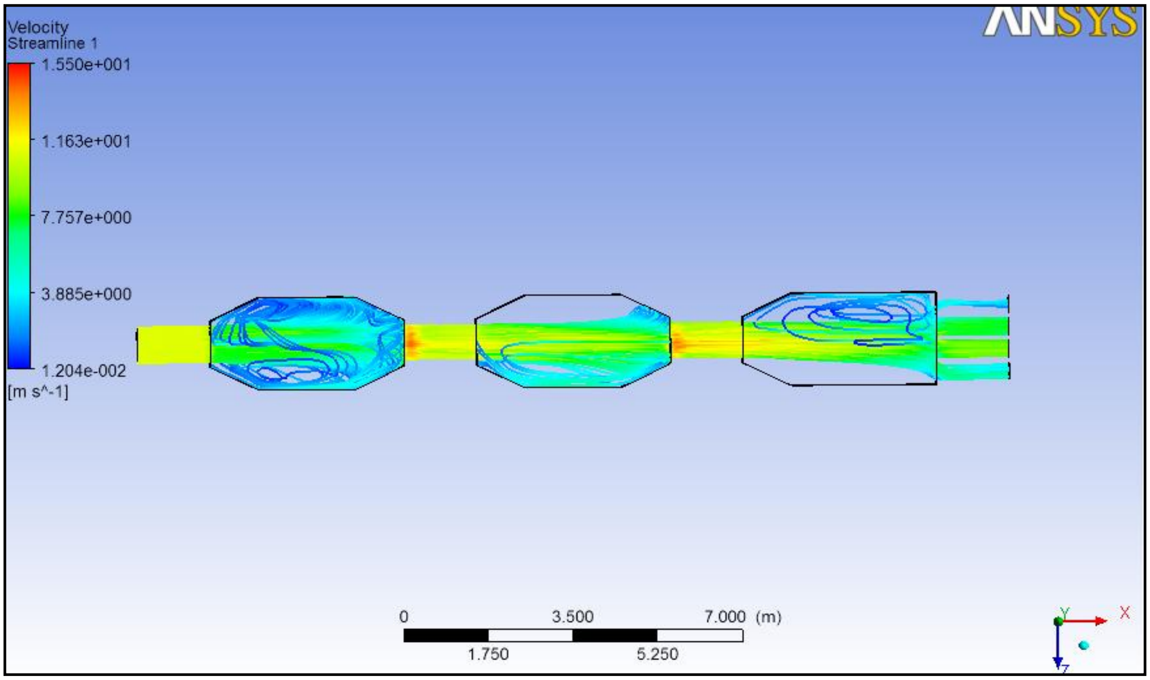

Figure 4.8: Water velocity streamline in triple tank parshall design.

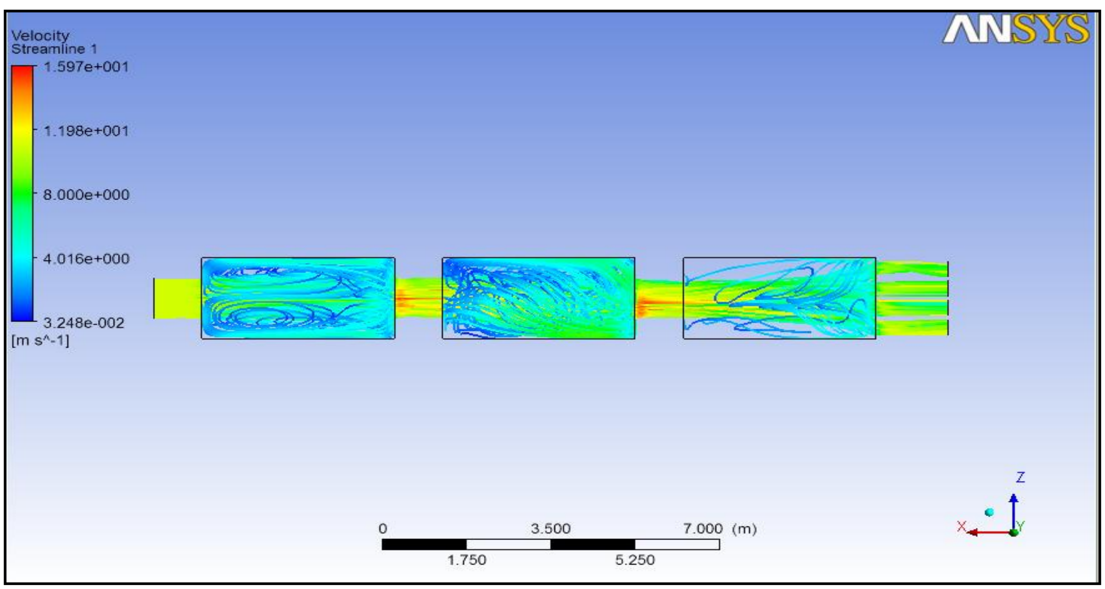

Figure 4.9: Water velocity streamline in triple tank rectangular design.

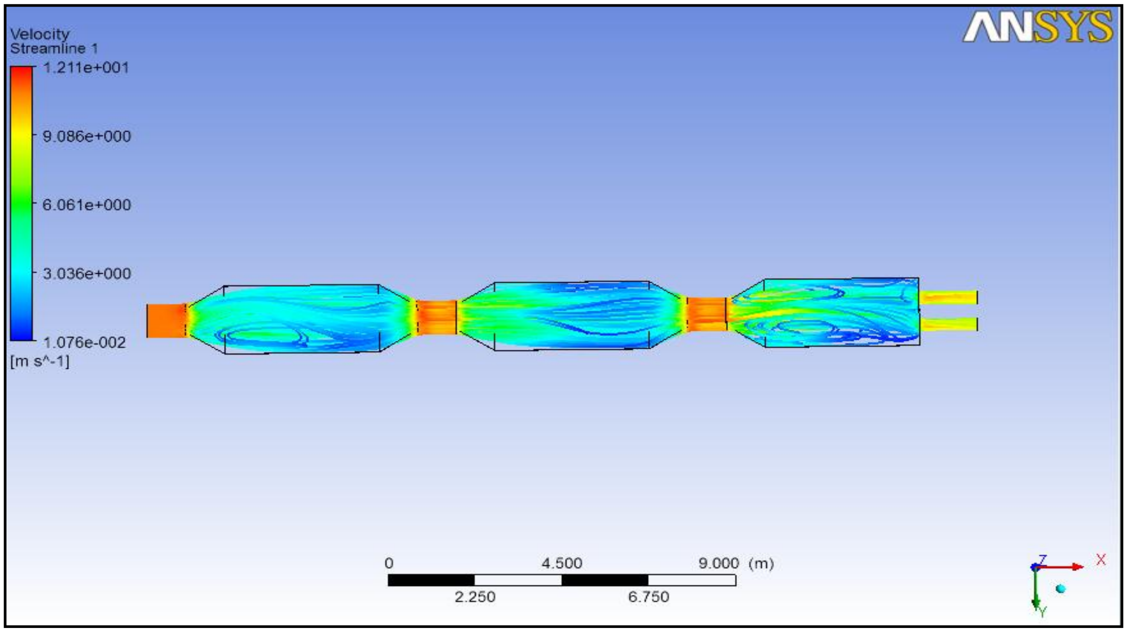

Figure 4.10: Water velocity streamline in double tank circular diffuser design.

4.3 MAXIMUM TOTAL PRESSURE EXERTED ON THE WALL

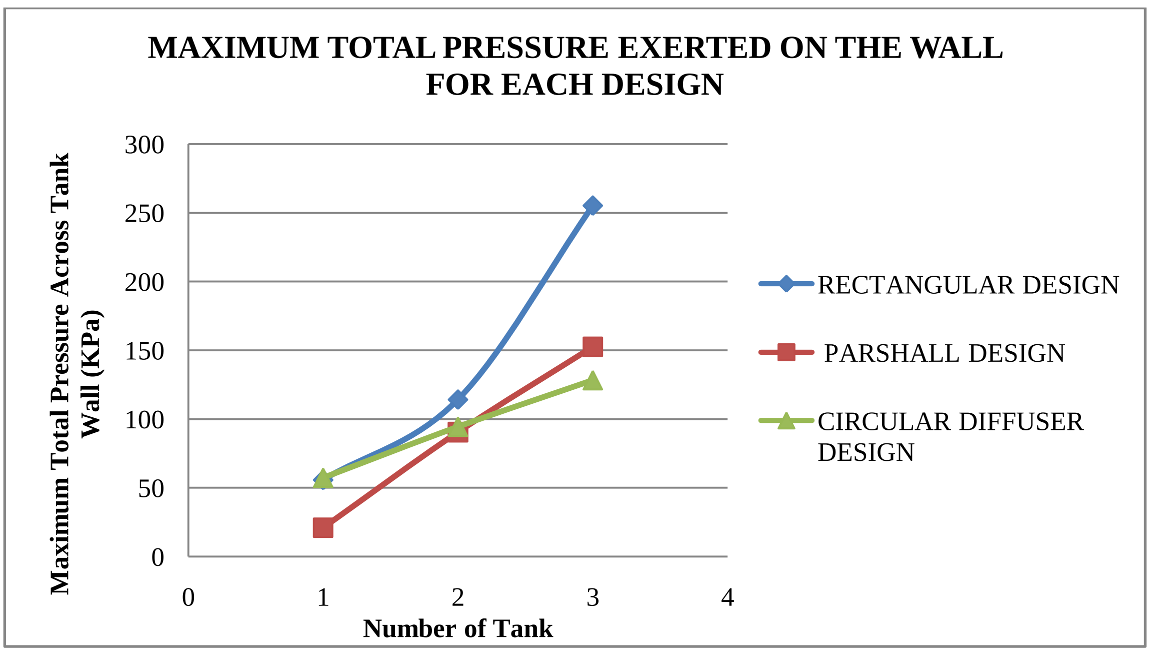

Figure 4.11: Maximum total pressure exerted on the wall for each design.

The figure 4.17 shows graph of maximum total pressure on wall tank varied with different number of tank for rectangular design, parshall design and circular diffuser design. For single tank, parshall design has the least maximum pressure with 11.572 KPa and the highest maximum pressure was circular design with 57.376 KPa, whereas rectangular design gives 55.924 KPa. In double tank design, still parshall design has the least maximum pressure value, that is 90.639 KPa and rectangular design receive the highest pressure with 114.287 KPa, for circular design the maximum pressure is equal to 94.536 KPa. For triple tank, design with highest pressure is rectangular design with 255. 270 KPa and the lowest is circular diffuser design, with 128.457 KPa, whereas for parshall design it received 128.457 KPa.

Looking at the graph pattern, the maximum pressure is gradually increasing from single tank to triple tank, this pattern also can be seen in pressure contour from figure 4.18-4.26, this is basically because the length of tank and swirling of water. Using the maximum total pressure as the parameter in choosing tank is not significant, because it did not show the efficiency of the tank on handling the pressure but then, the important of the data obtained is to be used in stress and strain analysis in order to determine the maximum deflection and the maximum von mises stress for each design; this is to choose a strong and low cost material.

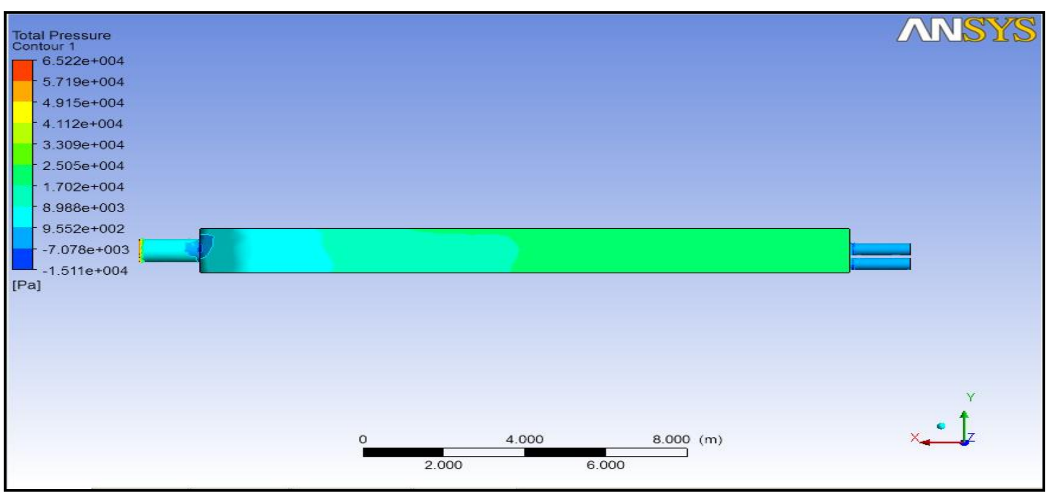

Figure 4.12: Total pressure contour for single tank parshall design.

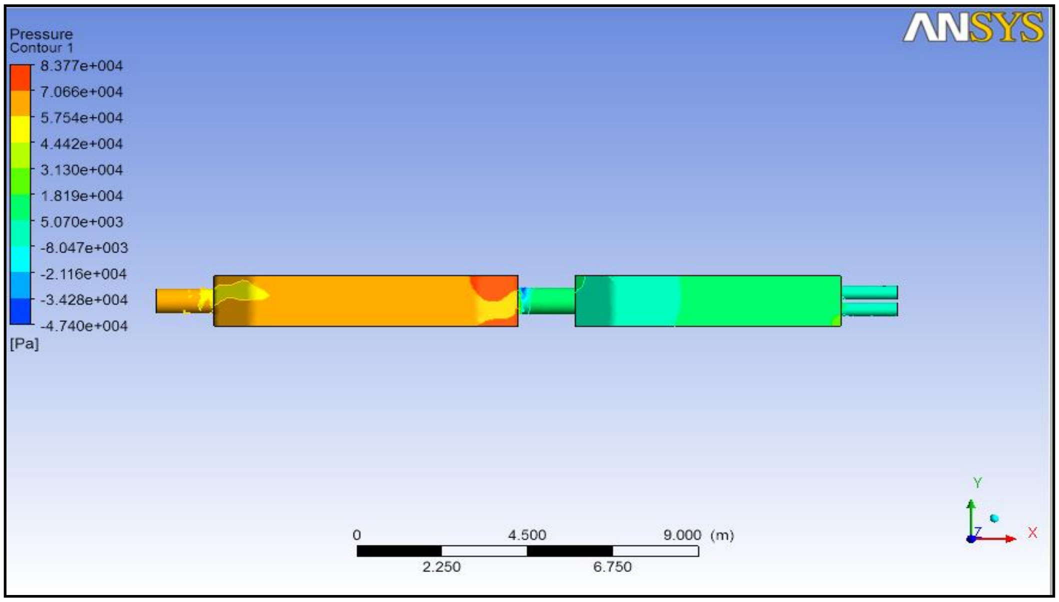

Figure 4.13: Total pressure contour for double tank parshall design.

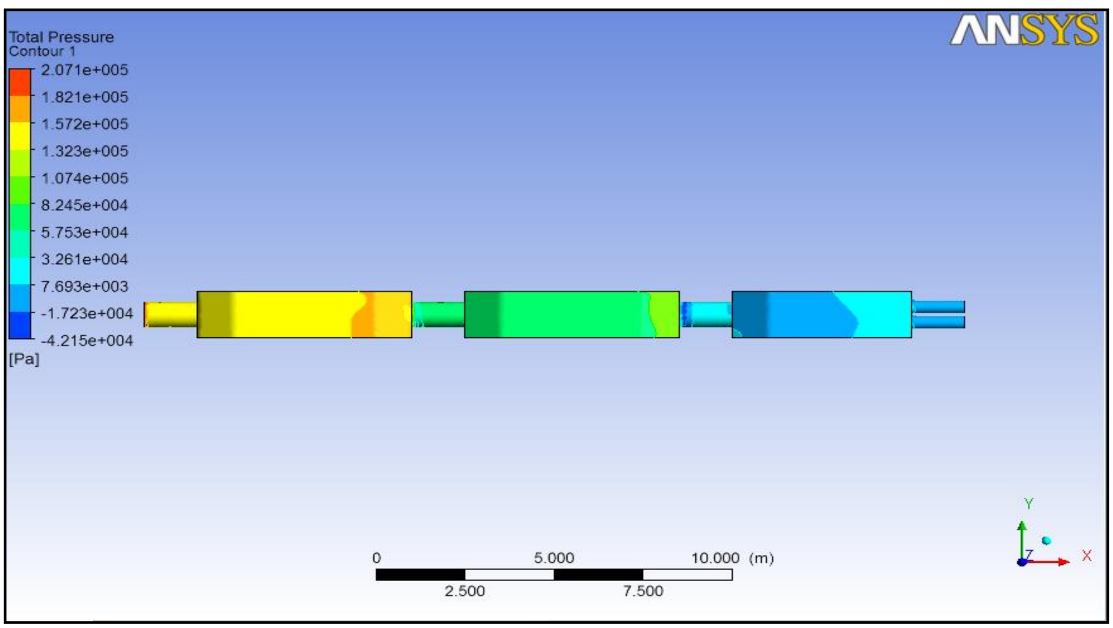

Figure 4.14: Total pressure contour for triple tank parshall design.

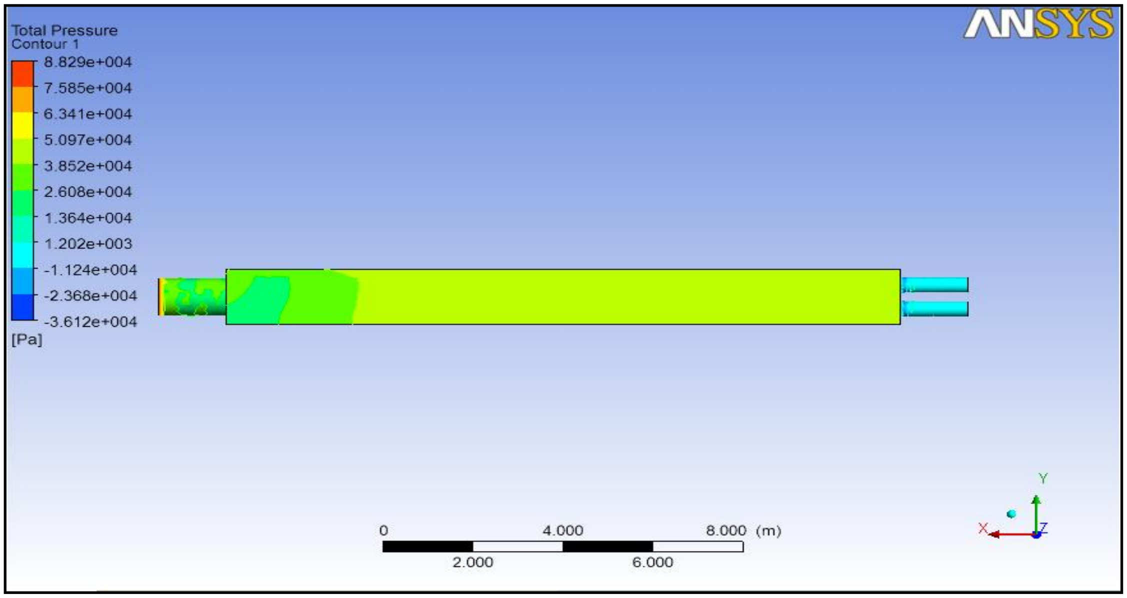

Figure 4.15: Total pressure contour for single tank rectangular design.

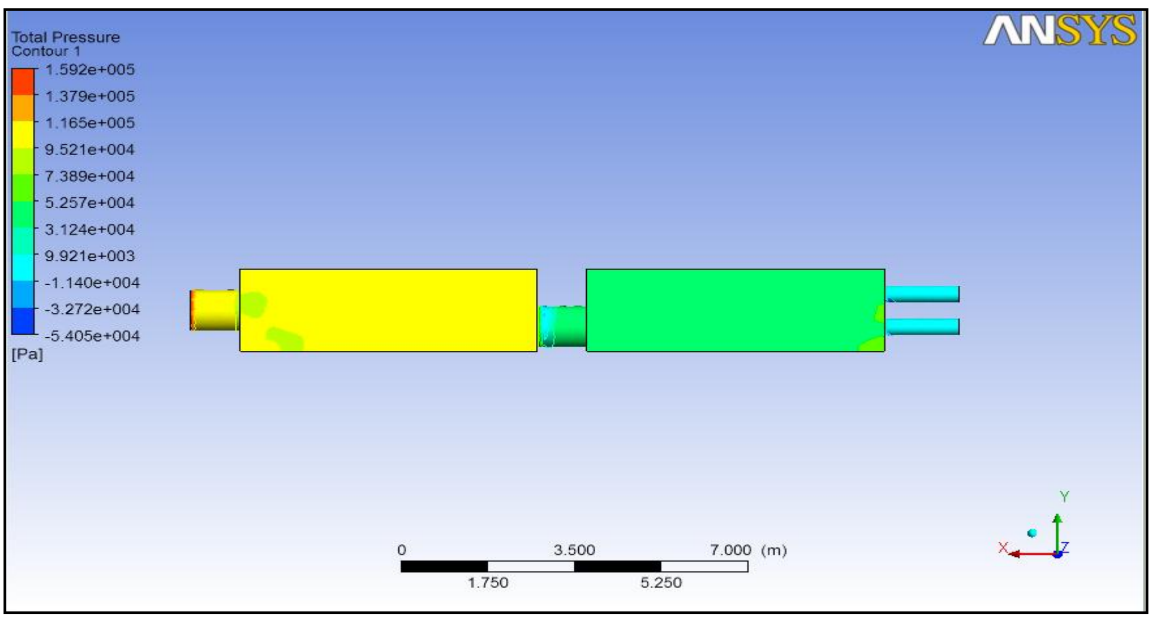

Figure 4.16 Total pressure contour for double tank rectangular design.

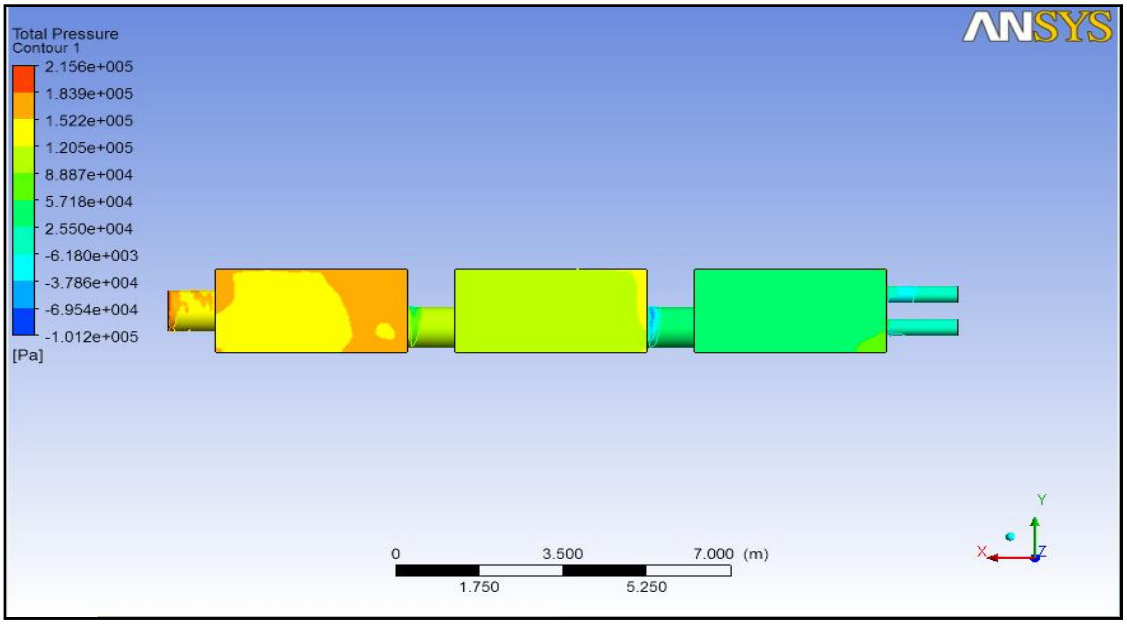

Figure 4.17: Total pressure contour for triple tank rectangular design.

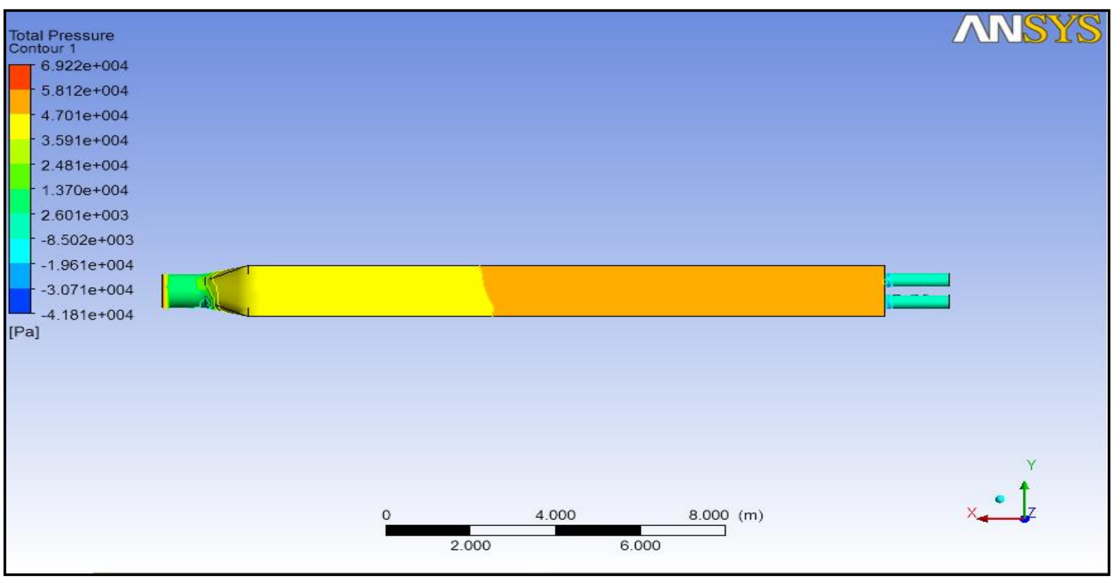

Figure 4.18: Total pressure contour for single tank circular diffuser design.

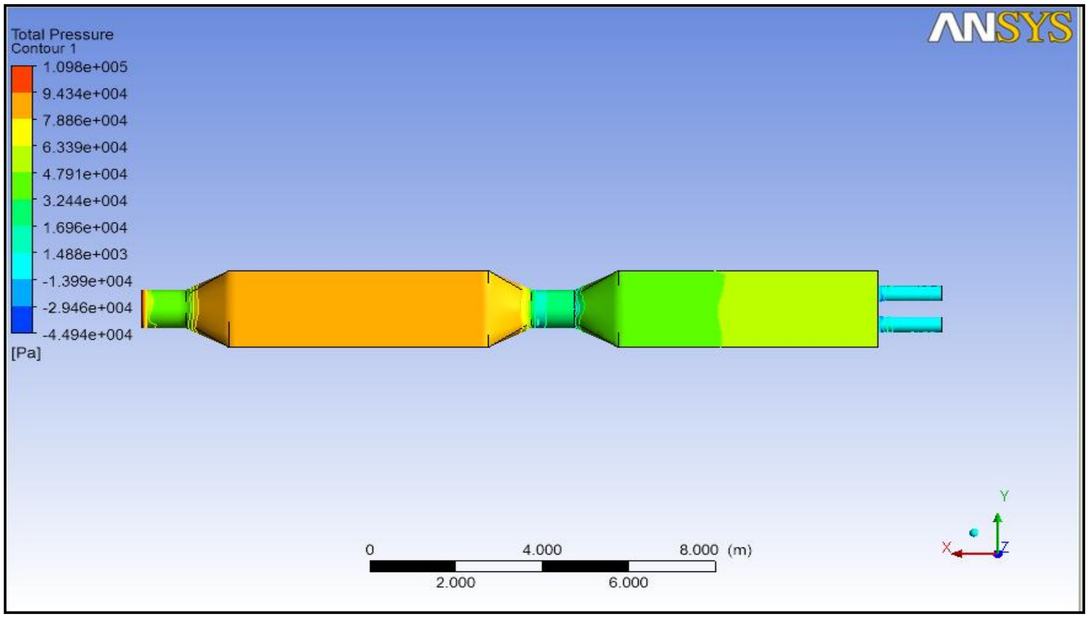

Figure 4.19: Total pressure contour for double tank circular diffuser design.

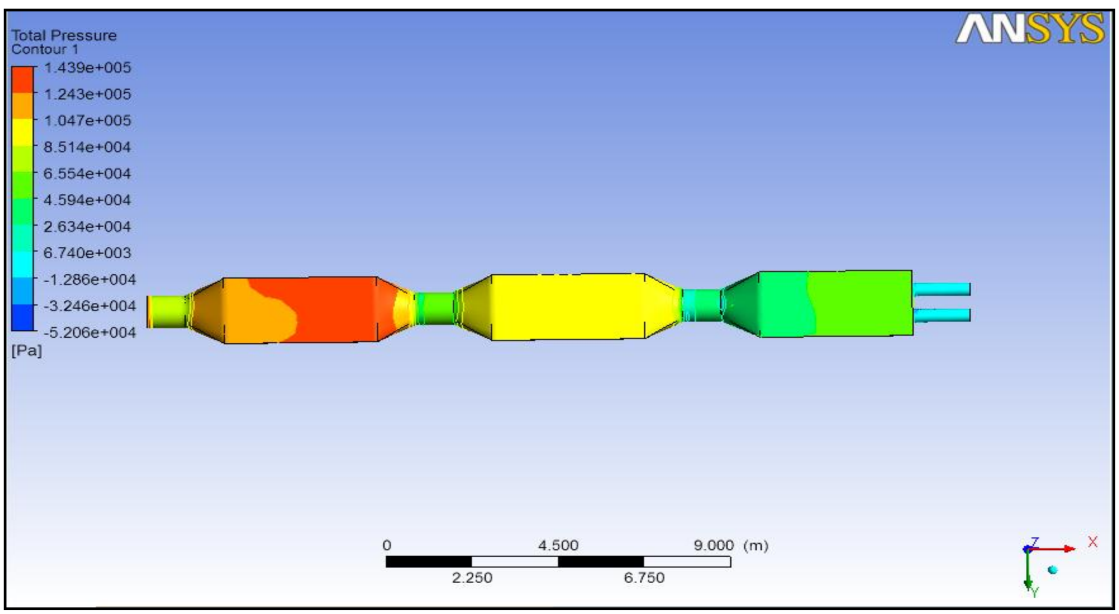

Figure 4.20: Total pressure contour for triple tank circular diffuser design.

4.4 MAXIMUM DEFLECTION ON DIFFERENT GRADE OF CONCRETE

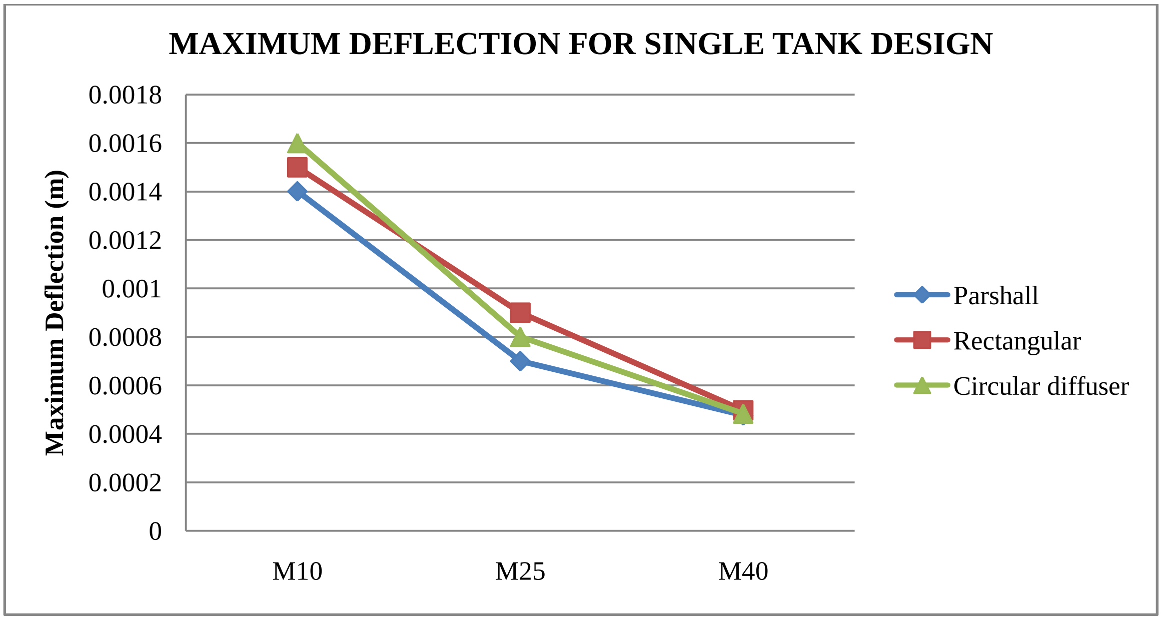

Figure 4.21: Maximum deflection for single tank design with different grade of ready mix concrete.

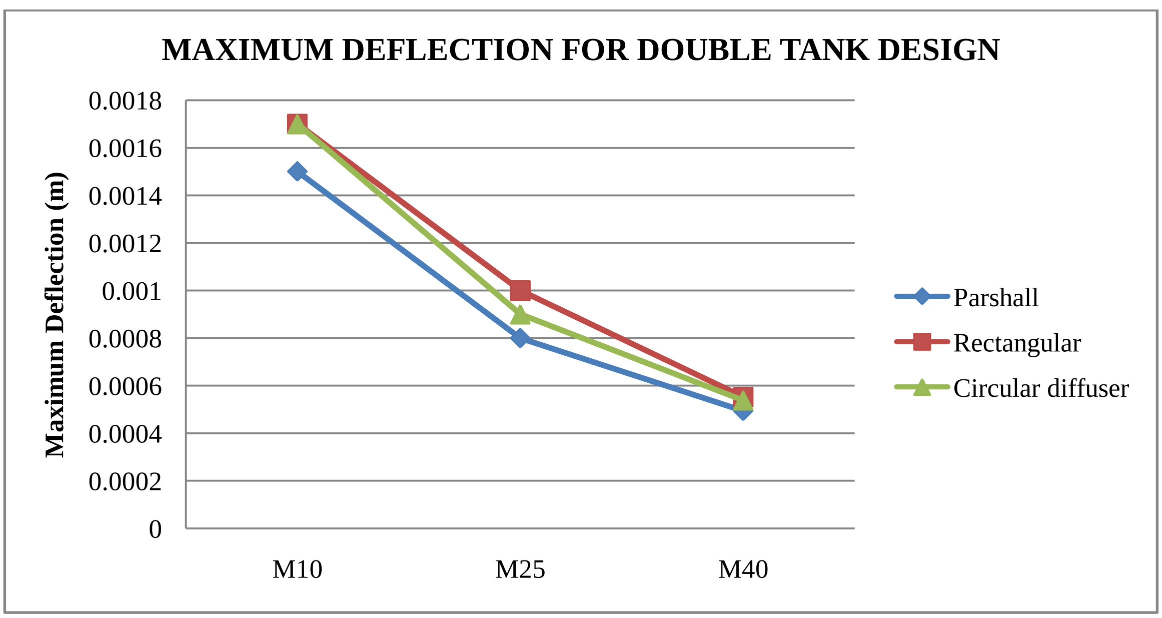

Figure 4.22: Maximum deflection for double tank design with different grade of ready mix concrete.

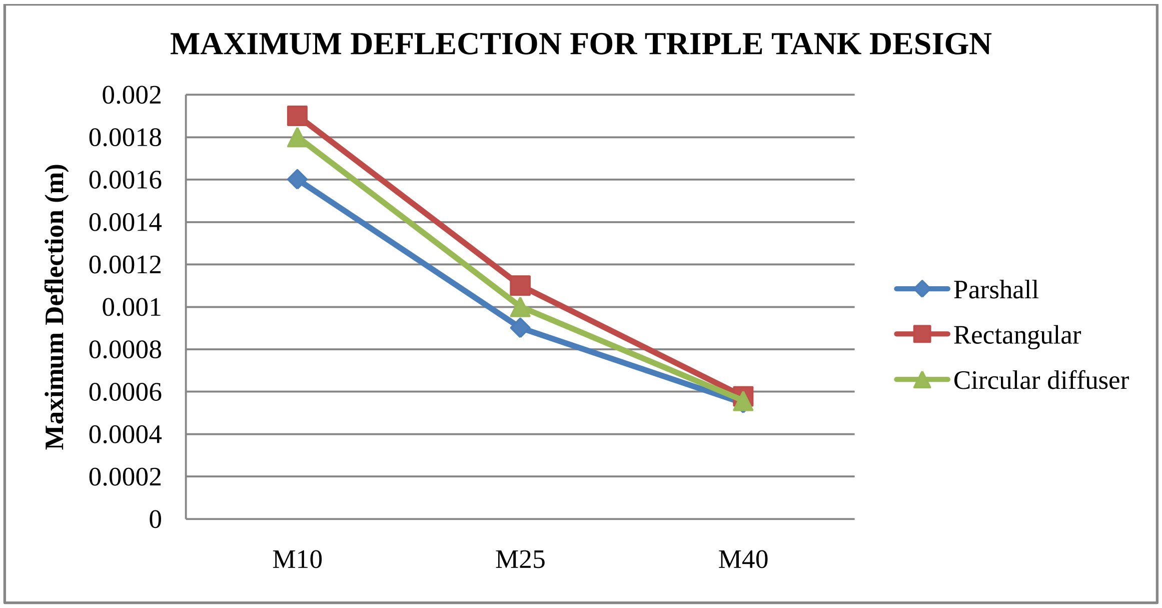

Figure 4.23: Maximum deflection for triple tank design with different grade of ready mix concrete.

Based on figure 4.27, 4.28 and 4.29, it shows the result for maximum deflection on single, double and triple tank for each design. The stress analysis was only done for ready mix concrete – Grade 10, 25 and 40 because these three grades can show more a clear differences on deflection for each design. The three graphs show an exact similar pattern of maximum deflection for each design on three different grade of concrete. Parshall design for single, double and triple tank give the lowest maximum deflection on each grade of concrete used compared with the other designs. Rectangular design basically gives an average of high deflection compared with circular diffuser design on each single, double and triple tank with different grade of concrete, the only stage where the circular diffuser has the highest deflection is on single tank design using grade 10 concrete.

The differences of deflection between these three design when using concrete – grade 40 is small, hence it can be consider that concrete – grade 40 is the material that is suitable for each design, but in order to reduce the cost, the maximum deflection on each material has to be known before choosing a cheaper material, this is to confirmed that the design will be still safe even though the material use is less in term of strength and price.

Base on the data obtained, it can be conclude that all grade of ready mix concrete is suitable to be apply on each design because the value of deflection can be consider as small, even the highest deflection that may occur is 0.2 mm, furthermore the data was obtained by using the highest pressure that exerted on the wall from the CFD simulation and in ALGOR simulation, the whole wall was defined to be exert with these pressure but in reality the pressure is varied across the length. Base on ALGOR simulation, the part where the maximum deflection occur on each design is the same, it was at the top stem of the wall, but it is impossible to have deflection on top part of the reservoir since the water depth is 1.5 m whereas the reservoir is 2 m height, hence the maximum deflection should be occur at below 1.5 m height of reservoir.

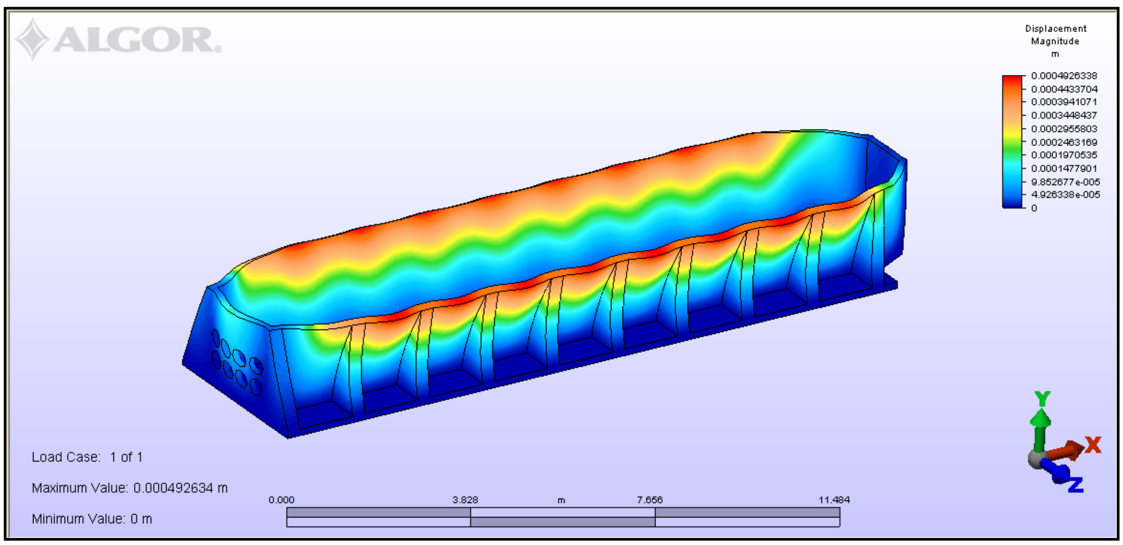

Figure 4.24: Stress and strain analysis in ALGOR software for single tank parshall design.

Table 4.1: Yield Stress for M10,M25 and M40 Ready Mix Concrete.

Grade of Ready Mix Concrete	Yield Stress (MPa)
M10	10
M25	25
M40	40

Table 4.2: Von mises stress for each design with different grade of concrete.

		Von Mises Stress (Mpa)		
Reservoir Design	**Number of Tank**	**Ready Mix Concrete-M10**	**Ready Mix Concrete-M25**	**Ready Mix Concrete-M40**
Parshall	Single	3.3	3.5	3.8
	Double	3.8	4	4.4
	Triple	4.2	4.5	4.8
Circular Diffuser	Single	3.8	4.1	4.5
	Double	4.8	5.1	5.3
	Triple	5.3	5.6	5.9
Rectangular	Single	3.8	4	4.3
	Double	4.3	4.6	4.9
	Triple	7.3	7.6	7.9

Table 4.1 and Table 4.2 shows the yield stress of the material and von mises stress for each design. The data shows that all the stress for each design does not exceed the yield stress of the material, if the stress is more than the yield stress of the material, it means that the material is not safe to use because the material will start to bend or fracture. Thus, from the data obtained in aspect of maximum deflection and von mises stress, it is highly supported that all grade of ready mix concrete can be use.

4.5 COSTS FOR EACH DESIGN USING READY MIX CONCRETE-M10

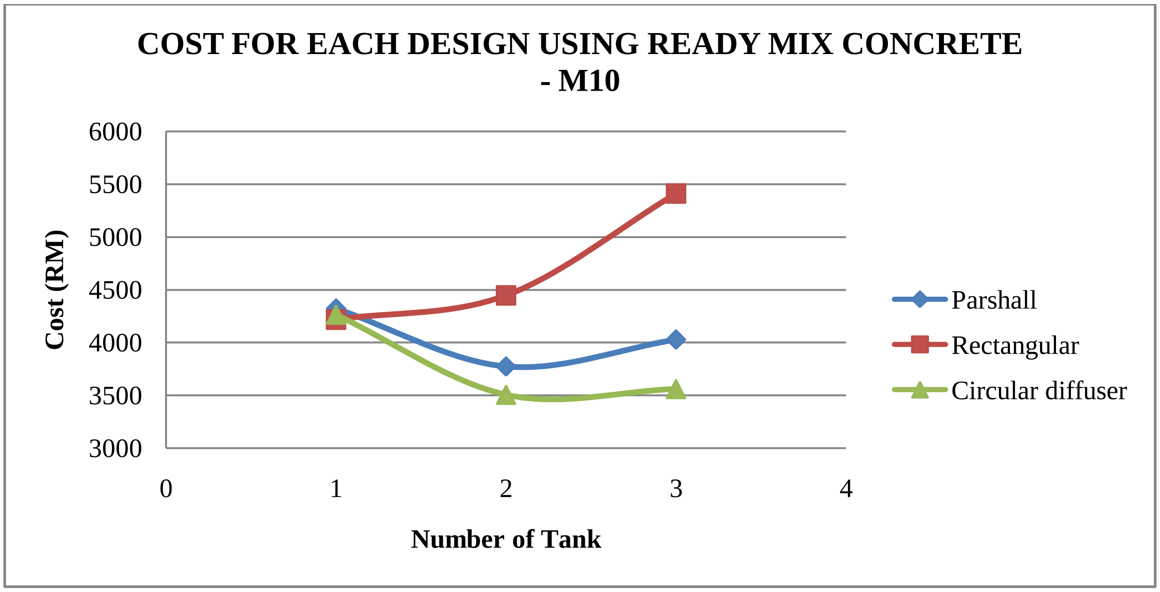

Figure 4.25: Cost for each design using ready mix concrete – M10.

From figure 4.25 above, it shows the cost on each design when using ready mix concrete - grade 10, because grade 10 is the cheapest material that is available by referring to CIDB Malaysia material price catalogue. For single tank, the designs that need the least cost is rectangular design with RM 4217 and parshall design need the most cost to build with RM 4323. In double tank categories, the designs that need the least cost is circular diffuser design with RM 3506 and the highest cost to build is rectangular design with RM 4446. For triple tank, the designs that need the least cost is circular diffuser design with RM 3561, while rectangular design need the highest cost to build with RM 5412.

Base on the data obtained, circular diffuser designs need the least cost to build in term of volume of material use for single, double or triple tank but since the diffuser need to be custom made because of the shape, so circular design cost is not significant with this analysis, it also must include the custom made cost. For rectangular and parshall design, the data is valid since the geometry is simple and did not need to be custom made.

In summarization for cost analysis by referring to the data obtained, the designs that need the least cost is double tank parshall design with RM 3773 , hence in term of price factor, this design is the best and most suitable to be apply on flume project.

4.6 DISCUSSION

In choosing the best reservoir design that needs to be applied in flume project, they are two main parameters that need to be considered, that is percentage of pressure drop and costing. Percentage of pressure drop symbolizes the efficiency of the design to be compatible with the pump system, so it is suitable to be the guideline on choosing the best design.

The purpose of maximum pressure exerted on the wall analysis is to determine the highest pressure that need to be apply in stress analysis in order to obtain the maximum deflection and the maximum von mises stress on the design. From the maximum deflection and maximum von mises stress data, process of deciding the material can be done and using the cost of material that have been choose, cost analysis for whole design can be determine.

For pressure drop analysis, it can be summarize that the design that have the least pressure drop is single tank circular diffuser design, whereas the highest pressure drop is double tank parshall design, since the design with the lowest pressure drop will have the highest efficiency, single tank circular diffuser design is the best design to be implement on this project.

Stress analysis shows that, all grade of ready mix concrete is applicable to each design because the maximum deflection occur for each design is relatively small, less than 2 mm and all the stress that exert on the wall is not exceeding the yield stress of the material, hence from this analysis it conclude that all grade of ready mix concrete is safe to use in each reservoir design.

Estimating cost analysis is the consequence from the stress analysis, the main parameter in costing is the price of material. Since it have been conclude that from stress analysis, any grade of ready mix concrete is applicable to the design, choosing the cheapest material is significant to reduce the cost, hence ready mix concrete M-10 is chosen as the optimum material because it is the cheapest compared with the other grade of concrete. The data from cost analysis conclude that, the design that needs the lowest cost in term of volume material use is double tank parshall design.

Comparing these two designs that have chosen through both parameters that is pressure drop and costing, the designs that have the least pressure drop is single tank circular diffuser tank design with 7% and estimated cost RM 4265(not including the custom made cost), while the design that need the least cost is double tank parshall design with RM 3773 and have 71.8% of pressure drop. By referring to both design, the differences of cost is about RM 500, it is a small difference of cost ,even if it include the custom made cost for circular diffuser design, the cost still can be consider as small in scope of high cost project.

Both design shows a big differences in pressure drop that is 64.8%, as mention before, the design with the least pressure drop has the highest efficiency, this efficiency is relate with the pump system, if the design can reduce the power use by the pump means that the design is efficient, to reduce the pump power there must be a high energy on the outlet of the reservoir. The energy is conserve if the energy inlet is equal to outlet, this energy can be measure as the pressure of the water flow and to have the maximum possible energy on the outlet reservoir, the pressure outlet should be closer with the pressure inlet, so that the pump will need a small amount of power to suck the water

So from both parameter cost and pressure drop, it is more preferable to use single tank circular diffuser design since it gives the least percentage of pressure drops and in term of cost, the differences of cost is small if it compared with the cheapest design, so cost factor can be neglected unless if the design is expensive and have a huge different with the cheapest one so cost factor is rational to be take in count.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

.This study give an evaluation and analysis for each design proposed, the designed was analyze and evaluate through stress and strain analysis, CFD analysis and costing analysis in order to choose the best design to be implement in the flume project. In this study, the design that has been chose is single tank circular diffuser design. This design gives the least percentage of pressure drop with 7 % and the material cost to build this design is RM 4265, hence the objective for choosing the best design is achieved.

5.2 RECOMMENDATION

As a result of findings in this study, recommendations for further work into area of design and analysis of water reservoir should include:

i. Swirling water effect on reservoir wall.
ii. The use of another type of wall in the design with different material, other than concrete for example PVC, fibreglass and steel.
iii. The Standard Operating Procedure (SOP) for reservoir, this is to smooth the water circulation process through the reservoir. A smooth water circulation means that there is no water spill out from the tank.

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