DESIGN AND DEVELOPMENT OF RAINWATER CONSERVATION SYSTEM FOR APPLICATION IN SCHOOL

HII DING FUNG

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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A report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering

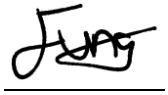
Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2020

DECLARATION

I declare that this project report entitled "Design And Development of Rainwater Conservation System For Application In School" is the result of my own work except as cited in the references

Signature : 

Name : HII DING FUNG

Date : 26 JUNE 2020

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : .....

Name of Supervisor : .....

Date : .....

DEDICATION

To my beloved mother and father

ABSTRACT

In this study, a feasible RWH system has been conceptually developed for the selected school premise which is a building in SJK(C) Ayeh Keroh. The design of the RWH system is mainly based on the purpose of the RWH system application within the school premise. The purpose of this RWH system is to supply as backup toilet flushing water for the school building and helps to solve water shortage problems in the school. If the rainwater is abundant, this system can replace the municipal water for flushing toilet purpose. The design components including collection system, piping system, filtering system and storage system. The components of the RWH system are uPVC gutters, filters, uPVC pipes, a 3000 liters polywater tank and a 1/2 HP booster pump. For the water tank component, material selection analysis compared three types of materials which are polywater tank, steel water tank and stainless-steel water tank. Ultimately, polywater tank material was chosen due to its high durability, easy installation, easy to maintenance and variety. The 3000 liters water tank capacity is determined by the demand side approach which the storage tank capacity is determined by analyzing the water demands of that building. For performance analysis, a stress analysis has been conducted by using Solidworks for storage tank component. The result shows that thee storage tank can withstand up to a maximum von Mises stress of 106986.1 N/m^2 and a minimum von Mises stress of 32.0 Nm^2 by defining a pressure of 126477.5 Pa that act onto the inlet of the water tank. The total estimated initial install cost by considering all the material costs and labor costs for this RWH system is about RM 5109.88, without considering the maintenance cost. The cost, application, treatment system, rainfall characteristics, policy, and public perception are the practice and implementation issues that we might face. Lastly, a comprehensive study about the RWH system need to be done before designing the RWH system due to various factors such as cost, application, rainfall characteristics, purposes of RWH system and implementation issues.

ABSTRAK

Dalam kajian ini, sistem RWH yang telah dibangunkan secara konsep untuk premis sekolah terpilih yang iaitu bangunan di SJK (C) Ayeh Keroh. Reka bentuk sistem RWH ini terutamanya berdasarkan tujuan sistem RWH dan keadaan premis sekolah. Tujuan sistem RWH ini adalah untuk membekalkan air pembuangan tandas sandaran untuk bangunan tersebut dan membantu menyelesaikan masalah kekurangan air di sekolah. Sekiranya air hujan melimpah, sistem ini dapat menggantikan air perbandaran untuk tujuan pembilasan tandas. Komponen reka bentuk termasuk sistem pengumpulan, sistem perpaipan, sistem penyaringan dan sistem penyimpanan. Komponen sistem RWH adalah talang uPVC, penapis, paip uPVC, tangki poli air 3000 liter dan pam penggalak 1/2 HP. Untuk komponen tangki air, analisis pemilihan bahan yang membandingkan tiga bahan iaitu tangki poli air, tangki air keluli dan tangki air keluli tahan karat. Pada akhirnya, bahan tangki poli air dipilih kerana ketahanannya yang tinggi, pemasangan yang mudah, penyelenggaraan yang mudah dan pelbagai. Kapasiti tangki air 3000 liter ditentukan oleh pendekatan sisi permintaan yang mana kapasiti tangki simpanan ditentukan dengan menganalisis permintaan air bangunan itu. Untuk analisis prestasi, analisis tegasan telah dilakukan dengan menggunakan Solidworks untuk komponen tangki simpanan dan hasilnya menunjukkan bahawa tangki simpanan anda boleh bertahan sehingga tekanan von Mises maksimum 106986.1 N / m^2 dan tekanan von Mises minimum 32.0 Nm^2 oleh mendefinisikan tekanan 126477.5 Pa yang bertindak ke dalam saluran masuk tangki air. Jumlah anggaran kos pemasangan awal dengan mempertimbangkan semua kos bahan dan kos tenaga kerja untuk sistem RWH ini adalah sekitar RM 5109.88, tanpa mempertimbangkan kos penyelenggaraan. Biaya, aplikasi, sistem perawatan, karakteristik hujan, kebijakan, dan persepsi masyarakat adalah masalah praktik dan pelaksanaan yang mungkin kita hadapi. Akhir sekali, kajian komprehensif mengenai sistem RWH perlu dilakukan sebelum merancang sistem RWH kerana pelbagai faktor seperti kos, aplikasi, ciri hujan, tujuan sistem RWH dan masalah pelaksanaan.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest appreciation to my supervisor Assoc. Prof. Dr. Tee Boon Tuan for giving me this opportunity to do final year project with him. He never hesitated to give me advice and guidance whenever I confronted problems. I am thankful for his patience and advice while leading me in this project.

I would like to thank my course mates for giving me their support, patience, and encouragement. I would also like to thank my family for their support. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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CAD	Computer Aided Design
DID	Department of Irrigation and Drainage
GPM	Gallons Per Minute
HDPE	High-Density PolyEthylene
JKR	Jabatan Kerja Raya
KTAK	Ministry of Energy, Water and Communication
NGT	National Green Tribunal
RWH	Rainwater Harvesting
SMKIS	Sekolah Menengah Kebangsaan Iskandar Syah Melaka
TDH	Total Dynamic Head
uPVC	unPlasticised Polyvinyl Chloride
WHO	World Health Organization

LIST OF SYMBOL

A	Area, m^2
P	Pressure, Pa
ρ	Density, kg/m^3
g	Acceleration due to gravity, ms^{-2}
h	Height, m
L	Length, m^3
P_L	Pressure loss per meter, Pa/m

1. CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Rainwater conservation or rainwater harvesting is a practice that is socially acceptable and environmentally responsible all the while and promoting self-sufficiency (Maxwell-Gaines, 2018). It provides us clean water for many purposes such as agriculture uses, household uses, school uses etc. The best way to conserve rainwater is by rainwater harvesting. Rainwater harvesting is a very good sustainable water management practice that can be implemented by anyone at any level. Rainwater harvesting system can be very simple and can be very complicated. Generally, rainwater harvesting is a method to store rainwater that falls to the roof into a tank for later use. Rainwater harvesting can help the community to resolve the water shortage problem and can also be reserved as emergency uses. Some communities were used to import water for their daily needs, by rainwater harvesting, they can reduce the need of imported water. For school, the rooftop rainwater harvesting system can supply the water for toilet flushing, cooking, washing hands and feet of students and staffs, hygiene and ultimately for drinking purpose, if the conserved rainwater is properly treated (Clean India Journal, 2012).

Rainwater harvesting can also help to reduce the energy used to pump and treat the municipal water to house or any building. The treatment and pumping of municipal water require a lot to operation energy. Hence, by using rainwater harvesting to replace municipal water with harvested rainwater, it can help to save a lot of energy consumption. By harvesting and using rainwater to replace municipal water, it can help to reduce the water

bill within the community. Rainwater has a very widely range of uses, it can be for irrigation use, indoor non-portable use, and portable water use. If other water sources unavailable, rainwater can be the water source in the areas. Rainwater harvesting can be the permanent solution to the water crisis problem in different parts of the world (Madaan, 2016). This method is best suit for those areas which has sufficient rain, but the groundwater supply is not sufficient. It can utilize the use of rainwater in that areas. Although our mother earth is made up of three-fourth of water, but only very little of it is suitable for human consumption or agriculture. The rainwater is also unpredictable there is some countries that constantly faced water shortage problem, by using this method, the problem can be easily solved.

The importance of rainwater collection or rainwater harvesting lies in the truth that it can be stored for future use. It is also an excellent source of water for plants and landscape irrigation since it contains no harmful chemicals such as fluoride or chloride. The stored water can used to revitalize the ground level water and improve its quality. This also can help to increase the ground level water which then can be easily accessible. When fed into the ground level wells and tube well are prevented from drying up. This increases soil fertility. Harvesting rainwater reduces soil erosion and checks surface run off water.

Thus, rainwater harvesting plays an important role in the sustainable water management strategies. The practice of rainwater harvesting is and vital part of developing the sustainable water resource path for all the communities. Rainwater harvesting can be the crucial water supply strategy and paradigm to resolve the demands of population growth and economic development. Rainwater harvesting is an untapped water resource that could be developed quickly within communities and will bring a huge impact.

1.2 PROBLEM STATEMENT

Rainwater harvesting (RWH) in both urban and rural areas has become an important practice worldwide. Generally, there is two types of RWH system that can be designed, which are systems that using surfaces or ground catchments areas and systems using above-ground or rooftop catchment areas (Sung, 2010). RWH system is a good education tools for school children to educate them about the benefits of conservation of water typically rainwater. By implementing this RWH system, they can encourage the next generations to have a responsibility to maintain the sustainability of our natural resources. In term of economy, this RWH system can save money by not wasting the water. RWH system can also solve the low energy pumps and controls problems (Education – School Rainwater Harvesting Systems, n.d.).

Due to the development process in Malaysia, there was a quite number of environmental issues existed and these issues getting serious day by day. The rapid development of Malaysia has caused some natural disasters such as flooding, greenhouse effect, pollution, and global warming. Malaysia has a good water supply system, but the demand of clean water has increased due to the population growth and development. RWH system is an innovative solution for this problem. This system can be used as an alternative water supply in the future and can reduce the cost of water bills for water supply among consumers such as schools. It is very suitable to be implemented in Malaysia due to the high rainfall intensity in Malaysia. In fact, many schools in Malaysia does not have a good rainwater conservation system that can conserved the rainwater for many purposes. Thus, an appropriate RWH system needs to be designed and developed to collect the rainwater and conserved in storage. The collected rainwater can be used as non-potable purposes such as irrigating, washing clothes, watering the gardens, washing cars, flushing toilets, washing hands, hygiene needs etc. RWH system is basically designed to provide enough water for

the needs of schools. The practice and implementation of RWH system in school also is an issue that is needs to consider.

Since 2017, the National Green Tribunal (NGT) has ordered all educational institutions in the capital to build RWH systems at their premises at their own expense in India. According to the status report submitted on November 20, 2018, the NGT committee has levied a Rs 5-lakh (RM0.28) fine on schools and colleges where there are no RWH systems (around 40% of schools) or existing ones are not operating. Schools were criticized and punished for not meeting the order in several news reports. But no one questions why these schools, following such strict orders, were unable to enforce the same. In fact, the schools that were able install RWH system were had no clue about how to operate and maintain them. Abundance support in terms of expertise regarding implementing RWH systems and the benefits need to be provided to those schools. The schools need to be made aware of the huge benefits of installing the RWH system in their school buildings. The RWH system in school buildings will help in water augmentation in terms of groundwater recharge or storage and can act as flood control measure. This green initiative can also be used as a demonstrative campaign for the dissemination of information and to provide students with an awareness of sustainability within the education program. To guide the schools to install the RWH system, the creation of zones according to site conditions of the school is necessary. There is a need to provide technical and managerial support to schools for a appropriate RWH implementation. Building capacity is essential to disseminating information in schools related to planning, developing, running, and sustaining the RWH program. Short-term training programs should be implemented for target audiences covering various subject areas on RWH systems. For instance, of teachers and school administrative units, training programs can be conducted; for government officials to manage the school; for organizational maintenance, etc. This model would be useful not only to design and

implement appropriately, but also to generate general awareness (Schools need a roadmap for rainwater harvesting, n.d.).

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To overview the practice and implementation issues of RWH system in SJK(C) Ayeh Keroh.
2. To design and develop a feasible RWH system for application in SJK(C) Ayeh Keroh.
3. To provide an overall analysis on the designed rainwater harvesting system.

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. The application of the RWH system is based on the school usage.
2. The design of the RWH system will be focusing on its feasibility and on how it can provide water for non-potable use.

1.5 SIGNIFICANCE OF THE PROJECT

In this project, a feasible RWH system design can be obtained and can be a reference and guideline for a school to implement and install an RWH system based on the conditions of the school premises. This project will let the user (school) to identify the best RWH system to be installed and implemented based on several criteria such as mechanism, cost, and design.

1.6 GENERAL METHODOLOGY

The actions that need to be carried out to achieve the objectives in this project are listed below:

1. Literature review

   Journals, articles, or any materials regarding the project will be reviewed.

2. Data collection

   Survey on the available design data from the market and previous work.

3. Drafting

   Design the RWH system by using CAD software.

4. Simulation

   Simulate the RWH system.

5. Analysis

   Evaluating the performance of the RWH system and analyse on the results.

6. Report writing

   A report on this study will be written at the end of the project.

1.7 SURVEY

An interview has been conducted with the principal of SJK(C) Ayeh Keroh. According to the principal, she thinks that the RWH system is applicable to the school premises, but there is some concerns on the system, for example the inconsistent rainfall at Melaka since as a matter of fact, Melaka city has relatively low rainfall based on her observation. She also has concern on the installation cost of the RWH system. However, she thinks that the RWH system was a good idea to solve the water shortage problem and to reduce the school's water bills. It can also act as a backup solution during the dry season.

2. CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

2.1.1 Water Status and Demand in World

According to Law & Bustami (2013), the earth is covered by 70% of water, but only 2% of the water is directly consumable fresh waters. Moreover, not all the 2% of freshwater can be used, about 30% of Earth's fresh water came from groundwater sources, river, and lakes. This indicate that only 0.6% of Earth's total water can provide freshwater that we can easily obtain and consume. There is no substitute for water. The amount of water that we have now is to be shared with our future generations. There is no additional water supply to meet the increased water demand by the people in the future.

2.1.2 Water Consumption and Reserves in Malaysia

According to Anang et al. (2019), there is an increasing demand for water in different sectors such as domestic and industry, irrigation, and others from 1980 to 2020. This growing demand of water is to sustain Malaysia's growing population and industrialization. No slowdown is expected given the plans for Malaysia's continued economic growth. Based on the National Water Resource Study 2000-2050 the water demand for the domestic consumer will be increased from 2000 till 2050, respectively 2,029 million m^3 to 5,904 million m^3. The total volume also rises from 10,833 million m^3 to 17,675 million m^3.

From the research by Christopher Teh (2015), Malaysia consumed more than 300 liters of water per person per day compared to 150 liters per person per day by Singaporeans