DESIGN AND DEVELOP OF SHOCK-ABSORBING OR SUSPENSION SYSTEM FOR A WASTE OR TRASH COLLECTOR CONVEYOR

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE) WITH HONOURS

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DEDICATION

I would want to dedicate this work to my dearly loved parents as well as to my supervisor, Ts Muhammad Zaidan Bin Abdul and Ts. Mohd Idain Fahmy bin Rosley , who have shown me love and support without condition and have been there for me no matter what. I cannot express how grateful I am to you for providing the motivation I needed to complete my Senior Project.

ABSTRACT

The aim of this project is to design and develop a shock-absorbing or suspension system for a waste or trash collector conveyor. Perbadanan Pembangunan Sungai Melaka contributed with this project. In order to absorb the wave energy generated by the Melaka River Cruise and the natural waves from the Melaka River, a suspension system will be installed on the trash collecting conveyor. However, the trash collector's conveyor system is not operating as efficiently as it should be due to this significant problem. In order to fix the issue, a shock absorber or suspension system must be installed on the conveyor, and the choice is chosen based on the suspension's durability to weather corrosion and low maintenance costs. Utilizing a three-dimensional computer-aided design (CAD) system or Inventor Software was used to create a prototype scale model of the suspension system's actual pieces or assembly. In addition, analyze and study wave force and drag force from previous studies to obtain the amount of force produced by rivers and boats. The analysis will be used in Inventor Analysis to ensure the suspension system is strong and safe to use. At the conclusion of this study, a fully working trash collector is anticipated to be collecting rubbish along the Malacca River's waterfront. The trash collector conveyor would also help the Malacca River solve the problems of pollution of the water. The installation of a trash conveyor system in Sungai Melaka shows a dedication to environmental sustainability, enhances the cleanliness of the river, and fosters community involvement.

ABSTRAK

Matlamat projek ini adalah untuk mereka bentuk dan membangunkan sistem penyerap hentakan atau penggantungan untuk penghantar sisa atau pemungut sampah. Perbadanan Pembangunan Sungai Melaka menyumbang dengan projek ini. Bagi menyerap tenaga ombak yang dijana oleh Pelayaran Sungai Melaka dan ombak semula jadi dari Sungai Melaka, sistem ampaian akan dipasang pada penghantar pengutip sampah. Walau bagaimanapun, sistem penghantar pemungut sampah tidak beroperasi dengan cekap seperti yang sepatutnya disebabkan masalah besar ini. Untuk menyelesaikan masalah ini, penyerap hentak atau sistem suspensi mesti dipasang pada penghantar, dan pilihan dipilih berdasarkan ketahanan suspensi untuk mengharungi kakisan dan kos penyelenggaraan yang rendah. Menggunakan sistem reka bentuk bantuan komputer (CAD) tiga dimensi atau Perisian Pencipta telah digunakan untuk mencipta model skala prototaip bagi kepingan atau pemasangan sebenar sistem penggantungan. Selain itu, menganalisis dan mengkaji daya ombak dan daya seret daripada kajian lepas untuk mendapatkan jumlah daya yang dihasilkan oleh sungai dan bot. Analisis akan digunakan dalam Analisis Inventor untuk memastikan sistem suspensi kukuh dan selamat digunakan. Pada akhir kajian ini, sebuah pemungut sampah yang bekerja sepenuhnya dijangka akan mengutip sampah di sepanjang persisiran Sungai Melaka. Pengangkut sampah juga akan membantu Sungai Melaka menyelesaikan masalah pencemaran air. Pemasangan sistem penghantar sampah di Sungai Melaka menunjukkan dedikasi terhadap kelestarian alam sekitar, meningkatkan kebersihan sungai, dan memupuk penglibatan masyarakat.

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CHAPTER 1

INTRODUCTION

1.1 Background

A trash collector conveyor is a device designed to capture and remove debris, garbage, and other pollutants from the river before it enters the sea or other natural bodies of water. Any object floating or submerged in water that is not naturally there is referred to as debris on a river including branches, leaves, rubbish, plastics, logs, pebbles, and other debris. Trash collector conveyor devices are typically installed at near river to prevent litter, sediment, and other debris from causing environmental harm in Sungai Melaka (Hua, 2017). Trash collector is also available in other countries such as Ballast Tank of RTCS (Mukhtar et al., 2020) ,The Ocean CleanUp. These big companies and technology also helped a lot to clean up rivers around the world.

In addition, there are several problems faced by this trash collector. Among the problems faced are the waves produced by the Melaka River Cruise and the natural waves from the Melaka River. The waves produced by the Melaka River Cruise and Sungai Melaka will result in the conveyor system on the garbage collection machine not being able to function properly with efficiency (Zong-Yu Chang et al., 2020). In order solve this issue, the conveyor must have a suspension system in order to reduce the stress due to wave. Therefore, there are several ways to face with the vibration that the waves cause including air suspension, helical isolators, absorbing fenders, and suspension. The trash collector conveyor may thus be indirectly made more efficient in this project by doing the analysis necessary to guarantee that the proper tools are installed in the conveyor.

The Trash Collector Conveyor is an innovative device designed to efficiently capture debris and garbage along the scenic Melaka River. Strategically located at Jeti Taman Rempah, Melaka, this static trash collector operates seamlessly alongside the riverbank as ilustrated in Figure 1.1. Positioned strategically to intercept debris on the river's edge, the conveyor is adept at capturing garbage propelled by the currents of the Melaka River Cruise and other boats. Its dynamic functionality allows the conveyor to adjust its height in response to the ebb and flow of the river, ensuring effective waste collection. The installation of this environmentally conscious solution marks a significant step towards preserving the pristine beauty of Melaka River and addressing the challenges posed by floating debris.

Figure 1.1 The area (shaded red) that is likely to be installed trash collector conveyor.

1.2 Problem Statement

The Melaka River in Malaysia shows a huge difficulty in preventing the buildup of floating trash due to both the waves produced by the Melaka River Cruise boats as well as the powerful and unpredictable river waves. Under these wave conditions, the current trash collector conveyor system that is installed in the river struggles to efficiently catch and remove the waste. The existing design is inefficient and might cause system damage since it cannot resist the forces generated by both Melaka River waves and waves created by Melaka River Cruise boats. Boats also can produce very strong waves and can affect the conveyor efficiency of this trash collector. To provide effective waste collection while maintaining structural integrity, a the most advanced trash collector conveyor system that can work in the presence of both Melaka River waves and Melaka River Cruise waves must be installed immediately.

It is essential to include a suspension mechanism on the trash collector's conveyor in order to increase the efficiency of the waste collection system. The Melaka River Cruise and Sungai Melaka's tremendous waves will be used to great effect from this suspension system. The conveyor will be able to efficiently collect and move the collected trash along the riverbanks by intentionally causing these waves. By guaranteeing that trash is removed from Sungai Melaka's River, the construction of such a suspension system would not only improve the trash collector's general operation but also aid in the preservation of the area's ecology.

1.3 Research Objective

The objective of the study are:

a) To analyze the structural strength of the suspension system using Inventor Software.

b) To fabricated the new suspension system for trash collector conveyor.

1.4 Scope of Research

The historical Malaysian city of Melaka's, Melaka River is important to the area's cultural history and tourism. However, the problem of river pollution compromises the river's attractiveness and environmental sustainability. This project's goal was to improve waste collection, stability, and efficiency by introducing suspension into a trash collector conveyor system that was especially created for the Melaka River. Additionally, this project was carried out in collaboration with Perbadanan Pembangunan Sungai Melaka. The conveyor mechanism for the trash collector was unable to operate correctly due to the waves produced by the Melaka River Cruise. To overcome this problem, a suspension system will be created. A analysis of potential challenges, such as trash collector frame strength, suspension system strength, and the suspension system's cost efficiency, should be done before installation and suspension system selection. A decision on the components should be taken after the analysis. To guarantee optimum performance and longevity, choose the proper suspension components, such as springs, dampers, or other mechanisms. After the components and components have been chosen and analysed, the suspension system must be fabricated.

1.5 Research methodology

Figure 1.2 shows the project flow chart for development of a new conveyor suspension system for a trash collector. It begins with conducting a comprehensive on research study drag force and wave characteristics of different boat hulls, and studying wave behavior using numerical simulations. Conceptual sketch for the suspension system are then created, with a focus on dimensions. After that, the suspension system will be designed using Inventor Cad and analyze the design of the suspension system using Inventor Software. The test results are then analyzed, and discussions are held to gain insights and identify potential improvements or modifications. The performance of the trash collector conveyor is evaluated through the analysis of displacement, von mises stress and safety factor. The next step, selecting a suspension system capable of withstanding extreme weather conditions and having reasonable maintenance costs. The project concludes with a summary and conclusion of the findings. Overall, this flow chart ensures a systematic and thorough approach to the design, development, and evaluation of the new conveyor suspension system.

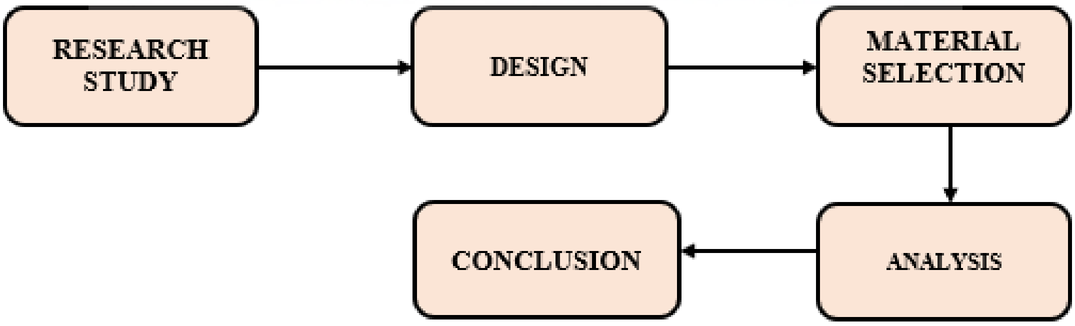


Figure 1.2 Project flow chart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The management of trash is a significant issue that affects communities all around the world. For the preservation of aquatic ecosystems and to avoid contamination, effective trash removal from rivers and other waterways is just as important as collecting rubbish from the land. The dynamic nature of river waves presents particular difficulties for trash collector conveyors, which have evolved as an effective method for gathering and moving debris from rivers. In order to better understand the current state of knowledge and research on the suspension of trash collector conveyors against river waves, this study of the literature will focus on design concerns, mitigation measures, and prospective advancements in the area.

The difficulties that trash collector conveyor suspension systems confront in river wave situations will also be examined in this project. It will look at how wave height, frequency, and direction affect the conveyors stability and functionality. The review will also include the safety issues for workers engaged in collecting trash operations as well as the possible concerns related to wave-induced vibrations, stress, and fatigue on the conveyor components.

In the end, the results of this literature research will help create trash conveyor suspension systems that are more reliable and effective and are adapted to river wave circumstances and implementing trash collector systems in riverine locations would benefit from the knowledge obtained from this review.

2.2 Shock Absorbing System

These conveyors play a pivotal role in removing debris and maintaining the cleanliness of waterways. However, the constant challenges posed by waves and water fluctuations can adversely impact the performance and longevity of these systems. To address this issue, the implementation of a robust Shock Absorbing System becomes imperative.

This innovation serves as a protective measure against the disruptive forces generated by Melaka river waves and the Melaka River Cruise, ensuring the smooth and uninterrupted functioning of trash collector conveyors. The Shock Absorbing System operates on the principle of mitigating impact forces, enhancing the overall reliability and durability of the conveyor system.

There are two main types of Shock Absorbing Systems designed to cater to the specific needs of trash collector conveyors. The first type is the Spring Absorbing System, which utilizes resilient springs to absorb and dissipate kinetic energy, preventing jolts and vibrations from affecting the conveyor's structural integrity. The second type is the Non-Spring Absorbing System, which employs alternative mechanisms to achieve the same objective without the use of springs. Both systems aim to provide an effective solution to the challenges posed by varying water levels and turbulent conditions, contributing to the overall efficiency and performance of trash collection operations on Melaka rivers.

2.2.1 Devices Or Tools To Reduce Wave Vibration

A suspension system must be created and installed with the conveyor in order to solve the issue of waves in the Melaka River brought on by the Melaka River Cruise. To guarantee that the conveyor's suspension is appropriate for reducing wave energy in the Melaka River, it is crucial to use the right type of suspension. many devices or tools are possible to reduce wave vibration, such as :

1. Impact absorbing fenders
2. Gas struts or gas spring
3. Helical Isolators
4. Air suspension (vehicle suspension)
5. Hydraulic suspension
6. Air suspension (bicycle suspension)
7. Motorcycle spring suspension

To guarantee that the conveyor system can operate successfully, choosing the right suspension is important. The durability of the components exposed to extreme weather conditions like hot and rain as well as reasonably priced maintenance expenses are taken into consideration when choosing the suspension. Additionally, the chosen suspension must adhere to the established dimension requirements. There shouldn't be an excessively long or short suspension. This is necessary to ensure effective for trash collector.

1. Impact absorbing fenders

Figure 2.1 W Type Rubber Fenders and M Type Rubber Fenders

Figure 2.1 shows Impact-absorbing fenders that can be installed along the conveyor system to assist reduce the power of river currents and safeguard the building. Fenders composed of durable materials, such as rubber or foam, can serve as shock absorbers, minimising damage and acting as buffers. Two different types of absorbent fenders exist such as W Type Rubber Fenders and M Type Rubber Fenders. M and W Type Rubber Fenders and other rubber fenders efficiently flex to absorb impact energy. Based on the project's requirements as well as wave characteristics, structural design, and specifications, the ideal impact-absorbing fender should be selected. Professionals may ensure the strength and performance of the system by carefully selecting and designing fenders to limit wave-induced vibrations (Atiq et al., 2022).

However, it has a few disadvantages, such maintenance requirements. Impact-absorbing fenders may require regular maintenance, just like any other component, to keep working properly. The fenders may degrade or experience damage over time as a result of their constant exposure to impact forces. Inspections, repairs, and the replacement of worn-out fenders are maintenance procedures that need to be included into the overall maintenance schedule for the conveyor system.

2. Gas struts or gas spring

Figure 2.2 Gas struts or gas spring

The energy storage mechanism of a gas spring or gas struts works similarly to that of a mechanical coil spring. The cylinder, piston rod with piston head, seal, and guide are the four main components of a gas spring. Compressed nitrogen gas that has been pumped into the cylinder equally presses on both sides of the piston. There are 3 types of adjustable locking gas springs such as adjustable locking gas springs, tension and traction gas springs, and standard gas springs. Referring to Figure 2.2, advantage of gas struts or gas springs is controlled and smooth movement. During compression and extension, gas springs provide smooth and controlled action. Gas struts offer predictable and consistent force throughout the stroke, enabling precise control over the speed and motion of moving parts.

However, it also has disadvantages, such as the possibility of very little gas leakage in gas springs over time. This can cause the gas spring to break or cause the force output to progressively decrease (Professor, 2006). Regular maintenance and inspection might mitigate this issue.

3. Helical Isolators

Figure 2.3 Helical Isolators

Helical isolators as in Figure 2.3 are mechanical devices that decrease the transfer of shock and vibration between two surfaces or objects. They go by the names helical vibration isolators or helical spring isolators. They are designed to isolate and dampen vibrations, safeguarding sensitive equipment or buildings from harm and improving overall performance. Helical isolators are often placed in between the source of vibration and the intended target object or structure. Studs, bolts, or other suitable fixing methods can be used to secure them in place. Helical isolators are available in a variety of load capacities to accommodate a variety of applications. They are designed to support the weight of the equipment or structure while efficiently isolating vibrations.

However, it also has disadvantages, such as size and space requirements. There might be dimension and space requirements for helical isolators (Tyan et al., 2006). To effectively isolate vibrations from the surrounding buildings or components without causing interference, they must be fitted and sized correctly. Helical isolators may be difficult to incorporate into some applications due to limited space or design restrictions.

4. Air suspension (vehicle suspension)

Figure 2.4 Air suspension for vehicle

Pressurised air is used in an air suspension system for vehicles to support the weight of the vehicle and provide a smoother, more comfortable ride ss shown in Figure 2.4. It may commonly be seen in luxury vehicles, SUVs, and some trucks. In air suspension systems, air springs, also known as airbags or air bellows, are utilised in place of traditional coil springs or leaf springs. These pressurised air hoses are frequently constructed from synthetic materials or reinforced rubber. Air suspension is advantageous in conveyor systems because of its ability to absorb stress when loads are subjected to unexpected jolts or vibrations (Truong Ho Xuan, 2023). The danger of damage to the materials being supplied and the apparatus itself is reduced because to the air springs' ability to absorb shocks and vibrations.

However, it also has disadvantages, such as air leakage. Systems using air suspension might over time develop air leaks. The air springs may progressively lose air pressure as a result, which may reduce their ability to provide sufficient support and vibration isolation. To promptly locate and fix any air leakage issues, frequent maintenance and inspections are crucial.

5. Hydraulic suspension

Figure 2.5 Hydraulic suspension

Motorcycles frequently employ hydraulic suspension systems as shown in Figure 2.5 to offer controlled and smooth motion over irregular terrain. These systems uses hydraulic fluid and the structure of pistons, cylinders, and val The system's hydraulic fluid serves as a medium for the force transfers between the various parts. Hydraulic fluid is pumped via valves and tiny orifices as the suspension compresses, creating resistance and damping the action. This aids in regulating the suspension's rate of compression and extension, preventing excessive bouncing or bottoming out.

The applications of hydraulic suspension systems in trash collector conveyor suspension has certain potential disadvantages, including the risk of fluid leaks, even if in some cases they might be advantageous. Hydraulic fluid is necessary for hydraulic suspension systems to function. Fluid leaks may be more likely in a setting with frequent movement and vibration, like a trash collector. These leaks may cause a drop in fluid pressure, which would impair the suspension system's functionality (Wang et al., 2020). To stop or handle fluid leaks, routine inspection and maintenance are required.

6. MTB Air suspension (bicycle suspension)

Figure 2.6 Mountain Bike air suspension

A type of suspension part used in mountain bikes as shown in Figure 2.6 to give rear wheel suspension and also known as an air rear shock. Due to its flexibility, lightweight design, and responsive performance, it is a well-liked option for off-road riding. It is made up of an air canister, a damping system, and positive, negative, and chambers for air. The compressed air is kept in the air canister and is controlled to provide the suspension the right amount of sag and rigidity. The combined effect of the positive and negative air chambers produces a balanced and responsive suspension feel.

When considering it for trash collector conveyor suspension, there are a number of possible disadvantages including Maintenance complexity. To guarantee maximum operation, air shocks need routine maintenance. This include examining and regulating air pressure, doing maintenance on seals, and maybe conducting overhauls. Compared to other kinds of suspension systems, the intricacy of maintaining air shocks, with their numerous chambers and damping mechanisms, may be more involved and time-consuming (Janse Van Vuuren, 2021).

7. Motorcycle spring suspension

Figure 2.7 Motorcycle spring suspension

Figure 2.7 shows an example of suspension system used in motorcycle to offer shock absorption and enhance riding comfort is known as motorcycle spring suspension. The primary component for absorbing shocks and preserving tire-to-ground contact is made of metal coil springs. Coil springs are often positioned between the frame or fork and the wheel hub in a motorcycle spring suspension system. The springs compress and absorb the impact when the bicycle hits bumps, potholes, or uneven terrain, minimising the jolts and vibrations imparted to the rider. Control, traction, and the general ride quality are all benefited by this.

There are some disadvantages, such as Limited Adjustability, to take into consideration. The adjustability of spring suspension systems is often less than that of air or hydraulic suspension. It could just feature a few choices to adjust the suspension's properties, such sag or rebound damping, to suit their individual tastes or riding circumstances (Ratekkar et al., 2022).The following disadvantage is more weight. Due to the bulk of the metal coil springs, spring suspension systems are often heavier than air or hydraulic suspension systems. The agility, climbing capability, and general manoeuvrability of the bike may all be impacted by the extra weight.

2.2.2 Summary Type Of Devices Or Tools To Reduce Wave Vibration

Table 2.1 Summary Type Of Devices Or Tools To Reduce Wave Vibration

AUTHOR	Devices Or Tools	STRENGTH	WEAKNESS	COMMENT
(Atiq et al., 2022)	Impact absorbing fenders	Cost-Effective: Compared to some alternative materials, rubber fenders can be cost-effective both in terms of initial investment and ongoing maintenance.	Temperature Sensitivity: Rubber can be sensitive to extreme temperatures, which may affect its performance. In very hot conditions, it could soften, and in very cold conditions, it might become brittle.	Not suitable for conveyor
(Professor, 2006)	Gas struts or gas spring	Adjustability: Gas struts offer adjustability in terms of force and damping, allowing for customization based on the specific requirements of the conveyor and the intensity of the waves.	Potential for Leakage: Over time, gas struts may experience leakage issues, affecting their performance. Regular maintenance and inspection are necessary to identify and address any leaks promptly.	Not suitable for conveyor

(Tyan et al., 2006)	Helical Isolators	Temperature Stability: Helical isolators are generally not sensitive to temperature variations, maintaining their performance across a range of environmental conditions.	Space Requirements: Helical isolators may require more space compared to some compact solutions, potentially posing challenges in constrained environments.	Suitable for conveyor but need to find large and perfet size of helical isolator.
(Truong Ho Xuan, 2023)	Air suspension (vehicle suspension)	Variable Load Capacity: Air suspension systems can adjust to varying loads, providing flexibility in handling different material loads on the conveyor.	Potential for Leaks: Air suspension systems are vulnerable to air leaks, which can affect performance. Regular inspections and maintenance are crucial to address potential leaks promptly.	Not suitable for conveyor

(Wang et al., 2020)	Hydraulic suspension	Adjustability: Many motorcycle hydraulic suspensions offer adjustability, allowing for customization based on the specific load requirements and environmental conditions of the conveyor system.	Maintenance Challenges: Maintenance of hydraulic systems can be more complex compared to some other suspension types. Regular checks and potential fluid leaks should be addressed promptly.	Suitable for conveyor
(Janse Van Vuuren, 2021)	Air suspension (bicycle suspension)	Adjustability: Many bicycle air suspension systems offer adjustability, allowing for customization based on the specific load requirements and environmental conditions of the conveyor system.	Maintenance Challenges: Maintenance of air suspension systems can be more complex compared to some other suspension types. Regular checks for air leaks and potential issues are necessary.	Not suitable for conveyor

(Ratekkar et al., 2022)	Motorcycle spring suspension	Simplicity: Motorcycle spring suspension systems are relatively simple in design, which can make them easier to install and maintain compared to more complex systems	Fixed Stiffness: Springs typically have fixed stiffness, limiting their ability to adapt to varying loads or environmental conditions. This lack of adjustability may impact their performance in specific situations.	Suitable for conveyor

The comparison in Table 2.1 indicates devices or tools that incorporate springs or coils may be more suitable for conveyor systems aiming to absorb the waves from the Melaka River compared to those using hydraulic and air systems. Springs and coils offer simplicity, cost-effectiveness, and a compact design. They are effective in shock absorption and are relatively easy to install and maintain. However, it's essential to consider their limited load capacity, fixed stiffness, and potential vibration transmission. In environments with moderate loads and straightforward requirements, spring-based systems may provide a practical and budget-friendly solution. Nevertheless, for more complex applications or heavier loads, hydraulic or air suspension systems may offer greater adjustability and shock absorption capabilities, despite being more complex and costly. The choice between these options should be based on a careful evaluation of the specific needs and conditions of the conveyor system along the Melaka River.

2.3 Water Drag Force

Water drag force, also known as hydrodynamic drag or fluid resistance, refers to the resistance experienced by an object moving through a fluid, such as water. The motion of an object through water is opposed by the force exerted by water molecules in its path. The magnitude of the drag force, which depends on factors such as the object's shape, size, speed, and the properties of the fluid, is commonly known as the drag force. The interaction between the object and the water molecules causes the drag force. Water is displaced and disturbances are created in the fluid flow as the object moves. The formation of vortices and turbulent flow patterns around the object due to these disturbances generates a resistance force that opposes the motion.

In conclusion, a trash conveyor operating in a river setting may experience a number of major consequences due to the drag force generated by waves. The requirement for particular design considerations is one of these impacts, along with greater resistance, potential belt slippage or misalignment, influence on the effectiveness of waste collection, and increased wear and strain on conveyor components.

The conveyor may encounter more overall difficulty to overcome during operation due to the waves' varying drag forces. This variation can also cause belt slippage or misalignment, decreasing the conveyor's effectiveness and perhaps resulting in operational problems. Waves' erratic movement of rubbish can interfere with collection efforts, lower collection rates, and perhaps let waste escape or gather in certain places.

2.3.1 Drag Force And Wave From Diference Dimension Of Boat

In the study by (Prabowo et al., 2022) a boat going forward on the water will exert force in the ship's opposing direction. The purpose of this study is to study the amount of resistance produced by boats. This experiment is done with different types of boats such as dimension and deadrise angles.

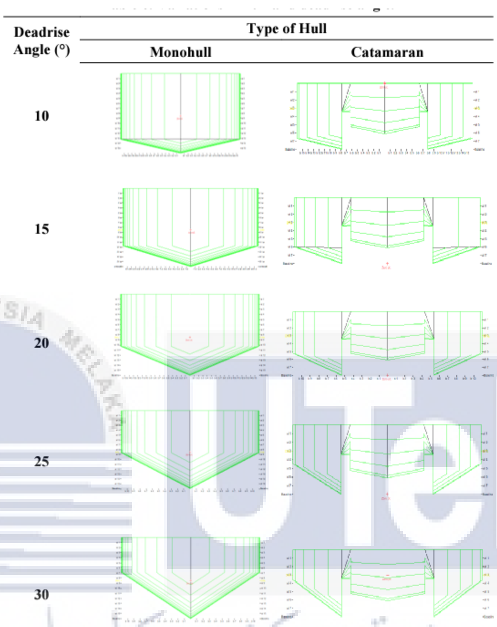


Figure 2.8 Type Of Hull

In accordance with the idea of the Savitsky mathematical model, the design was carried out by using numerical computation and analytical approach. In the preceding part, it was detailed how the design parameters were selected using real ship comparisons. Following a comparison of the real boats, Figure 2.8 show type of planing monohulls and type of planing catamarans with diference deadrise angles and diference specifics of the dimension characteristics. The speed also diference range from 5 to 30 knots was the controlled variable.

The hull resistance is made up of three forces: frictional force from tangential force, pressure force from viscous force, and wave force from normal force. The semi-empirical Savitsky technique, which was created based on experiments using a prismatic planing hull, may be used to the planing hull. Ship resistance as a result As a result of the arrangement of the deadrise angle, the value of the hull altered. The deadrise angle design also had an impact on the wave pattern through the hull. When the Froude number was low, there were waves along the body of the ship. When the ship had a significant deadrise angle, the waves that formed around it were smoother.

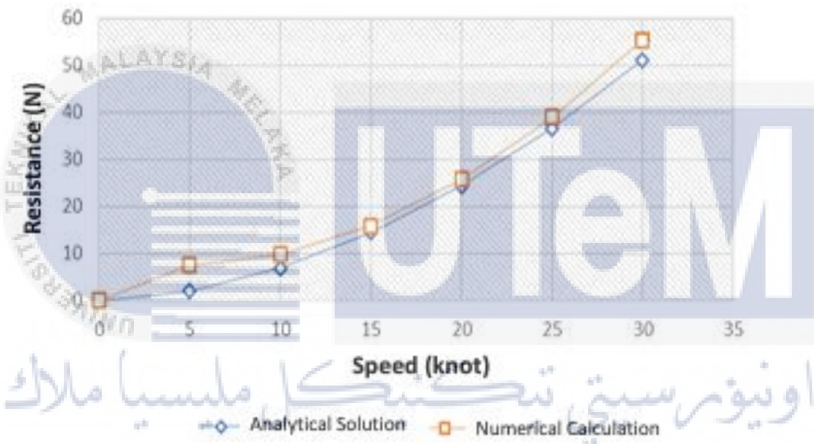


Figure 2.9 Deadrise Angle for 10° For Monohull Boat Type

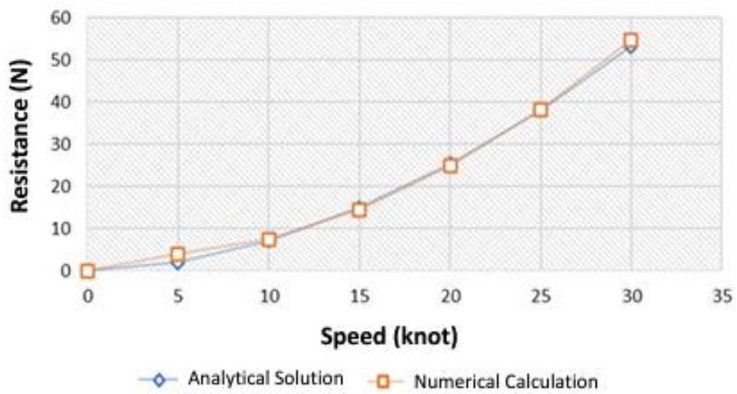


Figure 2.10 Deadrise Angle for 30° For Monohull Boat Type

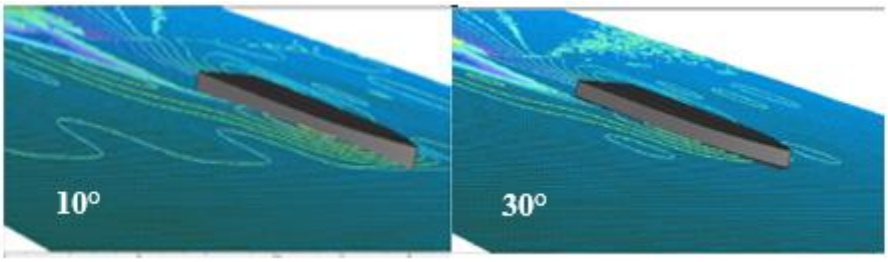


Figure 2.11 Wave Pattern From Monohull With Diference Angle

From the Figure 2.9, Figure 2.10 and Figure 2.11 , a conclusion can be made that resistance and drag force will increase if the deadrise angle gets smaller at boat speeds of 5 and 10 knots. A small deadrise angle will produce stronger waves and more wave pattern.

The results of this literature review can help obtain data, especially the amount of force or drag force produced by boats with different dimensions of the size of the boat. This data will be used to calculate the total force or drag force produced by the Melaka River Cruise Ship as demonstrated in Figure 2.12.

Figure 2.12 Wave Produced by The Melaka Cruise River

2.3.2 Wave Force and Drag Force Analysis

A systematic and structured approach is involved in researching wave analysis, which aims to investigate and comprehend the behavior, characteristics, and applications of waves in various fields. According to a research (Putri et al., 2023), numerical techniques based on CFD may be used to provide predictions about the size of ship drag in calm water with typical waves.

Table 2.2 Drag Force On CFD Calm Water

Fr	Drag Force [kN]
	CFD Calm Water
0.12	1.001
0.24	4.498
0.36	12.361
0.48	25.674
0.60	33.572
0.72	38.978

Froude number (Fr) dimensionless quantity used to indicate the influence of gravity on fluid motion.

The Table 2.2 shows CFD calculation types of Froude number (Fr) with different times. These waves are generated by ships passing over calm water. This data shows that different waves Fr will produce different drag force. Increasing the value of Fr will further increase the value of the drag force produced by the waves. The data, show that as the Froude number (Fr) increases, the drag force also increases. This indicates a positive relationship between the Froude number and the drag force.

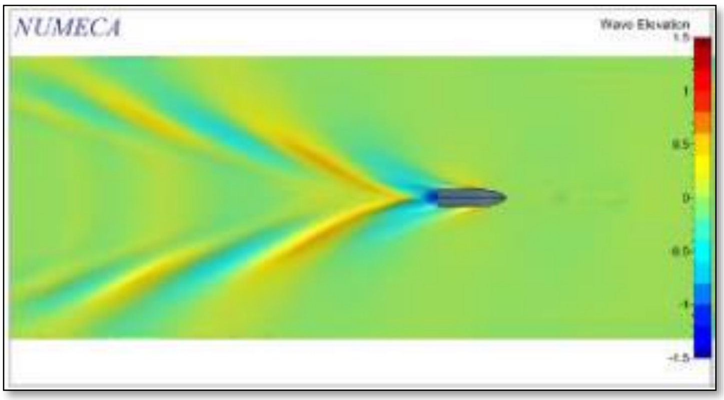


Figure 2.13 Calm Water Fr – 0.60

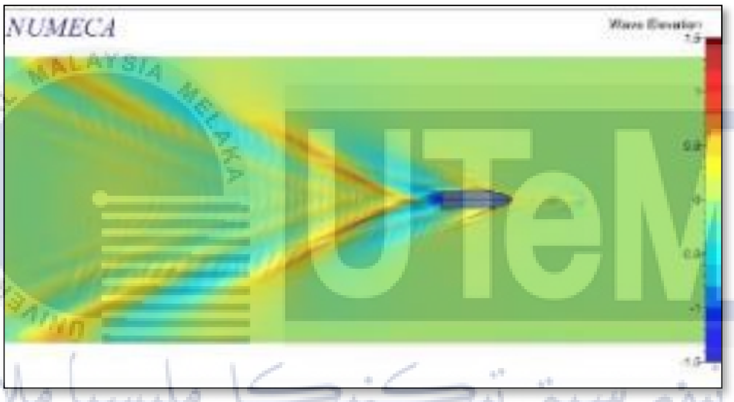


Figure 2.14 Calm Water Fr – 0.72

The waves created as a boat passes over water are clearly shown in the Figure 2.13 and Figure 2.14 above. It is important to notice that an increase in the Froude number (Fr) will have a substantial influence on the wave's morphology, leading it to strengthen and exhibit a more prominent pattern.

2.3.3 Summary For Wave Analysis

The analysis focuses on the drag force experienced by ships passing over calm water, specifically examining the relationship between the Froude number (Fr) and drag force in kilonewtons (kN). The provided table presents six data points, each corresponding to a different Froude number and its associated drag force. Notably, the results indicate a clear positive correlation between the Froude number and drag force. As the Froude number increases from 0.12 to 0.72, the drag force experienced by the waves generated by passing ships also increases, ranging from 1.001 kN to 38.978 kN. This observation underscores the significance of the Froude number in influencing the drag force, providing valuable insights for further analysis and applications, such as the utilization of this data in the design of suspension systems using Inventor Software.

The data's relevance to Inventor Software is highlighted, suggesting its application in the analysis of suspension system designs. Presumably, the drag force values obtained from the CFD calculations will be employed as input parameters in the software to enhance the understanding of how different Froude numbers impact the suspension system's performance. This integration of CFD data into Inventor Software allows for a comprehensive examination of the suspension system design, taking into the dynamic forces exerted by waves under varying Froude numbers. Overall, the analysis not only establishes a connection between Froude number and drag force but also emphasizes the practical implications of this relationship in engineering applications.

CHAPTER 3

CONCEPTUAL DESIGN

3.1 Introduction

A flowchart as in Figure 3.1 was used to demonstrate the study's methodology. A systematic approach is introduced by this methodology for designing and developing a shock absorption or suspension system for a trash collector conveyor. This approach is specifically tailored to mitigate the impact of wave-induced forces in the context of the Melaka River. To effectively collect trash along the river and operate under varying wave conditions, the conveyor system's performance and durability must be enhanced. During this chapter, various designs for the shock absorption or suspension system are brainstormed and created.

The most promising design concepts for further development and prototyping using Inventor software are identified through a systematic concept selection process. The specific components, materials, and manufacturing processes required for the selected concept are taken into account when creating detailed engineering drawings and specifications. During this stage, the consideration of integration with the current conveyor system for trash collector is also taken.

The design and development of a shock absorption or suspension system for a trash collector conveyor against wave-induced forces in the Melaka River can be approached systematically and comprehensively by following this methodology, resulting in an effective solution that improves the performance and longevity of the conveyor system in mitigating wave impacts.

3.2 Project Planning

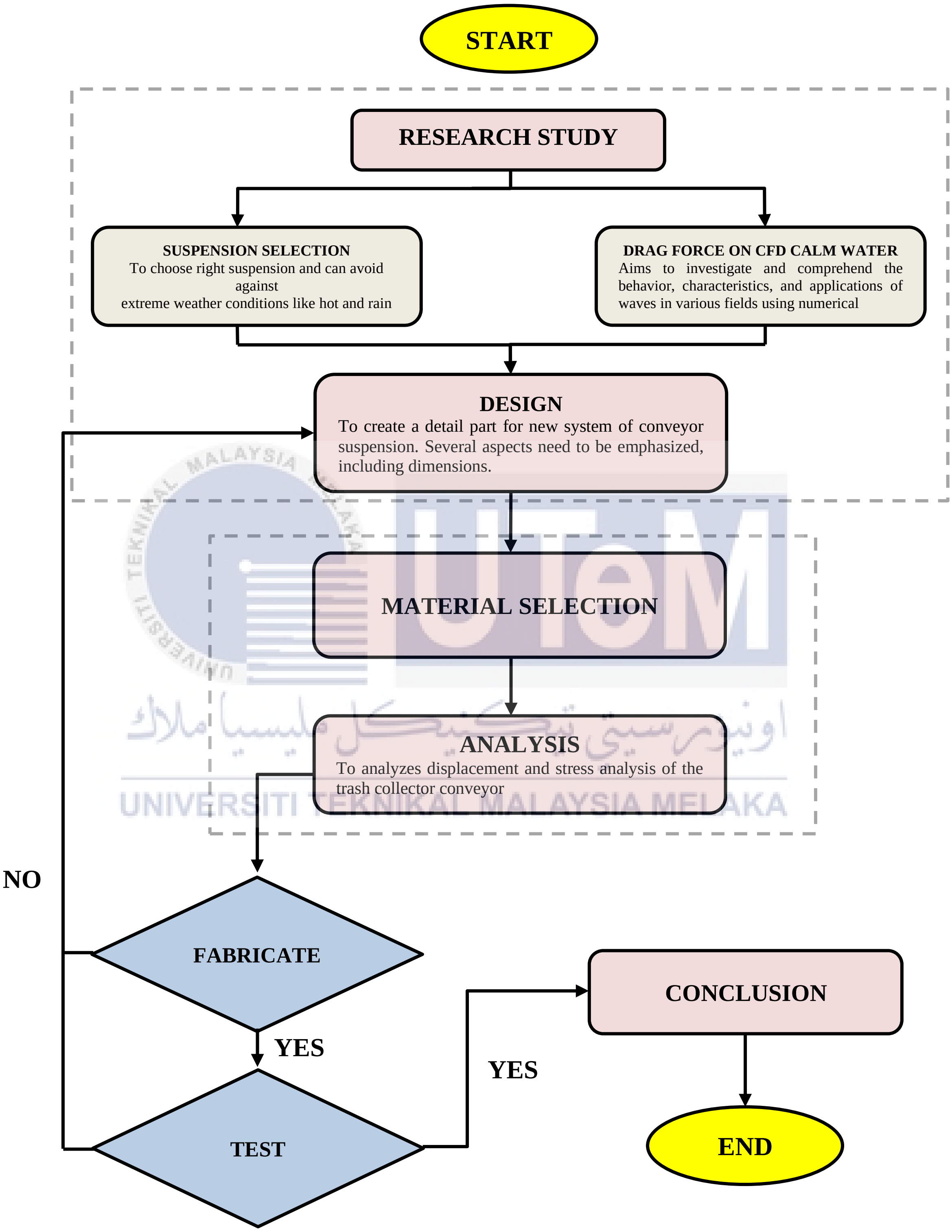


Figure 3.1 Project Planning Flow Chart

3.3 Benchmarking

3.3.1 Benchmarking Of Current Trash Collector Conveyor

There are several trash collector conveyor systems that may be found worldwide, according to benchmarks. It may be used in a variety of ways and can be cleaned in various environments, such as the sea or a river. This benchmark examines to see if there is a suspension mechanism on the conveyor of the trash collecting conveyor system that is readily accessible worldwide and the design for suspension system. The Interceptor 004 by The Ocean Cleanup, the Versi-Cat Trash Skimmer Boat by Water Witch, the Drone Wasteshark Removes Plastic Waste And Biomass, and the 4Ocean Harbour Skimmer are just a few examples of trash collector that have been benchmarked.

Large corporations from countries like the United States and the Netherlands are among those whose waste collection services have been mentioned. These big businesses are crucial in preventing the contaminating effects of human waste on the earth's ecology. Two forms of trash collector are present in this benchmark: the suction type (which is without a conveyor) and the conveyor type. Interceptor 004 by The Ocean Cleanup, Version-Cat garbage Skimmer Boat by Water Witch, and 4Ocean Harbour Skimmer are three conveyor-style trash collectors which possess a lot of characteristics and similarities with one another. Conveyor belts, electric motors, garbage cans, and solar energy are a few of them. These characteristics are available by the UTEM-designed trash collector system that will be used to remove waste from the Melaka River.

Table 3.1 Benchmark Mr. Trash Wheel

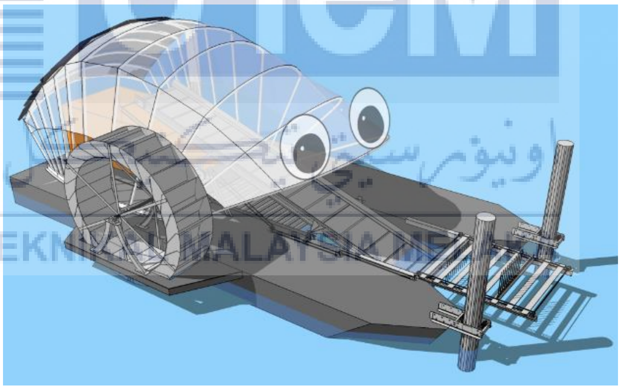
Product Name	**Mr. Trash Wheel, Officially Called The Inner Harbor Water Wheel**
Country	United States
Year Launch	Launched In May 2014
Garbage Capacity	19 Tons of Garbage
River / Sea	River
Relate To Suspension System	No
Powered by	Solar Power
Similarity Difference	• Similarity : Conveyor Belt , Trash Collection Compartment , Solar Panels • Difference : Solar Panels , Water Wheel , Skimmer Arms
Picture	 

Table 3.2 Benchmark Interceptor 004

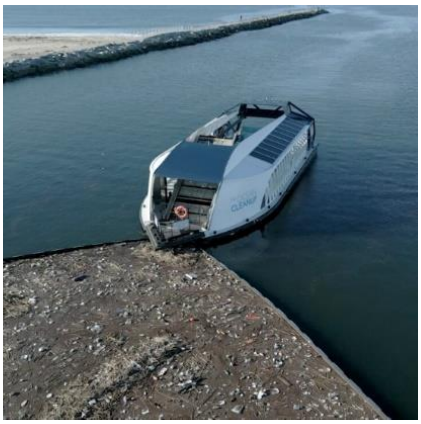
Product Name	**Interceptor 004 by The Ocean Cleanup**
Country	Netherlands
Year Launch	Launched In October 2019
Garbage Capacity	Capable of collecting up to 100,000 kg
River / Sea	River and Sea
Relate To Suspension System	No
Powered by	Solar Power
Similarity Difference	• Similarity : Conveyor Belt , Electric Motors , Collection Bins • Difference : Sensors and Cameras , The Ocean Cleanup
Picture	 

Table 3.3 Benchmark Versi-Cat Trash Skimmer Boat

Product Name	**Versi-Cat Trash Skimmer Boat by Water Witch**
Country	United States
Year Launch	Launched In 2020
Garbage Capacity	1 Tons of Garbage
River / Sea	River and Sea
Relate To Suspension System	No
Powered by	Diesel Or Gasoline-Powered Motor
Similarity **Difference**	• Similarity : Conveyor Belt • Difference : The hydraulic system , diesel or gasoline
Picture	 

Table 3.4 Benchmark Drone Wasteshark

Product Name	**Drone Wasteshark Removes Plastic Waste And Biomass**
Country	United States
Year Launch	Launched In 2020
Garbage Capacity	500 kilos of debris per day
River / Sea	River
Relate To Suspension System	No
Powered by	Rechargeable Batteries and Solar Power
Similarity **Difference**	• Similarity : Conveyor Belt , Electric propulsion , Waste Disposal • Difference : Sensors and Navigation
Picture	 

Table 3.5 Benchmark 4Ocean Harbor Skimmer

Product Name	**4Ocean Harbor Skimmer**
Country	United States
Year Launch	Launched In 2019
Garbage Capacity	2.5 cubic yards of debris
River / Sea	River and Sea
Relate To Suspension System	No
Powered by	Rechargeable Batteries and electric motor
Similarity Difference	• Similarity : Conveyor Belt , Electric motor • Difference : Collection bin (limited to 2.5 cubic yards of debris)
Picture	 

3.3.2 Benchmarking Of Current Conveyer Belt System On Water

To study several types of conveyor belts, especially those that are widely used in river, sea, lake or water areas. The purpose of this study is to study the mechanism on this conveyor belt and to ensure whether the conveyor uses a suspension system or not.

Table 3.6 Benchmark Current Conveyer Belt System On Water

1. Aquatic weed conveyor 	A specialised kind of conveyor belt called a "aquatic weed conveyor" is used to remove and control aquatic weeds in bodies of water. These conveyors are especially made to deal with the difficulties of taking care of invasive aquatic plants including water hyacinth, water lettuce, and algae.
2. The kayaks conveyor 	An S.50-608 plastic modular conveyor belt with a particular pattern for water sports has been developed with high friction grip. When the trip is over, the kayaks, rubber boats, etc. will be hoisted out of the water.

3. Goal mining conveyor

Goal mining conveyor is widely used by gold mining companies. The conveyor belt of this machine works to transport sand or soil that has been excavated in rivers or gold mining sites.

Summary Benchmark

Table 3.1, Table 3.2, Table 3.3, Table 3.4, Table 3.5, and Table 3.6 was discovered that none of the boat conveyors on this trash collector have a suspension system based on all comparisons to the current trash collector conveyor and current conveyor belt system on water. The body of the trash collector and conveyor, which is bigger and more sturdy than the ship's body, is also particularly built to handle waves. On this benchmark table, a trash collector and conveyor are normally made to be straightforward and affordable. The conveyor system's complexity, manufacturing costs, and maintenance needs could all rise if suspension is included. It's important to remember that these arguments are hypothetical and predicated on broader engineering issues. The actual design choices for certain trash collectors at sea or river may differ based on a range of elements, including the intended use, the resources at hand, and recent technical developments.

3.4 Conceptual Sketches

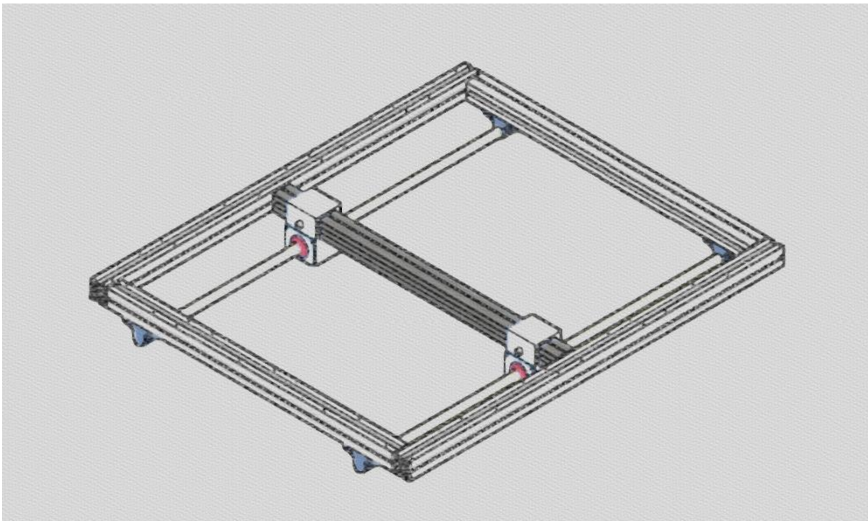
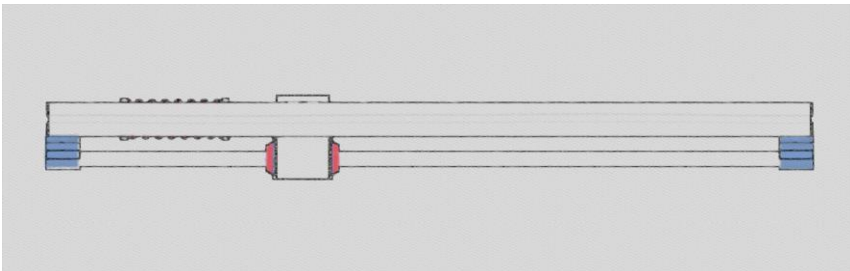
In the realm of waste management, the development of an efficient and robust shock-absorbing or suspension system for trash collector conveyors is very important. This conceptual exploration delves into two distinct designs, Suspension System 2099 A as shown in Table 3.7 and Suspension System 2099 B in Table 3.8, each offering unique attributes to enhance the overall performance of the waste collection process.

Suspension System 2099 A incorporates a configuration featuring small rail supports, strategically positioned slightly lower than its counterpart, Suspension System 2099 B. The innovation lies in the parallel alignment of the shock absorber and beam, contributing to a harmonized system that effectively mitigates the impact of shocks and vibrations, ensuring a smoother operation.

On the other hand, Suspension System 2099 B adopts a design characterized by substantial rail supports, instilling a heightened sense of stability to the suspension system. The pivotal element in this concept is the introduction of a more flexible beam supporting the conveyor. This structural flexibility is engineered to adapt and absorb shocks with greater efficiency, thereby optimizing the overall performance and longevity of the trash collector conveyor. These two conceptual sketches represent pioneering approaches to the design and development of a shock-absorbing or suspension system, each offering a distinctive solution to address the challenges inherent in waste and trash collector conveyors.

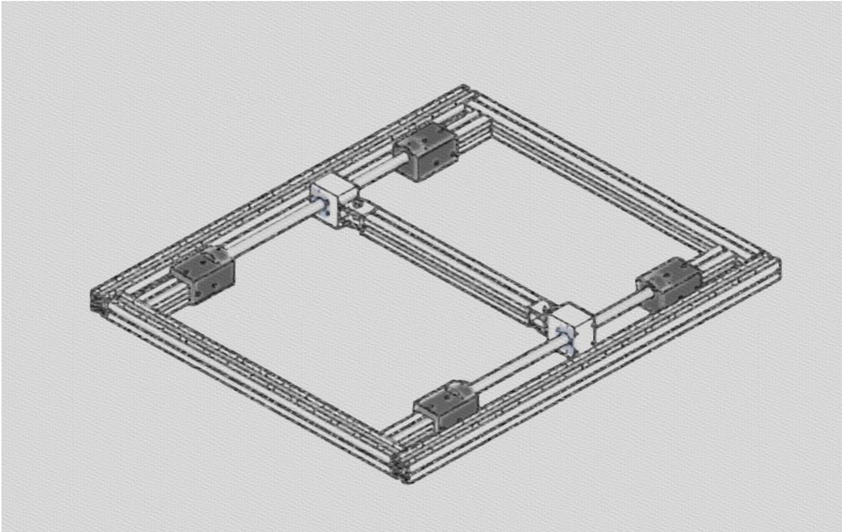
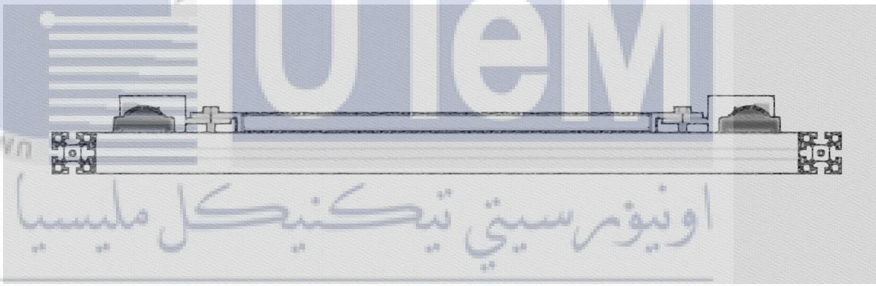
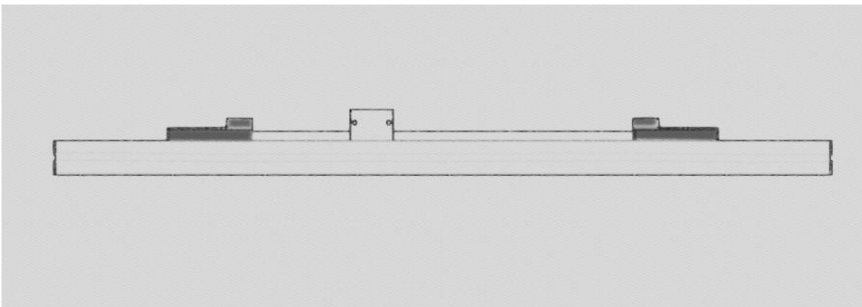
3.4.1 Conceptual Sketches Suspension System 2099 A

Table 3.7 Conceptual Sketches Suspension System 2099 A

Conceptual Sketch For Suspension System 2099 A	
Front View Conceptual Sketch For Suspension System 2099 A	
Side View Conceptual Sketch For Suspension System 2099 A	

3.4.2 Conceptual Sketches Suspension System 2099 B

Table 3.8 Conceptual Sketches Suspension System 2099 B

Conceptual Sketch For Suspension System 2099 B	
Front View Conceptual Sketch For Suspension System 2099 B	
Side View Conceptual Sketch For Suspension System 2099 B	

3.4.3 Conceptual Design Body Frame 616

Table 3.9 Conceptual Design Body Frame 616

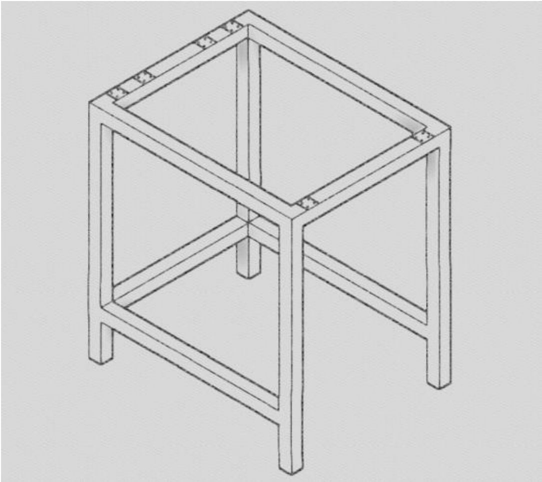
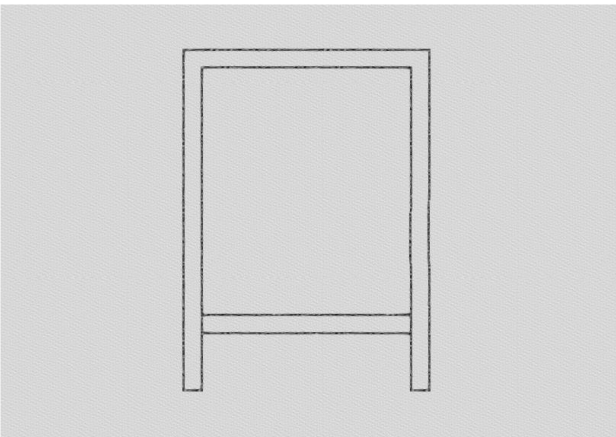
Conceptual Sketch Body Frame 616	
Front View Conceptual Sketch For Body Frame 616	
Side View Conceptual Sketch For Body Frame 616	

Table 3.10 Conceptual Design Body Frame 064

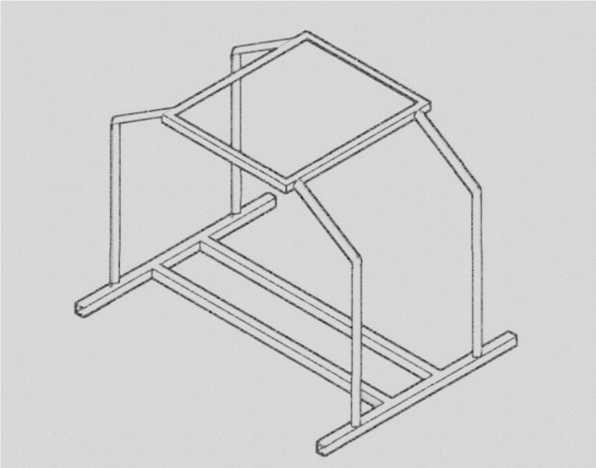
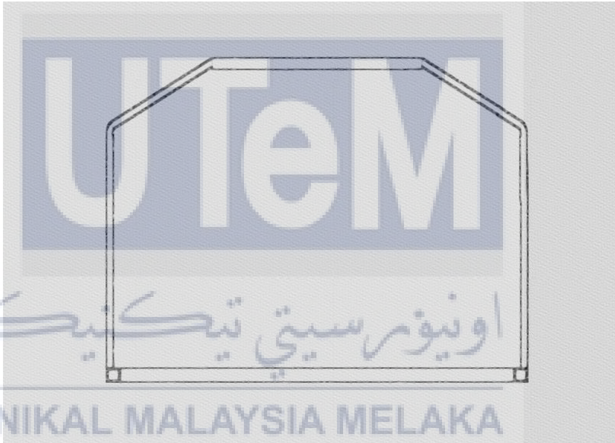
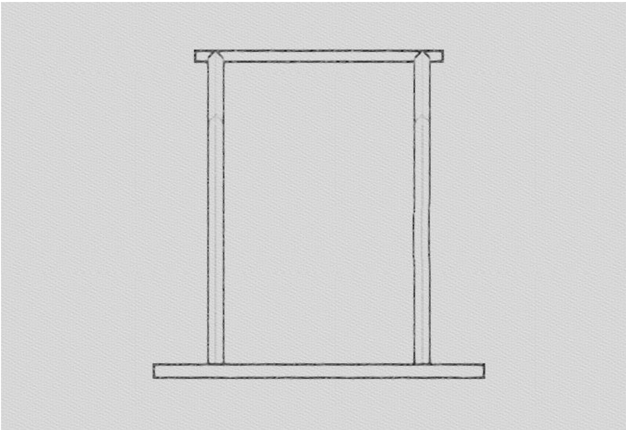
Conceptual Sketch Body Frame 064	
Front View Conceptual Sketch For Body Frame 064	
Side View Conceptual Sketch For Body Frame 064	

Table 3.9 and Table 3.10 illustrates two distinct body frame concepts, 616 and 064, cater to diverse operational needs within the waste management landscape. The selection between these body frames will depend on factors such as space constraints, capacity requirements, and the specific environmental challenges faced by the waste or trash collector conveyor.

In the subsequent phases of this project, both the suspension system designs and the body frames will be subjected to rigorous analysis and evaluation. The integration of Inventor software tools will facilitate a comprehensive examination of structural integrity, load-bearing capacity, and overall performance. Through this meticulous approach, the goal is to select the most suitable combination of suspension system and body frame to ensure the optimal functionality and longevity of trash collector conveyors in real-world applications.

CHAPTER 4
DETAIL DESIGN AND MECHANISM

4.1 3D Assembly For Body Frame

In the dynamic realm of waste management and environmental sustainability, the development of a trash collector conveyor is a crucial endeavor. A fundamental aspect influencing the performance and longevity of such systems is the integration of a robust shock-absorbing or suspension system. As part of this comprehensive exploration, there are two distinctive conceptual sketches, each featuring a unique body frame designed to optimize the performance of the suspension system for trash collector conveyors.

4.1.1 3D Assembly For Body Frame 616

Dimensions: Long 870 mm, Width 685.8 mm, Height 950 mm

Figure 4.1 3D Assembly For Body Frame 616

As shown in Figure 4.1, body frame 616 specification is characterized by its compact design. The emphasis on reduced length and width makes it an ideal choice for applications where space optimization is paramount. The moderate height ensures a balanced center of gravity, contributing to the stability of the overall conveyor system. The Body Frame 616 concept aims to provide an efficient suspension solution without compromising on structural integrity.

4.1.2 3D Assembly For Body Frame 064

Dimensions: Long 1219.2 mm, Width 1574.8 mm, Height 1210 mm

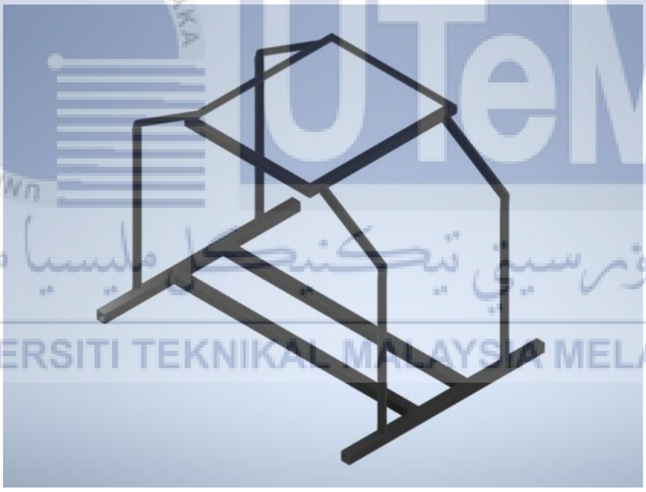


Figure 4.2 3D Assembly For Body Frame 064

In Figure 4.2, it is evident that body frame 064 boasts larger dimensions, offering increased length, width, and height. This configuration is tailored for scenarios where a more extensive conveyor system is required. The elongated length and width provide additional space for trash collector, while the greater height accommodates a larger shock-absorbing or suspension system. Body Frame 064 is designed to cater to applications demanding a higher capacity for trash collector and a robust suspension solution.

4.2 3D Assembly For Suspension System

The Suspension System 3D Assembly represents a critical facet in the meticulous design and development of the waste or trash collector conveyor system. Leveraging the advanced capabilities of Autodesk Inventor software, this segment focuses on the intricate interplay and integration of components within the suspension system. The primary objective is to achieve a seamlessly functioning assembly that effectively dampens shocks and vibrations, ensuring optimal performance in the challenging operational environment. Through the lens of 3D assembly modeling, this chapter unfolds the intricacies of the suspension system, offering a comprehensive understanding of its structural coherence and functional synergy.

4.2.1 3D Assembly For Suspension System 2099 A

Suspension System 2099 A, Figure 4.3 introduces a thoughtfully design aimed at enhancing the shock-absorbing capabilities of trash collector conveyors. This system is characterized by several key features that collectively contribute to its functionality and efficiency The system incorporates small rail supports that serve as the foundation for the suspension mechanism. These supports are strategically positioned to provide stability to the conveyor while ensuring a degree of flexibility to absorb shocks and vibrations effectively.

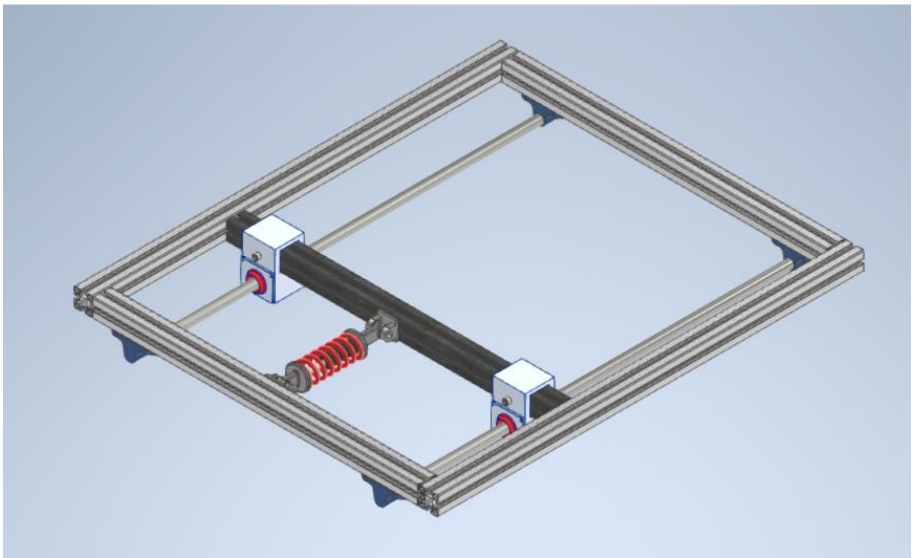


Figure 4.3 3D Assembly For Suspension System 2099 A

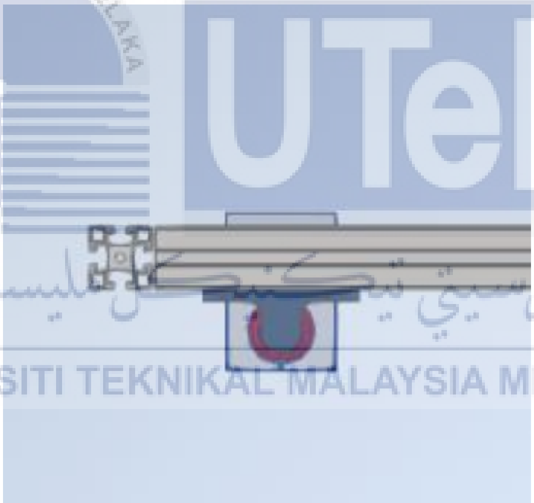


Figure 4.4 Front View 3D Assembly For Suspension System 2099 A

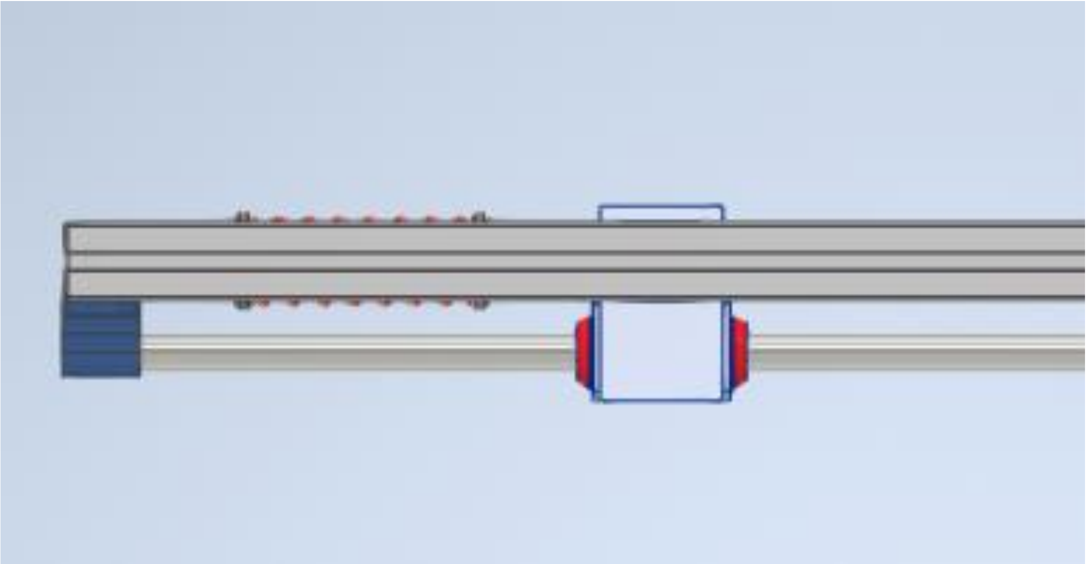


Figure 4.5 Side View 3D Assembly For Suspension System 2099 A

From the Figure 4.4 and Figure 4.5, there are some features of Suspension System 2099 A is the positioning of the rail slightly lower than its counterpart, Suspension System 2099 B. This lower placement is a deliberate design choice, intended to optimize the center of gravity and improve the overall balance of the conveyor system. In this design, the shock absorber and beam are arranged in parallel. This configuration ensures that the shock-absorbing elements work cohesively with the structural support provided by the beam. This parallel alignment aims to evenly distribute and dissipate forces generated during the operation of the trash collector conveyor.

The parallel arrangement of the shock absorber and beam contributes to the harmonized operation of the suspension system. By aligning these components in a coordinated manner, the system can effectively absorb and dampen shocks and vibrations, leading to a smoother and more controlled conveyance of trash. Suspension System 2099 A is designed to be adaptable to varying conditions and loads.

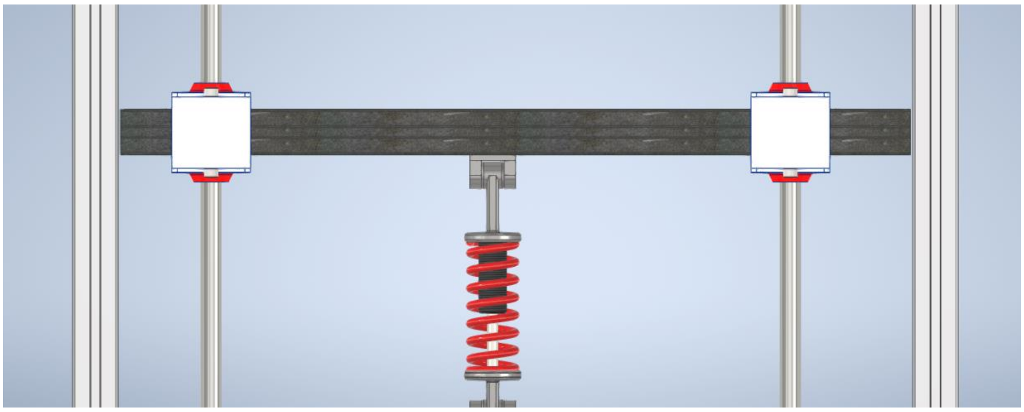


Figure 4.6 Solid Steel Beam

From the Figure 4.6, the Suspension System 2099 A also using solid steel material on beam. This solid steel beam can help accommodate the load of the conveyor support that will be installed as well as the wave force from the Melaka River. The solid steel material on beam also absorbs wave force energy very well without bending and breaking.

In summary, Suspension System 2099 A is a well-conceived conceptual sketch that prioritizes balance, adaptability, and coordinated shock absorption. By incorporating small rail supports, adjusting their position, and ensuring a parallel alignment of critical components, this suspension system aims to set new standards in the development of trash collector conveyors. The focus on efficiency and resilience positions Suspension System 2099 A as a promising solution in the evolving landscape of waste management technology.

4.2.2 3D Assembly For Suspension System 2099 B

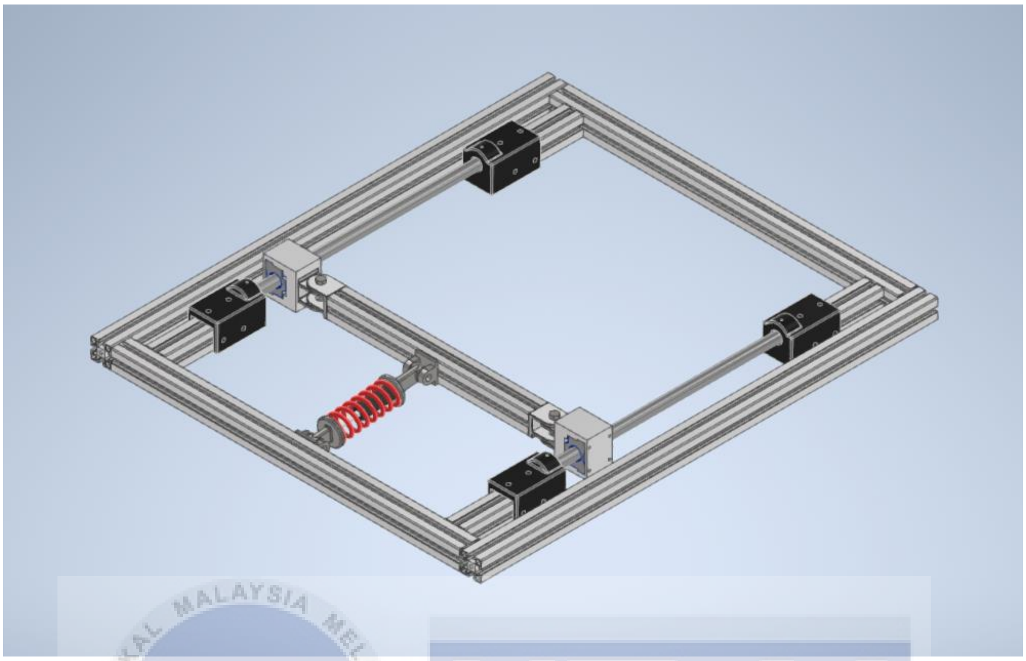


Figure 4.7 3D Assembly For Suspension System 2099 B

Suspension System 2099 B in Figure 4.7 have a difference design than suspension System A. Suspension System 2099 B uses larger rail elements to improve the suspension system's overall stability. The increased size of the rails contributes to a robust foundation, providing a secure platform for the trash collector conveyor. The stable suspension design is particularly advantageous in scenarios where the conveyor is subjected to heavy loads or operates in challenging environments.

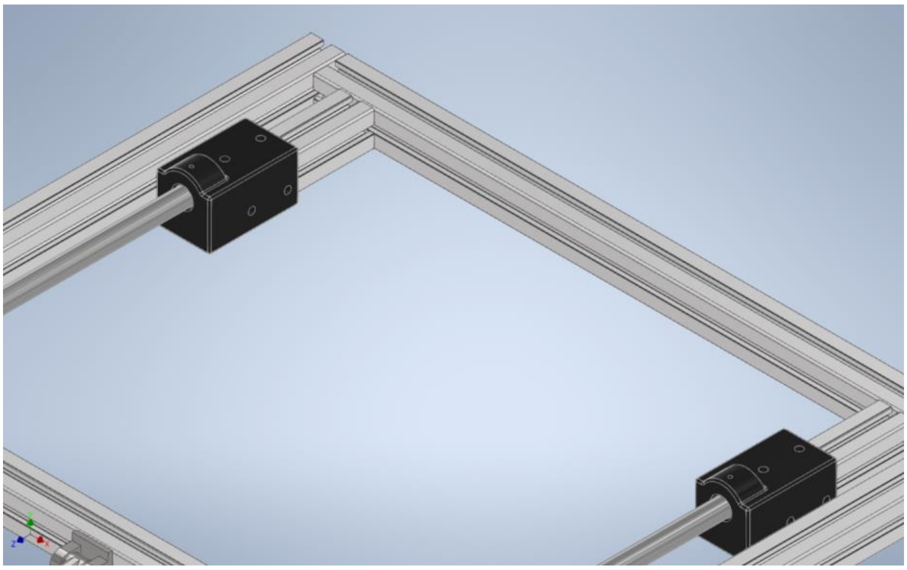


Figure 4.8 Large rail Support Suspension System 2099 B

Figure 4.9 Large Rail Support From Top View

The emphasis on big or large rail (Figure 4.8 and Figure 4.9) supports aligns with the overarching goal of creating a more stable suspension system. This design choice is intended to minimize lateral movements and vibrations, offering a heightened level of stability during the operation of the conveyor.

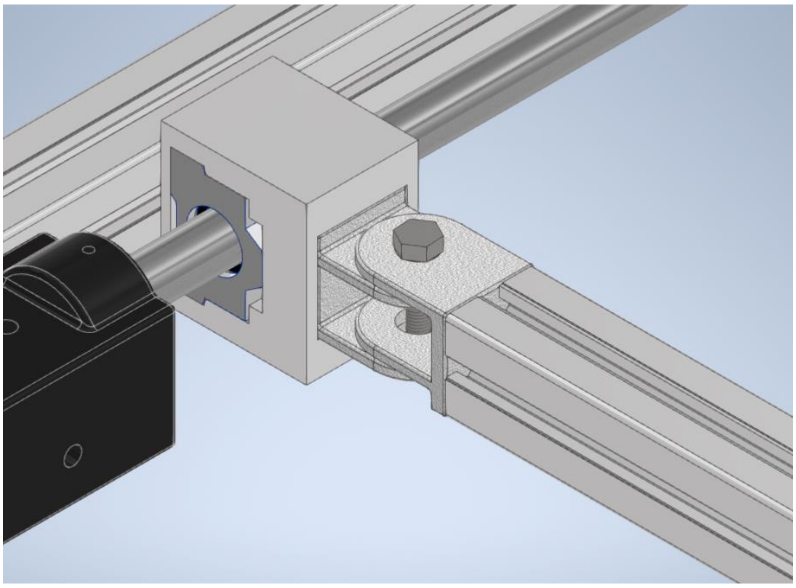


Figure 4.10 Flexible Beam Support

Figure 4.10 illustrates notable feature of Suspension System 2099 B is the incorporation of a flexible beam to support the conveyor. This beam is design to offer a degree of flexibility, allowing it to absorb and distribute shocks more effectively. The flexibility of the beam is a key component in the system's ability to adapt to dynamic conditions and varying loads, contributing to overall resilience.

The flexible aluminium beam adds a layer of structural flexibility to the system. The structural flexibility is designed to optimize the performance of the trash collector conveyor by reducing the impact of shocks and vibrations on the system. Suspension System 2099 B is engineered with a focus on optimizing shock absorption capabilities. The combination of big rail supports and a flexible aluminium beam creates a system that effectively absorbs and dissipates shocks, minimizing the transfer of impact forces to the conveyor components. This optimization is crucial for extending the lifespan of the conveyor and reducing maintenance requirements.

4.3 3D Assembly For Conveyor

Figure 4.11 illustrates 3D assembly for the Conveyor, crafted through Inventor software, serves a vital role in efficiently managing waste by transporting it from the river into a garbage container. Powered by a motor, the conveyor functions by moving a chain, propelling the conveyor to turn and facilitate the seamless transfer of garbage. Notably, the conveyor base is constructed from durable plastic, ensuring a robust foundation for the waste management process. This user-friendly and eco-conscious design highlights the simplicity and effectiveness of the solution in addressing environmental challenges through innovative and accessible means.

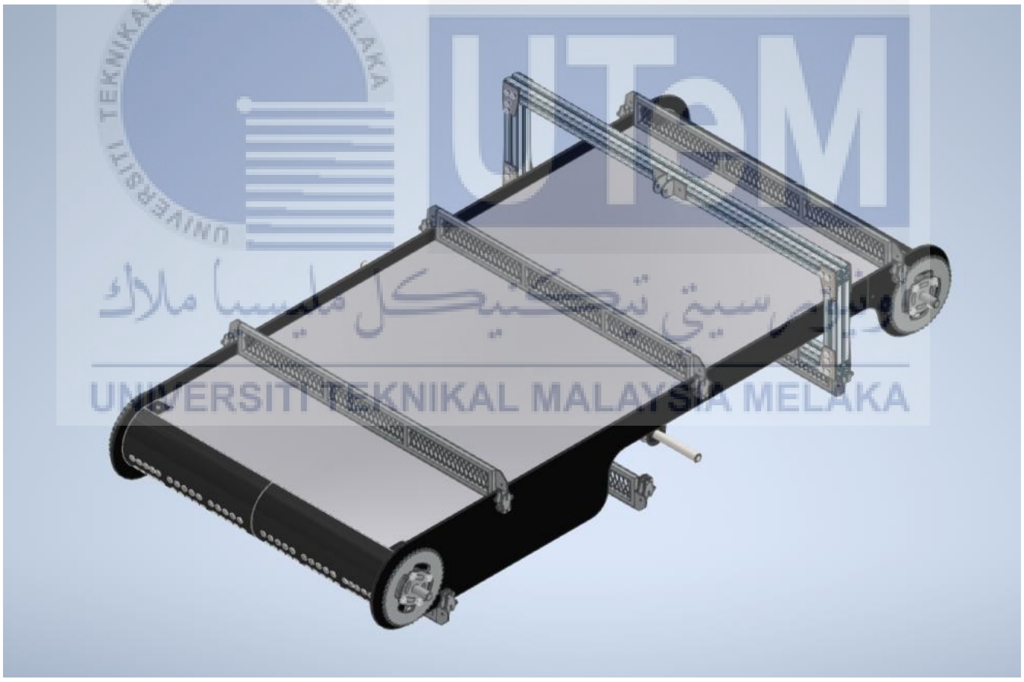


Figure 4.11 3D Assembly For Conveyor

4.4 Suspension System 2099 A Mechanism

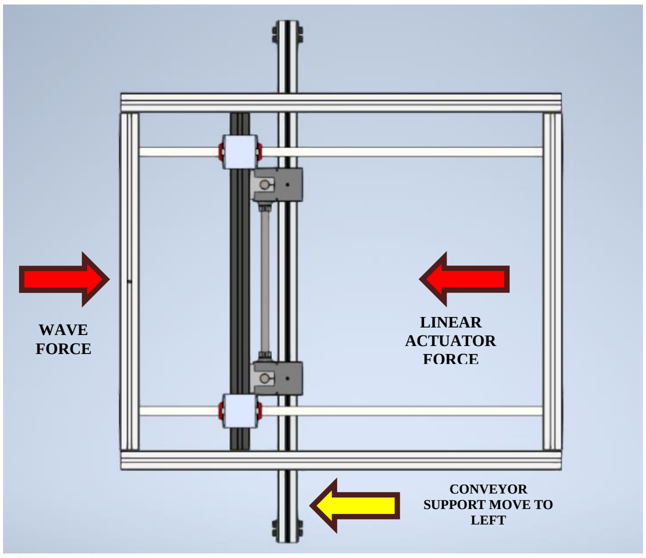


Figure 4.12 Top View Suspension System 2099 A Mechanism (Before)

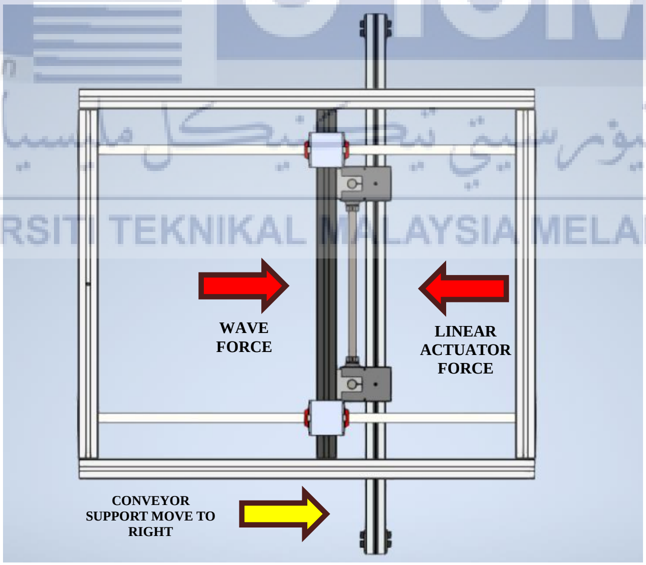


Figure 4.13 Top View Suspension System 2099 A Mechanism (After)

4.5 Suspension System 2099 B Mechanism

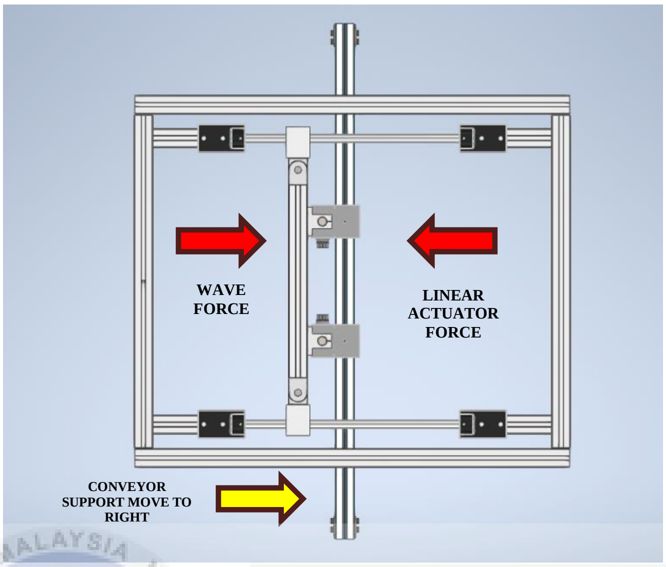


Figure 4.14 Top View Suspension System 2099 B Mechanism (Before)

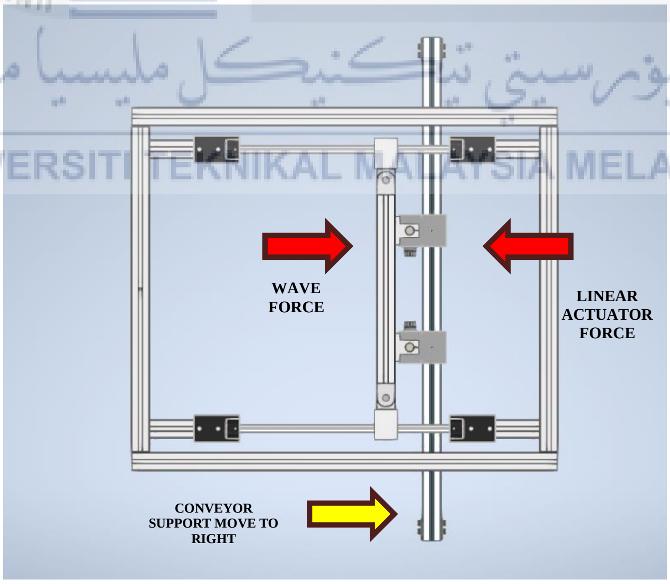


Figure 4.15 Top View Suspension System 2099 B Mechanism (After)

Suspension Mechanism System as depicted in Figure 4.12 and Figure 4.13 are the same with Suspension System B based on the Figure 4.14 and Figure 4.15. The beam moves to the right due to waves from the Melaka River and a small force effect from the linear actuator's rejection.

4.6 Suspension System Mechanism with Conveyor

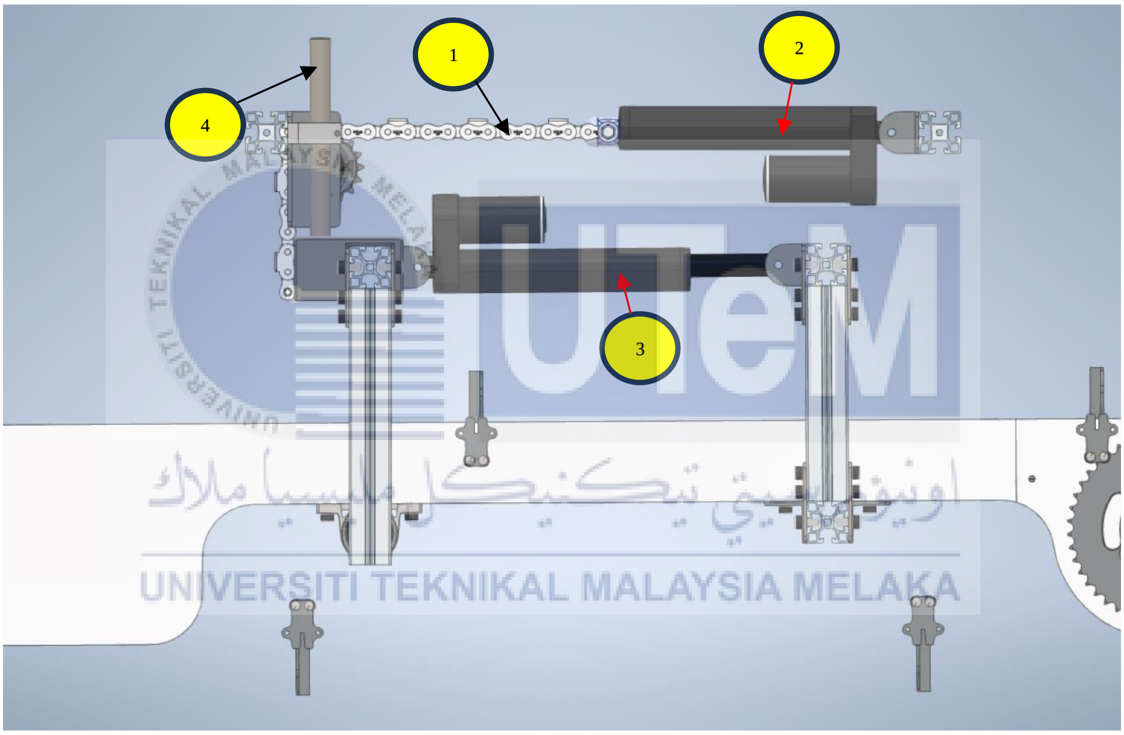


Figure 4.16 Suspension System Mechanism with Conveyor

Figure 4.16 shows the four main part of suspension system mechanism which is chain to lower and pull the conveyor. The second is Linear Actuator 1 to pulling and pushing the chain. The third part is Linear Actuator 2 to change the angle or tilt of the conveyor and lastly is Slider. Slider functions as a track while the conveyor is raised or lowered by the combined action of the chain and Linear Actuator 1.

4.6.1 Chain

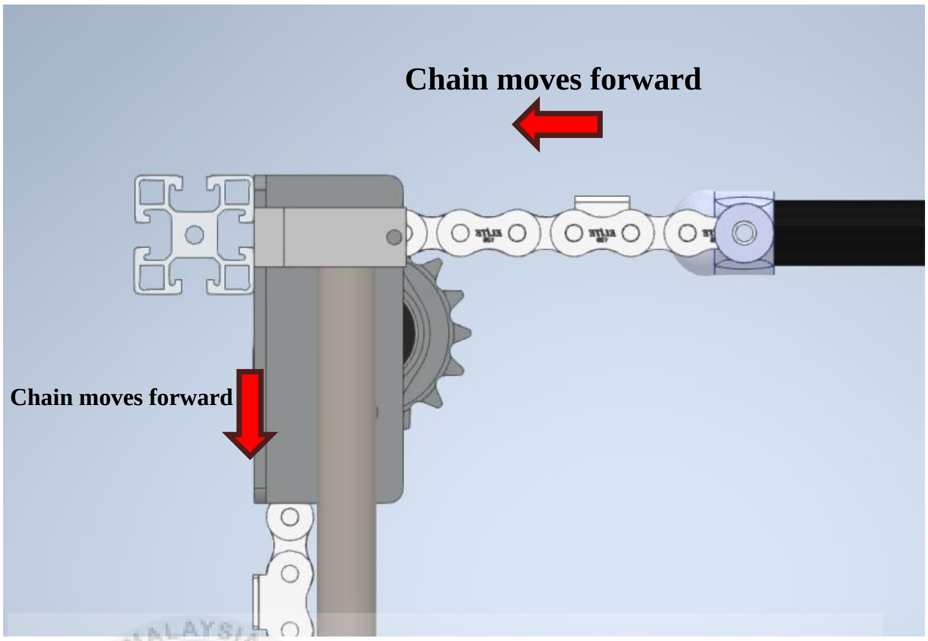


Figure 4.17 Chain Mechanism

The chain serves as a fundamental component in the suspension system mechanism. Its primary function is to lower and pull the conveyor. This is achieved by linking the chain to Linear Actuator 1 as shown in Figure 4.17. As Linear Actuator 1 moves, it imparts motion to the chain, consequently affecting the position of the conveyor. The chain plays a crucial role in the controlled vertical movement of the conveyor system.

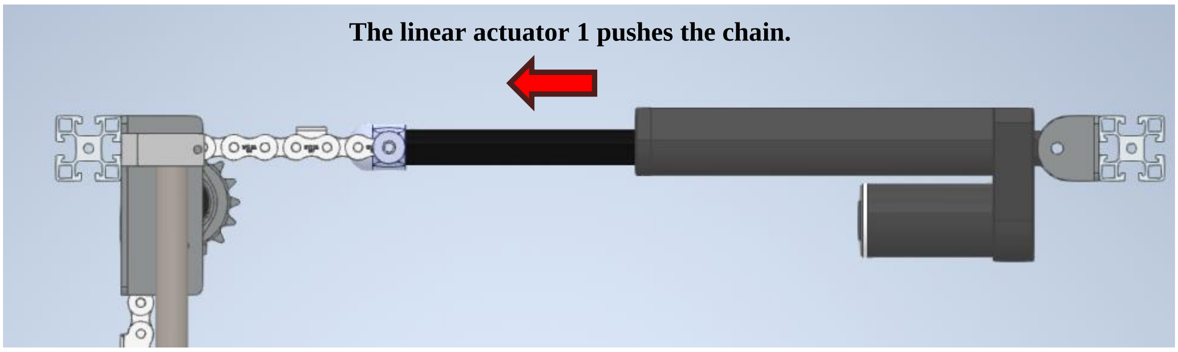


Figure 4.18 Linear Actuator 1 Mechanism

4.6.2 Linear Actuator 1

Linear Actuator 1 is a dynamic component that actively participates in the conveyor's elevation and descent. Its role involves pulling and pushing the chain, which, in turn, directly influences the position of the conveyor. When Linear Actuator 1 extends or pushes out the chain, the conveyor automatically lowers as shown at Figure 4.18. Conversely, when Linear Actuator 1 retracts or pulls back the chain, the conveyor is raised. This linear actuation mechanism provides a precise and controlled means of adjusting the height of the conveyor.

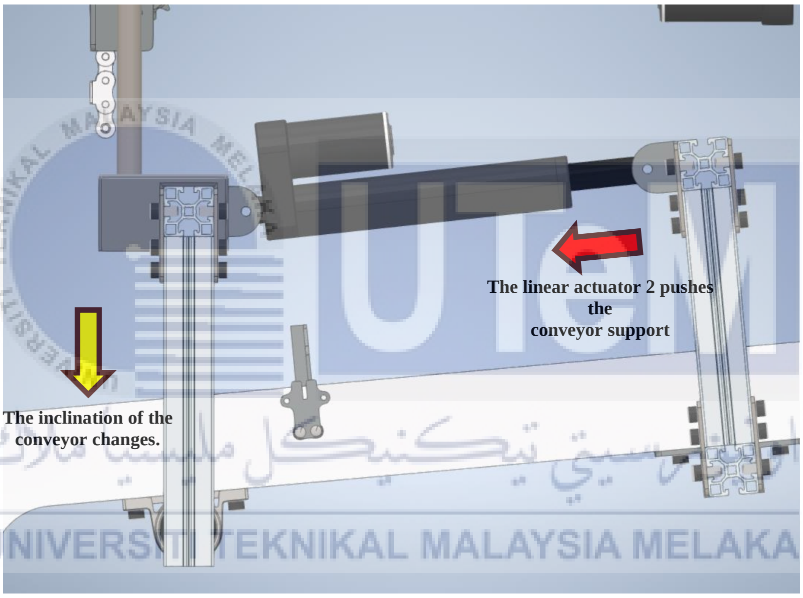


Figure 4.19 Linear Actuator 2 Mechanism

4.6.3 Linear Actuator 2

Linear Actuator 2 is specifically tasked with altering the inclination of the conveyor. Unlike Linear Actuator 1, which focuses on vertical movement, Linear Actuator 2 introduces a dynamic element by adjusting the angle or tilt of the conveyor as demonstrated in Figure 4.19. This capability allows for additional flexibility in the operation of the trash collector, accommodating different terrain or operational requirements.

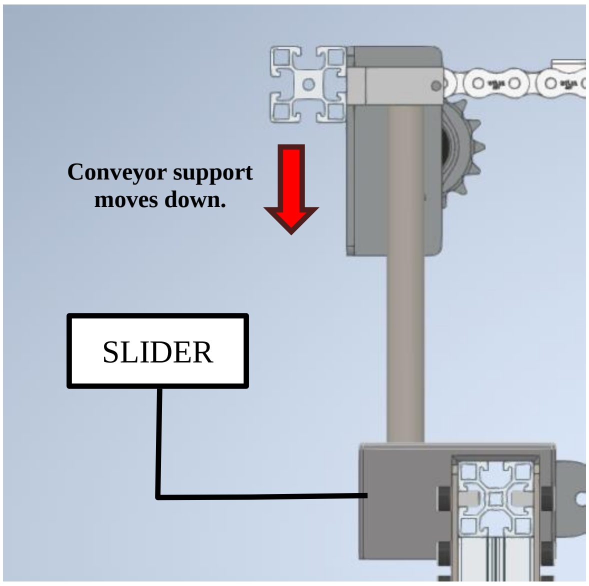


Figure 4.20 Slider Mechanism

4.6.4 Slider Up and Down

The slider mechanism functions as a track, facilitating the smooth and parallel movement of the conveyor during its ascent and descent as shown in Figure 4.20. As the conveyor is raised or lowered by the combined action of the chain and Linear Actuator 1, the slider guides and supports this motion, ensuring stability and precision. The slider's role is crucial in maintaining the alignment of the conveyor system, contributing to a reliable and controlled suspension mechanism.

In summary, the "Suspension System Mechanism with Conveyor" integrates various components such as the chain, Linear Actuator 1, Linear Actuator 2, and the slider to enable a sophisticated and adaptable suspension system. This system not only manages the vertical displacement of the conveyor but also allows for the dynamic adjustment of its inclination. The synchronized operation of these components ensures a controlled and efficient trash collection process, addressing the challenges posed by different terrains and operational conditions.

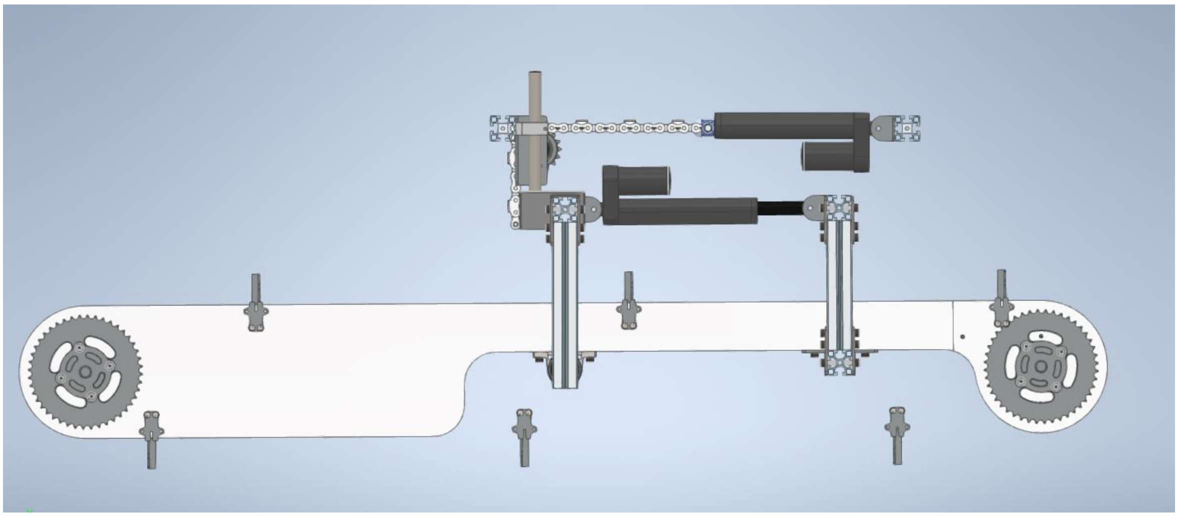


Figure 4.21 Conveyor Condition Before

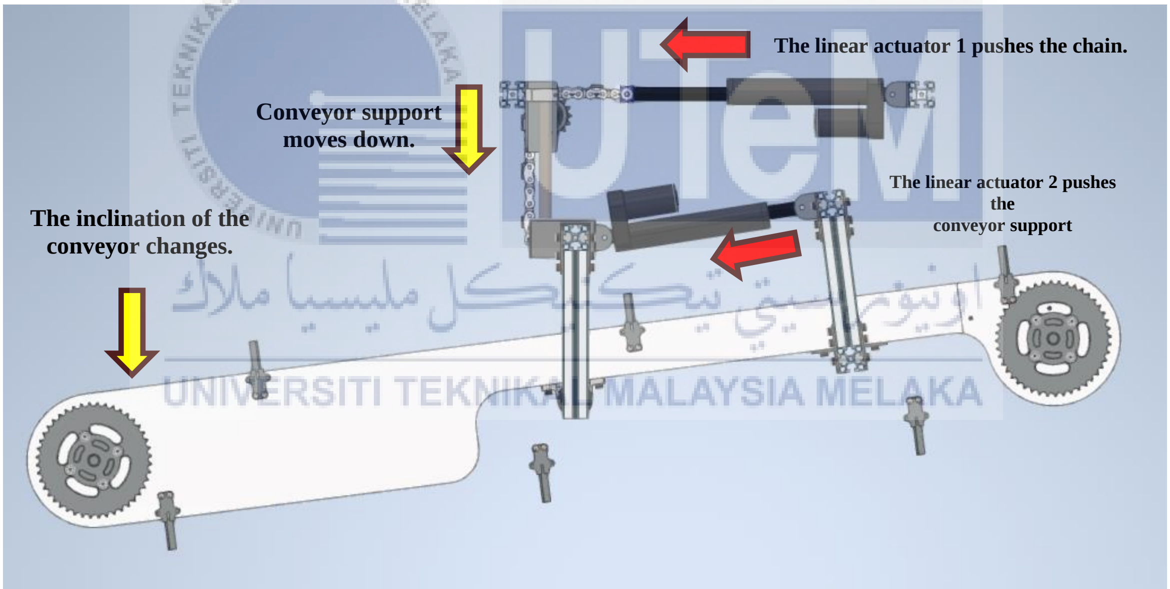


Figure 4.22 Conveyor Condition After

Figure 4.21 and Figure 4.22 shows the conveyor condition before and after the mechanism is active. The red arrow shows that the linear actuator is pushed out and causes the conveyor to go down and the conveyor tilt changes according to the yellow arrow above.

CHAPTER 5
ANALYSIS

5.1.1 Analysis For Body Frame

The upcoming analysis focuses on evaluating the structural integrity of Body Frame 616 and Body Frame 064, aiming to determine the solidity of each frame under specified conditions. The analysis will involve subjecting both frames to various loading scenarios and assessing factors such as stress distribution, deformation, and overall stability. By employing engineering simulations and computational methods, the study seeks to provide quantitative insights into the frames' structural performance.

To gauge the solidity of Body Frame 616 and Body Frame 064, the analysis will incorporate diverse loading conditions, including forces and moments relevant to the anticipated operational environment. The study aims to identify potential weak points, stress concentrations, or areas susceptible to deformation within each frame. The evaluation will also consider safety margins to ensure that the frames not only meet the minimum structural requirements but also have a sufficient factor of safety against failure.

The results will serve as a critical input for optimizing the design, reinforcing weak areas if necessary, and ensuring that the selected body frame can withstand the demands of its intended application. Ultimately, this analysis will contribute valuable data for the fabrication process, helping to create a robust and reliable structure for the specified purpose.

5.1.1.1 Analysis For Body Frame 616

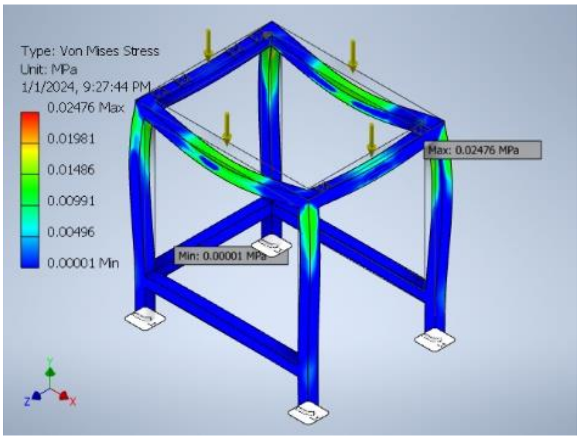


Figure 5.1 Von Mises Stress For Body Frame 616

Figure 5.1 highlights the maximum von mises stress is significantly below the yield strength of the material (0.0247615 MPa < 275 MPa). This suggests that the body frame can withstand the applied loads without experiencing plastic deformation, indicating a robust and strong design.

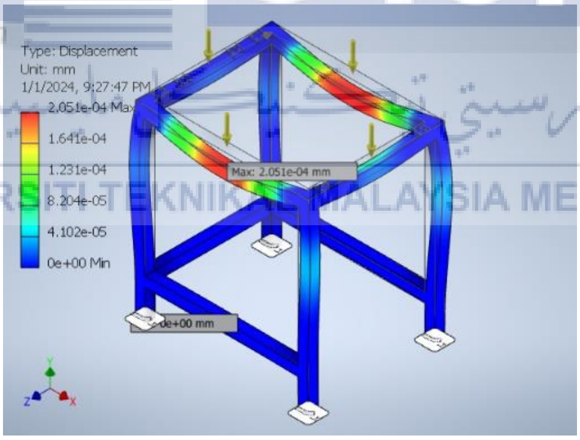


Figure 5.2 Displacement For Body Frame 616

The displacements as shown in Figure 5.2 are very small, suggesting that the body frame experiences minimal deformation under the applied loads. This is generally favorable as it implies structural stability and rigidity. The low displacements indicate that the body frame is capable of maintaining its shape and integrity, pointing towards a robust design with minimal distortion.

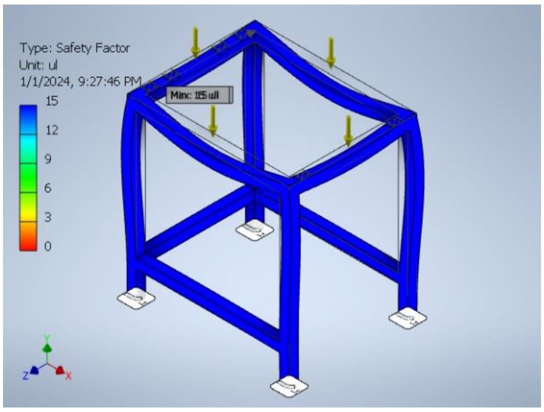


Figure 5.3 Safety factor For Body Frame 616

According to the data presented in Figure 5.3, safety factor of 15 indicates a substantial margin of safety, suggesting that the body frame is well-designed to handle the applied loads. The safety factor is a ratio of the material's yield strength to the maximum stress experienced, and a value of 15 signifies that the body frame can withstand loads 15 times greater than what it is subjected to in the analysis. Therefore, based on the safety factor results, the analysis indicates that the body frame is strong and has a significant safety margin, indicating a robust and reliable design.

5.1.1.2 Analysis For Body Frame 064

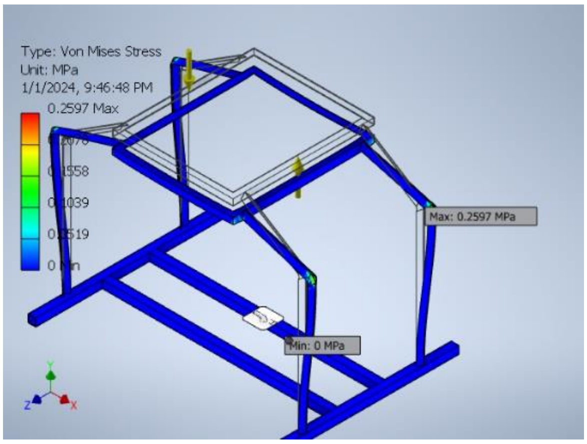


Figure 5.4 Von Mises Stress For Body Frame 064

As depicted in Figure 5.4, maximum von mises stress is less than the yield strength of the material (0.259688 MPa < 275 MPa), indicating that the body frame can withstand the applied loads without reaching its yield point. However, the stress values are relatively low, suggesting that the structure is not under significant loading but the body frame still consider safe.

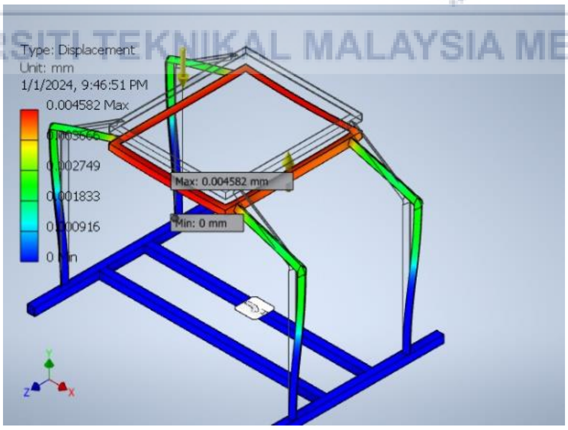


Figure 5.5 Displacement For Body Frame 064

In Figure 5.5, it is evident that the displacements are relatively small, suggesting that the body frame experiences minimal deformation under the applied loads. While the maximum displacement is nonzero, its value (0.00458241 mm) is generally small, indicating that the structure maintains stability and rigidity. In conclusion, based on the displacement results alone, the analysis indicates that the body frame is generally stable and exhibits limited deformation.

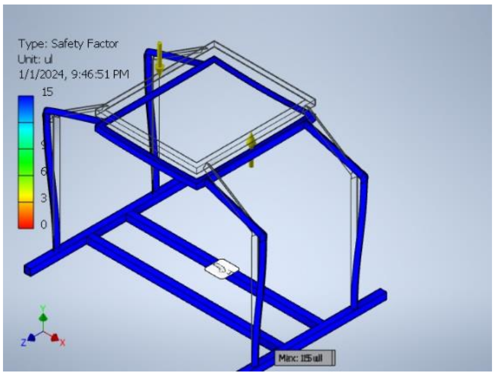


Figure 5.6 Safety Factor For Body Frame 064

As shown in Figure 5.6, the safety factor of 15 indicates a substantial margin of safety, suggesting that the body frame is well-designed to handle the applied loads. The safety factor is a ratio of the material's yield strength to the maximum stress experienced, and a value of 15 signifies that the body frame can withstand loads 15 times greater than what it is subjected to in the analysis. Therefore, based on the safety factor results, the analysis indicates that the body frame is strong and has a significant safety margin, indicating a robust and reliable design.

5.1.2 Analysis For Suspension System

In the analysis of Suspension System 2099 A and Suspension System 2099 B, critical parameters such as von Mises stress, displacement, and safety factor have been meticulously evaluated to determine the suitability of each system for fabrication. These key metrics play a pivotal role in assessing the structural integrity and performance of the suspension systems under the specified load conditions. The analysis involves subjecting both systems to a load equivalent to the average drag force of 20kN, as obtained from the Drag Force on CFD Calm Water table. The von Mises stress values provide insights into the material's capacity to withstand the applied forces, while displacement measures help understand the extent of deformation under load. Additionally, the safety factor is crucial in ensuring that the suspension systems possess adequate margin against failure. The comparison of these results between Suspension System 2099 A and Suspension System 2099 B will guide the decision-making process in selecting the optimal system for fabrication.

The analysis output will enable to make informed decisions regarding the choice between Suspension System 2099 A and Suspension System 2099 B. By quantifying the performance metrics under standardized load conditions, the evaluation process becomes systematic and data-driven. Furthermore, this detailed analysis allows for a comprehensive understanding of how each system responds to external forces, aiding in the identification of potential weaknesses or areas for improvement. Ultimately, the insights gained from this comparative analysis will inform the fabrication decision, ensuring that the chosen suspension system meets the required standards of safety, reliability, and performance for the intended application.

5.1.2.1 Analysis Suspension System 2099 A

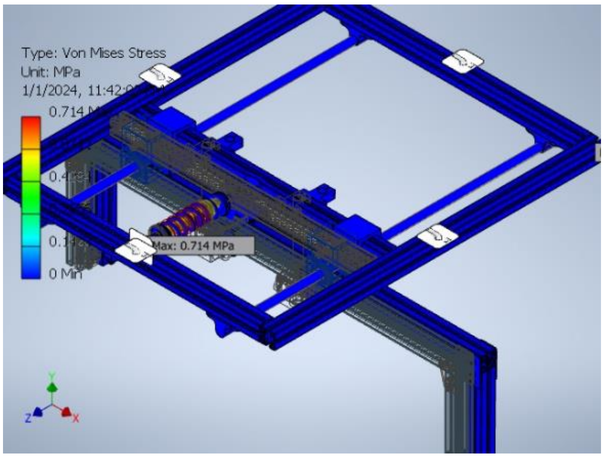


Figure 5.7 Von Mises Stress For Suspension System 2099 A

The maximum Von Mises stress is less than the yield strength of the material (0.714 MPa < 275 MPa) as shown in Figure 5.7, indicating that the suspension system can withstand the applied loads without reaching its yield point. This suggests a sufficient safety margin in the design.

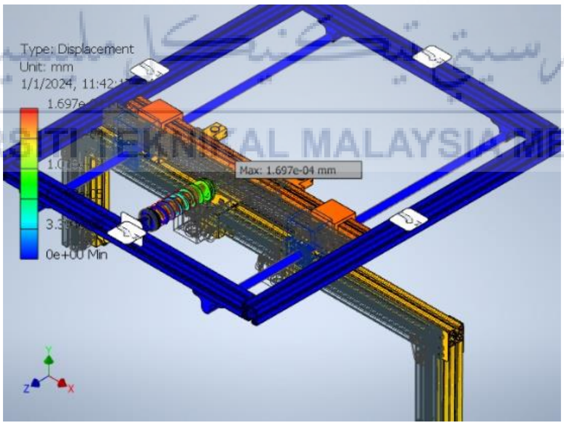


Figure 5.8 Displacement For Suspension System 2099 A

Figure 5.8 shows the displacements are extremely small, suggesting that the suspension system experiences minimal deformation under the applied loads. The maximum displacement value of 0.000169708 mm indicates that the system maintains stability and rigidity, and the deformations are within acceptable limits.

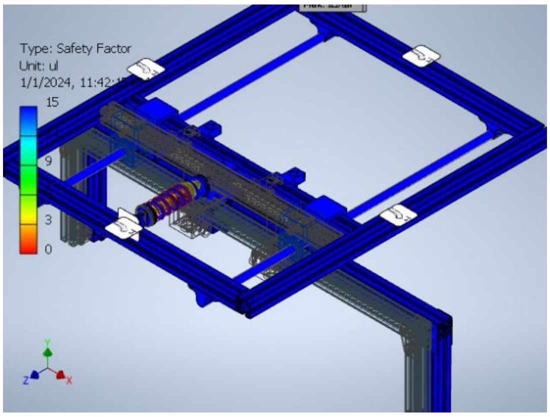


Figure 5.9 Safety Factor For Suspension System 2099 A

Safety factor of 15 indicates a substantial margin of safety, suggesting that the suspension system is well-designed to handle the applied loads as shown in Figure 5.9. The safety factor is a ratio of the material's yield strength to the maximum stress experienced, and a value of 15 signifies that the suspension system can withstand loads 15 times greater than what it is subjected to in the analysis.

5.1.2.2 Analysis Suspension System 2099 B

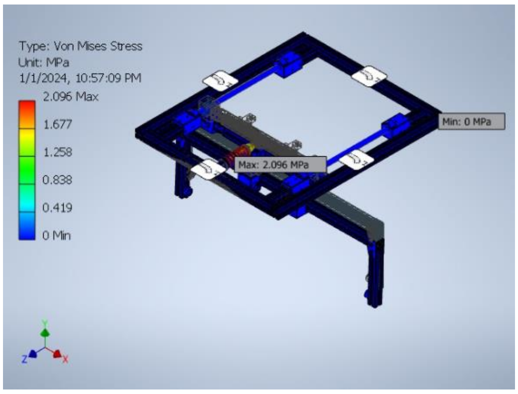


Figure 5.10 Von Mises Stress For Suspension System 2099 B

Figure 5.10 highlights the maximum Von Mises stress is less than the yield strength of the material (2.09619 MPa < 275 MPa), indicating that the suspension system can withstand the applied loads without reaching its yield point. This suggests a sufficient safety margin in the design. This analysis suggests that the Suspension System 2099 B is strong and meets the structural integrity requirements for the specified loads.

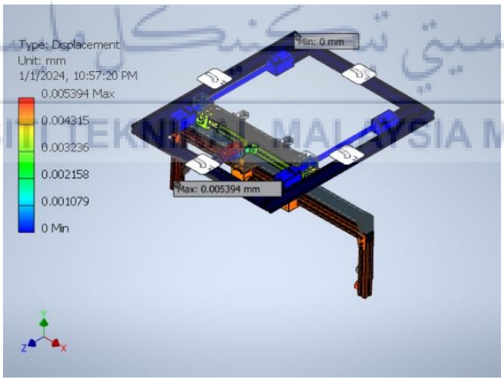


Figure 5.11 Displacement For Suspension System 2099 B

The displacements are relatively small, suggesting that the suspension system experiences limited deformation under the applied loads as shown in Figure 5.11. While the maximum displacement of 0.00539414 mm is nonzero, it is generally small, indicating that the system maintains stability and rigidity. Based on the displacement results, the analysis suggests that Suspension System 2099 B is strong and acceptable deformation under the specified loads. The small displacements imply that the system can effectively handle the applied forces.

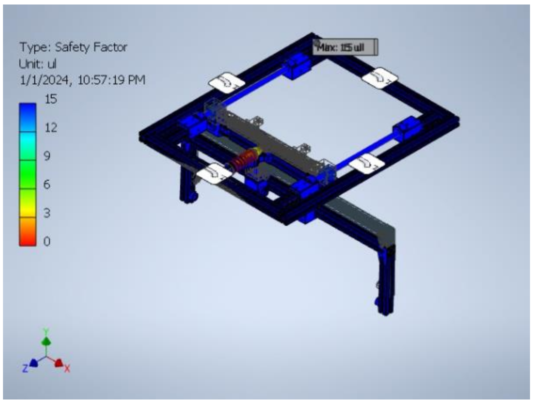


Figure 5.12 Safety Factor For Suspension System 2099 B

Safety factor of 15 indicates a substantial margin of safety, suggesting that the suspension system is well-designed to handle the applied loads as shown in Figure 5.12. The safety factor is a ratio of the material's yield strength to the maximum stress experienced, and a value of 15 signifies that the suspension system can withstand loads 15 times greater than what it is subjected to in the analysis. Therefore, based on the safety factor results, the analysis suggests that the Suspension System 2099 B is robust and has a significant safety margin, indicating a reliable design. The structure appears to be well within its safe operating limits, providing confidence in its ability to handle the specified loads.

Table 5.1 Analysis Summary Comparison For Body Frame 616 and Body Frame 064

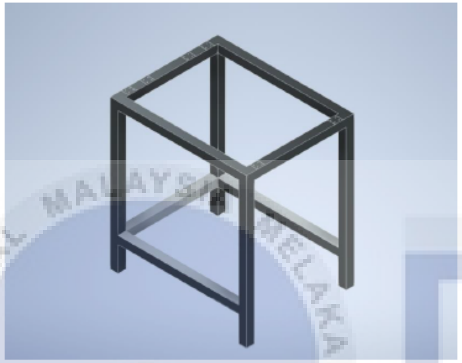
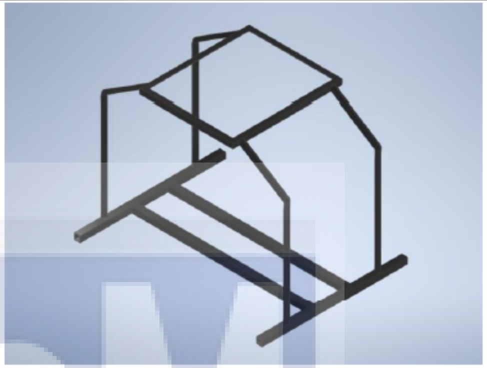
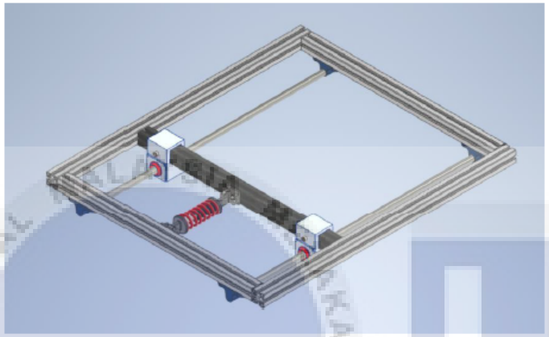
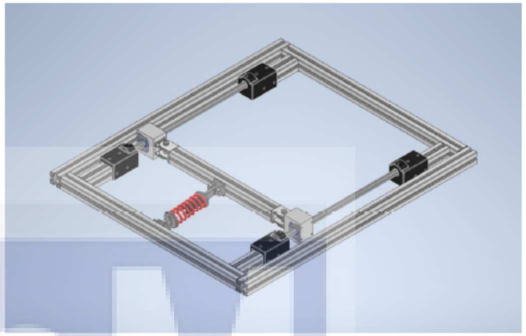
	Body Frame 616		Body Frame 064	
	 **Body Frame 616**		 **Body Frame 064**	
Mass	69.335 kg		55.9453 kg	
Von Mises Stress	MIN: 0.00000659769 MPa	MAX: 0.0247615 MPa	MIN: 0.00000000187933 MPa	MAX: 0.259688 MPa
Displacement	MIN: 0 mm	MAX: 0.000205107 mm	MIN: 0 mm	MAX: 0.00458241 mm
Safety Factor	MIN: 15 ul	MAX: 15 ul	MIN: 15 ul	MAX: 15 ul
Equivalent Strain	MIN: 0.0000000000273888 ul	MAX: 0.000000105726 ul	MIN: 0.000000000000000955134 ul	MAX: 0.00000108008 ul

Table 5.2 Analysis Summary Comparison For Suspension System 2099 A And Suspension System 2099 B

	 **Suspension System 2099 A**		 **Suspension System 2099 B**	
Mass	30.4602 kg		25.6015 kg	
Von Mises Stress	MIN: 0 MPa	MAX: 0.714 MPa	MIN: 0 MPa	MAX: 2.09619 MPa
Displacement	MIN: 0 mm	MAX: 0.000169708 mm	MIN: 0 mm	MAX: 0.00458241 mm
Safety Factor	MIN: 15 ul	MAX: 15 ul	MIN: 15 ul	MAX: 15 ul
Equivalent Strain	MIN: 0 ul	MAX: 0.00000301373 ul	MIN: 0 ul	MAX: 0.00000889666 ul

5.2 Summary Analysis

In summary, the analysis of Suspension System 2099 A and Suspension System 2099 B yielded positive results, indicating the structural adequacy of both systems. However, Suspension System 2099 A was found to be slightly heavier compared to Suspension System 2099 B according to the data presented in Table 5.2. Despite both systems demonstrating safe safety factors and favorable von Mises stress values, the lighter weight and ease of tool accessibility in Suspension System 2099 B make it the preferred choice. The decision to select Suspension System 2099 B is driven by a balance of weight considerations, design simplicity, and strength assurance. This choice ensures not only a reliable and robust suspension system but also facilitates ease of installation and maintenance, contributing to the overall efficiency of the chosen system.

Body Frame 616 and Body Frame 064 concluded with positive outcomes, indicating the structural soundness of both frames. Despite being heavier, Body Frame 616 demonstrated satisfactory von Mises stress, safety factor, and Equivalent Strain results as shown in Table 5.1. However, the lighter weight and cost-effectiveness of Body Frame 064, coupled with a comprehensive analysis ensuring its safety, make it the preferred choice for the project. Despite some sections being thinner, the analysis assures the structural integrity of Body Frame 064, affirming its suitability for use. The decision to utilize Body Frame 064 is further justified by its advantageous characteristics, including reduced weight, lower cost, and enhanced maneuverability, aligning with project requirements and resource optimization.

CHAPTER 6
FABRICATION

6.1 Introduction

Following the comprehensive analysis of the project requirements, the subsequent phase involves the creation of the design. In this context, the chosen suspension system is the 2099 B model as shown in Figure 6.1 and Body Frame 064. The selection of this particular suspension system and frame stems from its suitability and alignment with the project's specifications and objectives. This introduction sets the stage for the fabrication chapter, where the focus will be on transforming the design concept into a tangible reality through a meticulous fabrication process.

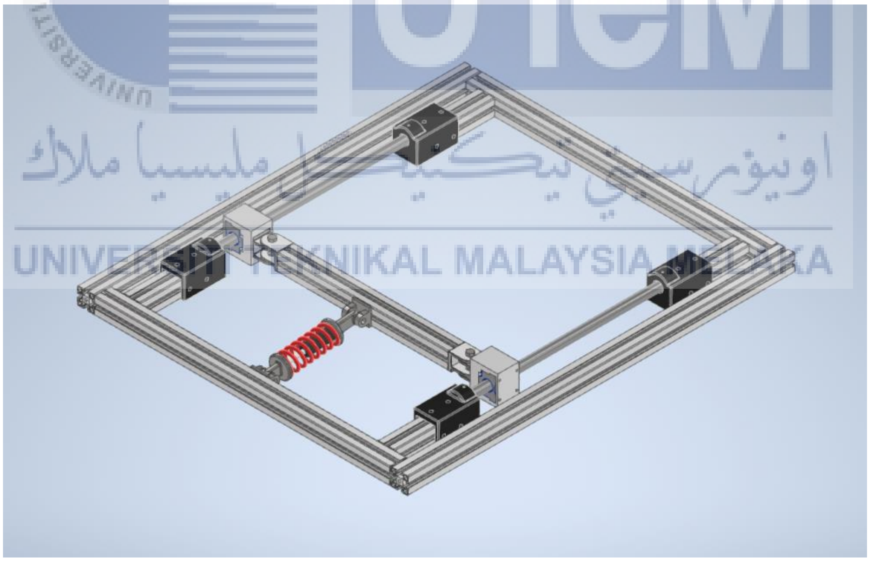


Figure 6.1 Suspension Sytem 2099 B

6.2 Material Selection

In the process of designing and developing an efficient trash collector conveyor system, the careful selection of materials is a critical factor that profoundly influences the system's performance, durability, and overall effectiveness. Each component demands a thoughtful consideration of material properties to ensure optimal functionality in diverse operational conditions. This introduction outlines the strategic choices made for key components within the conveyor system.

6.2.1 4040 Aluminium Profile for Suspension System Body Frame

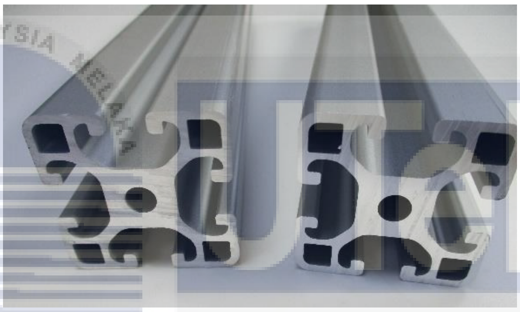


Figure 6.2 4040 Aluminium Profile

The backbone of conveyor system is its body frame, and for the suspension system, 4040 Aluminium Profile as shown in Figure 6.2 stands out as a robust and versatile choice. Renowned for its lightweight yet durable properties, the 4040 Aluminium Profile provides an ideal structural foundation. Its adaptability allows for a streamlined and efficient suspension system, contributing to enhanced stability and ease of assembly.

6.2.2 Mild Square Steel for Trash Collector Conveyor Body Frame

Figure 6.3 Mild Square Steel

For the body frame of the trash collector conveyor, the choice of upon mild square steel is the best as shown in Figure 6.3. This material is selected for its inherent strength and reliability. Mild square steel offers the structural integrity required to withstand the varying loads and environmental conditions encountered in waste management operations. Its durability ensures a resilient foundation for the conveyor, optimizing its performance and longevity.

6.2.3 Aluminium Cylinder Bar for Rail Slider

Figure 6.4 Aluminium Cylinder Bar

The rail slider attachment is a critical element responsible for guiding and supporting the conveyor components. Aluminium cylinder bar as shown in Figure 6.4 is chosen for its combination of strength and lightness. This material ensures smooth and efficient movement along the rail, contributing to the overall precision and reliability of the conveyor system.

6.2.4 Nylon PA12

Figure 6.5 Nylon PA12

Innovating the manufacturing of key components, Nylon P12 material is employed through the advanced process of 3D Selective Laser Sintering (SLS) Printing. This additive manufacturing technique allows for the creation of intricate components. Nylon P12, with its high tensile strength and wear resistance, proves to be an optimal choice for crafting components like rail stoppers and shock holders as depicted in Figure 6.5. This combination of material and manufacturing technology ensures durability, customization possibilities, and cost-effective production for these critical elements.

6.3 Suspension selection

Each tool and device has advantages and disadvantages, according to the literature review that was done. The pros and disadvantages are highlighted because they have an impact on how well the conveyor works. To ensure that the cost of the instrument or item is reasonable, maintenance expenses will also be considered.

All of the items on the list on Table 2.1 are suitable for use as a suspension. Motorcycle suspension is one tool that fit into this category as depicted in Figure 6.6. Motorcycle suspensions can potentially be used to reduce the effect of vibrations on the conveyor system because they are made to absorb shocks and vibrations. By implementing this solution, the goal is to increase the conveyor's effectiveness and lifetime, reduce component wear and tear, and better the entire waste collection operation. In addition, there are also considerations in this selection including service and maintenance. Service and maintenance for this motorcycle suspension is easier than other suspensions such as hydraulic suspension and air suspension. It can avoid problems such as liquid leaks, gas leaks and finally wear and tear on the tools.

Figure 6.6 Motorcyecle Suspension

6.4 Machine Equipment

1. Sodick Wire Cut Machine

The Sodick wire cut machine as shown in Figure 6.7 is chosen for its exceptional precision and accuracy in material shaping. This machine employs an electrical discharge machining (EDM) process, where a thin wire is used to cut through the material, ensuring intricate and detailed designs with minimal material wastage. The Sodick wire cut machine precisely follows the programmed design, cutting through the material with a fine wire electrode. This process ensures that the Slider Holder and Angle Bracket Connection as illustrates in Figure 6.8 and Figure 6.9 is shaped with utmost accuracy, conforming to the specified dimensions and features.

Figure 6.7 Sodick Wire Cut Machine

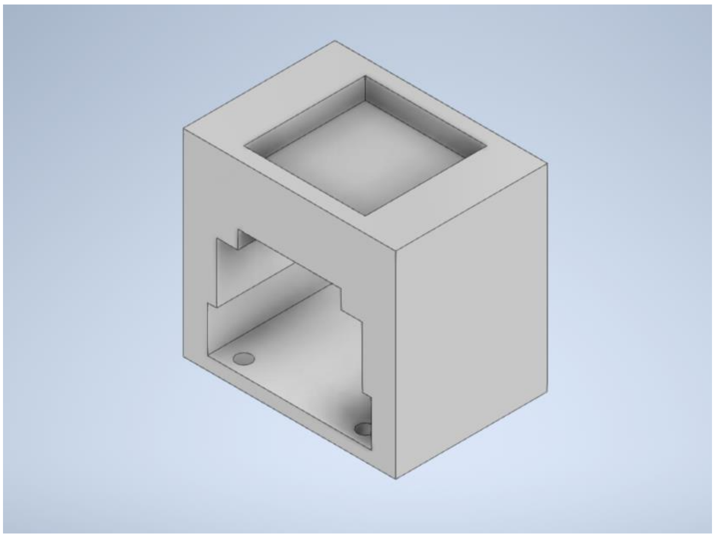


Figure 6.8 Slider Holder

Figure 6.9 Angle Bracket Connection

2. SLS Machine

SLS as depicted in Figure 6.10 is an additive manufacturing technology that uses a high-powered laser to sinter or fuse powdered materials, layer by layer, to create three-dimensional objects. This method is particularly advantageous for its ability to produce complex and detailed designs with various materials.

Figure 6.10 Selective Laser Sintering (SLS) machine

The Rail Holder as shown in Figure 6.11, another integral component of the suspension system, is designed and fabricated with precision using SLS machine. This component plays a key role in providing support and guidance to the moving parts of the suspension system, contributing to its overall stability and performance.

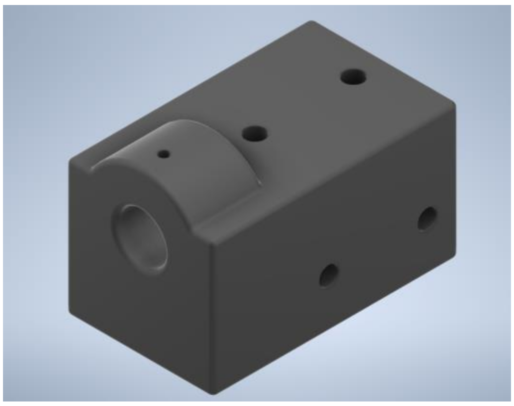


Figure 6.11 Rail Holder

6.5 Fabrication Methods

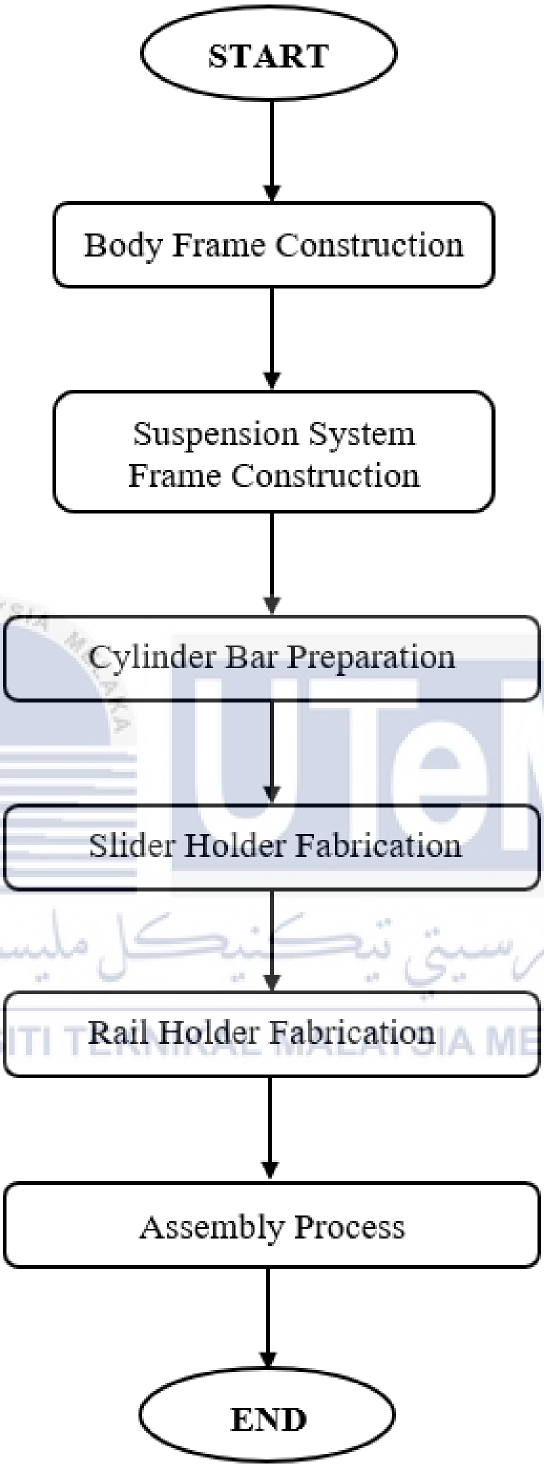


Figure 6.12 Fabrication Process Flow

The fabrication of the trash collector conveyor begins by following fabrication process flow as demonstrated in Figure 6.12. Step 1, focusing on the construction of the body frame. The process kicks off by carefully selecting the appropriate steel for the body frame. Skilled technicians then cut and weld the steel pieces according to a meticulously designed sketch. This initial step lays the foundation for the entire suspension system, ensuring the structural integrity required for the conveyor's efficient operation.

Figure 6.13 Metal Cut Off Saw Machine

Following the completion of the body frame, the focus shifts to the Suspension System Frame Construction in Step 2. The utilization of Aluminum Profile 4040 is paramount, with dimensions meticulously measured according to the specifications outlined in the Inventor software. A Metal Cut Off Saw Machine as shown in Figure 6.13 is employed for the precise cutting of aluminum, forming the frame that will play a crucial role in the overall functionality of the trash collector conveyor.

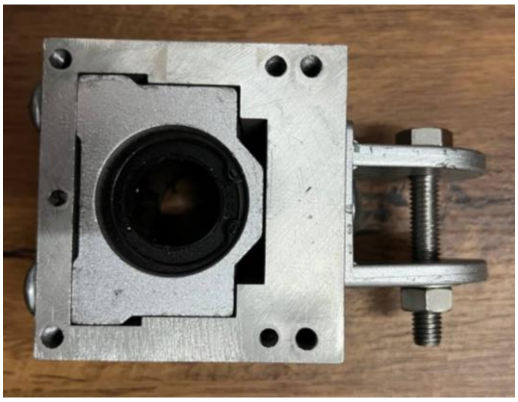


Figure 6.14 Slider Holder

In Step 3, attention turns to the preparation of the Cylinder Bar, a key component integrating with the aluminum profile in the suspension system. Precision is maintained as the cylinder bar is cut to the specified size, ensuring seamless integration within the overall structure. Moving forward, Step 4 involves the fabrication of the Slider Holder using the Sodick Wire Cut Machine. Collaborating with a lab assistant, this crucial component is meticulously crafted, with dimensions double-checked for accuracy to facilitate the smooth insertion of the slider as depicted in Figure 6.14.

Figure 6.15 Rail Holder

In Step 5, the Rail Holder as shown in Figure 6.15 comes into focus. Manufactured in the SLS room under the guidance of a lab assistant, the Selective Laser Sintering machine is employed for production. Post-printing, a thorough validation of dimensions ensures the proper integration of the Rail Holder with the aluminum cylinder bar in the suspension system.

Figure 6.16 Fully Assembly Body Frame With Suspension System

The final step, Step 6, involves the Assembly Process. With all components now fabricated, the aluminum 4040 elements and suspension system components are connected according to the predetermined design as depicted in Figure 6.16. The fully assembled suspension system is then installed onto the previously constructed body frame, and a meticulous verification process is undertaken to ensure the overall integrity and functionality within the broader context of the trash collector conveyor project.

CHAPTER 7
CONCLUSION

7.1 Conclusion

The completion of this project marks a significant achievement in the design and implementation of an advanced suspension system. The project's workflow, from the initial parameter study encompassing wave force analysis, suspension type selection, and material considerations to the final selection of the suspension system design, reflects a systematic and thorough approach.

The utilization of Inventor analysis played a pivotal role in evaluating the chosen design concepts. Through parameters such as von Mises stress, Safety Factor, and Displacement, the performance of the suspension system was rigorously tested. The application of a 20kN force, derived from CFD Calm Water research, further validated the system's ability to withstand real-world conditions.

From the analysis results, both Suspension System 2099 A and Suspension System 2099 B demonstrated robustness, yet considerations such as cost and maintenance directed the final selection towards Suspension System 2099 B. The fabrication phase is now the logical next step, propelling the project towards its ultimate realization.

7.2 Limitation

Throughout the project implementation, certain limitations were encountered. Notably, the non-parallel alignment of blade and blunt iron cutting machines posed challenges. This resulted in slightly skewed and non-parallel cuts during the fabrication process. Future projects should account for such limitations and explore alternative cutting methods to achieve precise and parallel results.

7.3 Recommendation

Recommendation for future iterations or enhancements of this suspension system involves a focused consideration on the spring rate. The existing spring suspension exhibits a higher spring rate, and it is recommended to explore and implement a variant with a lower spring rate. This adjustment aims to optimize the system's response to dynamic forces, potentially improving overall performance for Trash Collector Conveyor.

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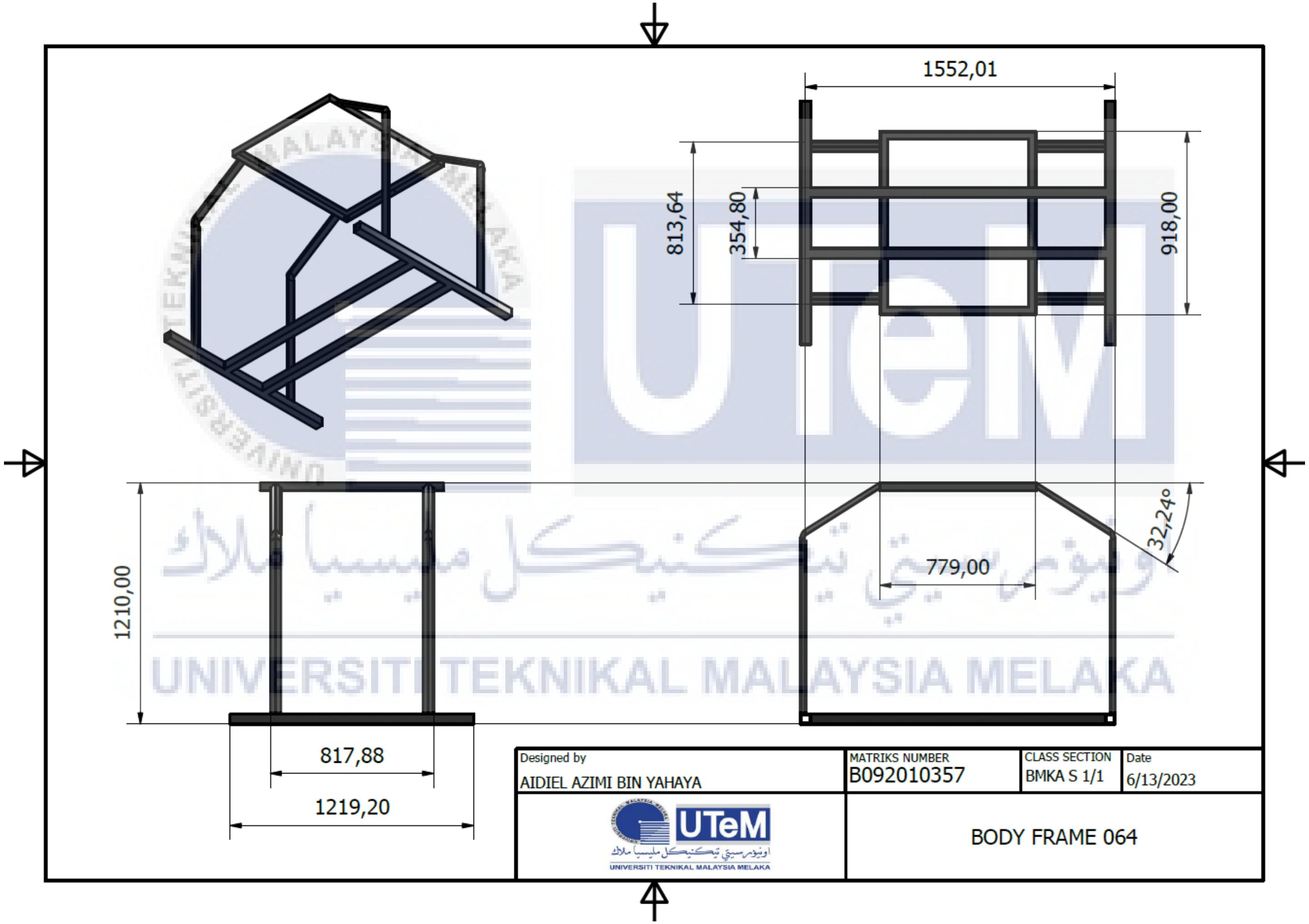
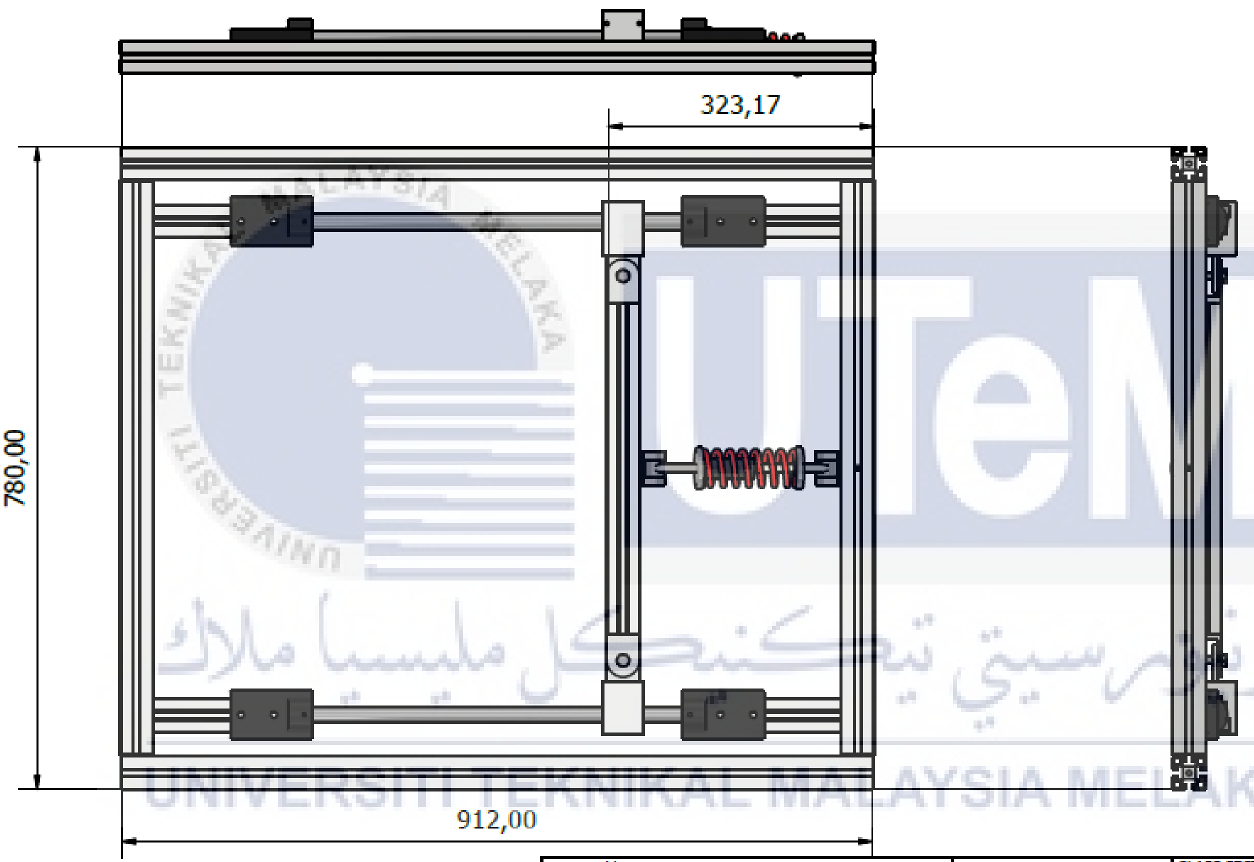
APPENDIX A
GANTT CHART FYP

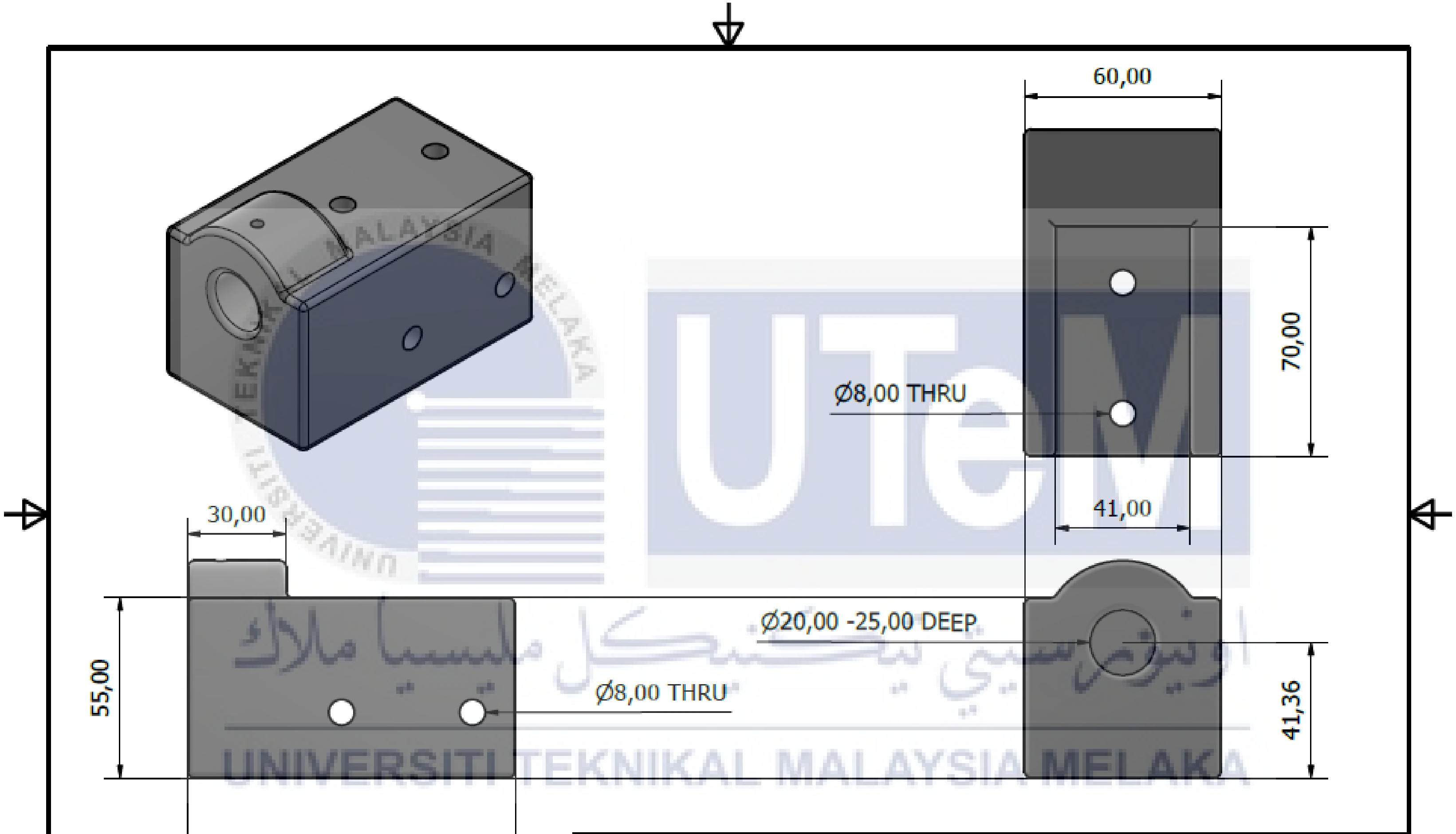
		PSM 1														PSM 2													
TASK ID	TASK / WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**INTRODUCTION**																												
1.2	Background Study																												
1.3	Find Problem Statement																												
1.4	Research Objective																												
1.5	Research Methodology																												
2	**LITERATURE REVIEW**																												
2.1	Find Devices or Tools to Reduce Wave Vibration																												
2.2	Summary Type of Devices or Tools to Reduce Wave Vibration																												
3	**METHODOLOGY**																												
3.1	River Drag Force Study																												
3.2	Benchmarking Of Current Trash Collector Conveyor																												
3.3	Benchmarking Of Current Conveyer Belt System on Water																												
3.4	Conceptual Sketches for Suspension System																												
3.5	Conceptual Sketches for Body Frame																												
4	**DETAIL DESIGN AND ANALYSIS**																												
4.1	Create 3D Assembly for Suspension System																												
4.2	Analysis Suspension System and Body Frame																												
4.3	Material Selection and Suspension selection																												
5	**FABRICATION**																												
5.1	Start Fabricate																												
6	**CONCLUSION**																												
6.1	Conclude The Project																												

APPENDIX B
DETAILE DESIGN WITH DIMENSION





Designed by	MATRIKS NUMBER	CLASS SECTION	Date
AIDIEL AZIMI BIN YAHAYA	B092010357	BMKA S 1/1	6/13/2023
UTeM UNIVERSITI TEKNIKAL MALAYSIA MELAKA	SUSPENSION SYSTEM 2099 B		



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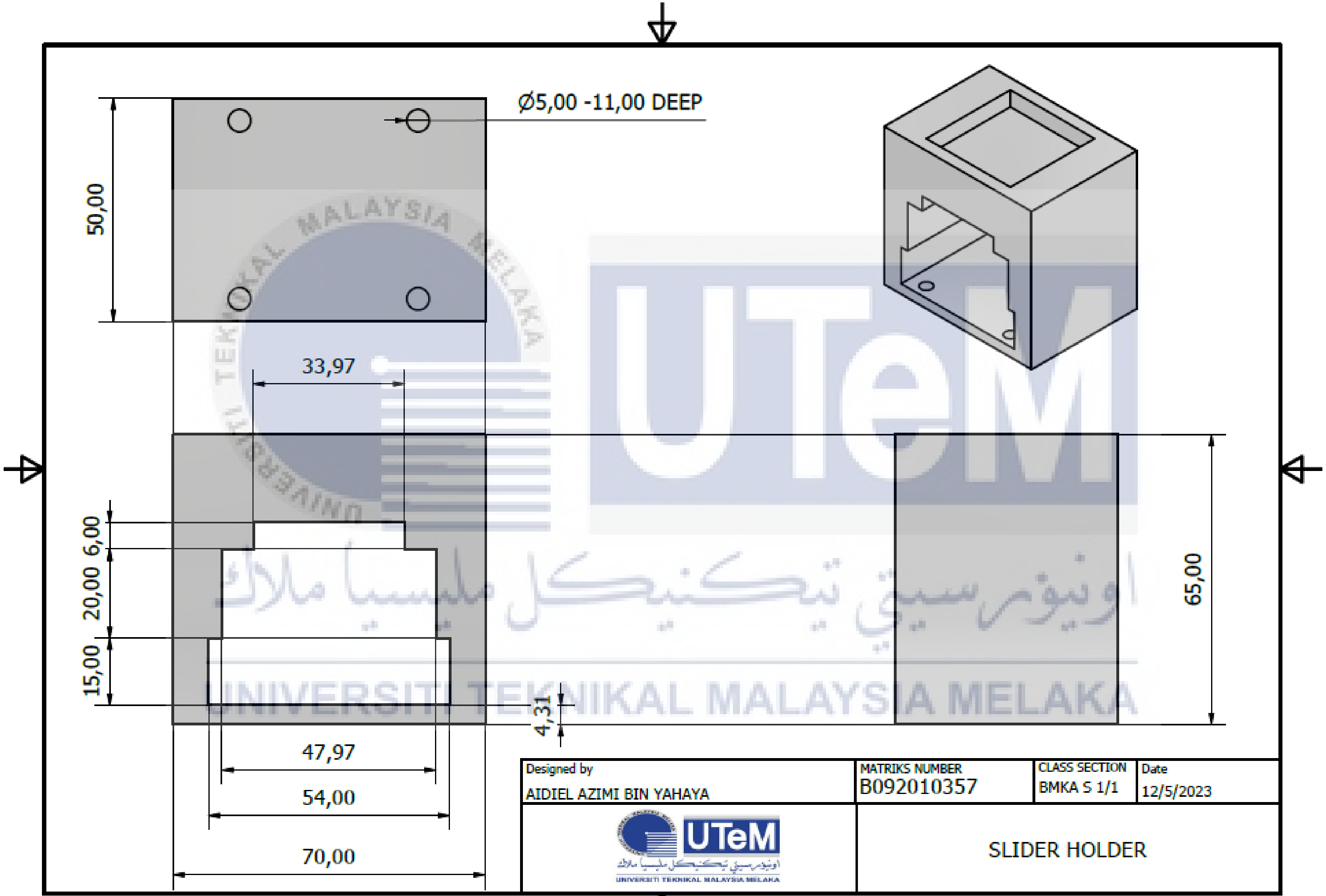
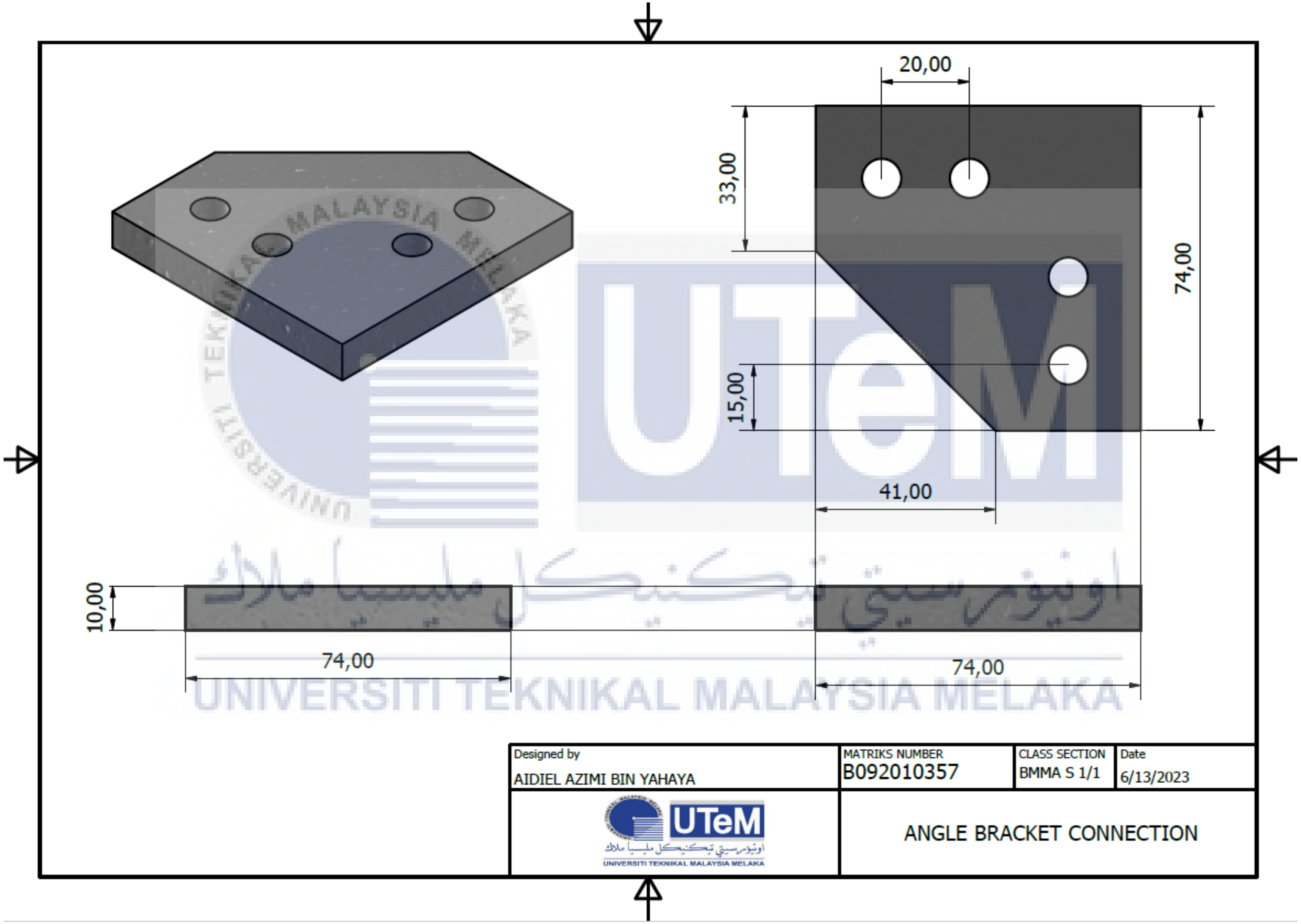
UTeM UNIVERSITI TEKNIKAL MALAYSIA MELAKA	RAIL HOLDER		



Designed by	MATRIKS NUMBER	CLASS SECTION	Date
AIDIEL AZIMI BIN YAHAYA	B092010357	BMKA S 1/1	12/5/2023

SLIDER HOLDER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MATRIKS NUMBER
B092010357
CLASS SECTION
BMMA S 1/1
Date
6/13/2023
ANGLE BRACKET CONNECTION

APPENDIX C
ANALYSIS RESULT

Analysis For Body Frame 616

Name	***Minimum***	***Maximum***
Volume	21571400 mm^3	
Mass	69.335 kg	
Von Mises Stress	0.00000659769 MPa	0.0247615 MPa
1st Principal Stress	-0.00566448 MPa	0.0178544 MPa
3rd Principal Stress	-0.0265695 MPa	0.00210161 MPa
Displacement	0 mm	0.000205107 mm
Safety Factor	15 ul	15 ul
Stress XX	-0.0173453 MPa	0.0169792 MPa
Stress XY	-0.00351323 MPa	0.00343096 MPa
Stress XZ	-0.0037884 MPa	0.00391739 MPa
Stress YY	-0.0262759 MPa	0.0178379 MPa
Stress YZ	-0.00586155 MPa	0.00647227 MPa
Stress ZZ	-0.0170359 MPa	0.0113696 MPa
X Displacement	-0.0000641074 mm	0.0000656372 mm
Y Displacement	-0.000205102 mm	0.0000114474 mm
Z Displacement	-0.0000401713 mm	0.0000401922 mm
Equivalent Strain	0.0000000000273888 ul	0.000000105726 ul
1st Principal Strain	0.0000000000168154 ul	0.0000000829047 ul
3rd Principal Strain	-0.000000121344 ul	0.00000000182526 ul
Strain XX	-0.0000000822979 ul	0.0000000807981 ul
Strain XY	-0.0000000217486 ul	0.0000000212393 ul
Strain XZ	-0.000000023452 ul	0.0000000242505 ul
Strain YY	-0.000000119526 ul	0.0000000827735 ul
Strain YZ	-0.0000000362858 ul	0.0000000400664 ul
Strain ZZ	-0.0000000634973 ul	0.0000000502424 ul

Analysis For Body Frame 064

Name	***Minimum***	***Maximum***
Volume	5725520 mm^3	
Mass	55.9453 kg	
Von Mises Stress	0.00000000187933 MPa	0.259688 MPa
1st Principal Stress	-0.0632222 MPa	0.345149 MPa
3rd Principal Stress	-0.228478 MPa	0.115832 MPa
Displacement	0 mm	0.00458241 mm
Safety Factor	15 ul	15 ul
Stress XX	-0.143102 MPa	0.154797 MPa
Stress XY	-0.0752729 MPa	0.0944979 MPa
Stress XZ	-0.0678905 MPa	0.0747355 MPa
Stress YY	-0.160596 MPa	0.218561 MPa
Stress YZ	-0.0923525 MPa	0.0861151 MPa
Stress ZZ	-0.147686 MPa	0.344975 MPa
X Displacement	-0.00283107 mm	0.0028209 mm
Y Displacement	-0.00458148 mm	0.000065657 mm
Z Displacement	-0.000417749 mm	0.000423066 mm
Equivalent Strain	0.0000000000000955134 ul	0.00000108008 ul
1st Principal Strain	-0.0000000000845285 ul	0.00000115564 ul
3rd Principal Strain	-0.000000974568 ul	0.000000000000686935 ul
Strain XX	-0.000000446053 ul	0.000000522158 ul
Strain XY	-0.000000465975 ul	0.000000584987 ul
Strain XZ	-0.000000420275 ul	0.000000462648 ul
Strain YY	-0.000000649645 ul	0.00000074291 ul
Strain YZ	-0.000000571706 ul	0.000000533093 ul
Strain ZZ	-0.000000922025 ul	0.00000115456 ul

Analysis For Suspension System 2099 A

Name	Minimum	Maximum
Volume	6497360 mm^3	
Mass	19.4602 kg	
Von Mises Stress	0 MPa	0.714 MPa
1st Principal Stress	-0.078937 MPa	0.750792 MPa
3rd Principal Stress	-0.428409 MPa	0.111292 MPa
Displacement	0 mm	0.000169708 mm
Safety Factor	15 ul	15 ul
Stress XX	-0.307685 MPa	0.253421 MPa
Stress XY	-0.170226 MPa	0.160533 MPa
Stress XZ	-0.276407 MPa	0.374041 MPa
Stress YY	-0.282498 MPa	0.254507 MPa
Stress YZ	-0.279851 MPa	0.282476 MPa
Stress ZZ	-0.135297 MPa	0.692132 MPa
X Displacement	-0.00000782705 mm	0.00000527607 mm
Y Displacement	-0.0000397508 mm	0.00000379197 mm
Z Displacement	-0.000166904 mm	0.00000015557 mm
Equivalent Strain	0 ul	0.00000301373 ul
1st Principal Strain	-0.0000000258136 ul	0.00000341668 ul
3rd Principal Strain	-0.00000244226 ul	0.00000000564801 ul
Strain XX	-0.00000145655 ul	0.00000121395 ul
Strain XY	-0.00000107948 ul	0.00000101801 ul
Strain XZ	-0.00000175282 ul	0.00000231549 ul
Strain YY	-0.00000128076 ul	0.00000122193 ul
Strain YZ	-0.00000177467 ul	0.00000179131 ul
Strain ZZ	-0.000000619979 ul	0.00000305355 ul
Contact Pressure	0 MPa	1.51692 MPa
Contact Pressure X	-0.573745 MPa	0.593449 MPa
Contact Pressure Y	-1.13225 MPa	0.856755 MPa
Contact Pressure Z	-1.25122 MPa	0.567759 MPa

Analysis For Suspension System 2099 B

Name	***Minimum***	***Maximum***
Volume	6270910 mm^3	
Mass	16.6015 kg	
Von Mises Stress	0 MPa	2.09619 MPa
1st Principal Stress	-0.357907 MPa	1.62414 MPa
3rd Principal Stress	-1.8819 MPa	0.381211 MPa
Displacement	0 mm	0.00539414 mm
Safety Factor	15 ul	15 ul
Stress XX	-0.499084 MPa	0.493905 MPa
Stress XY	-0.23558 MPa	0.24645 MPa
Stress XZ	-0.678687 MPa	0.739077 MPa
Stress YY	-0.707425 MPa	0.789525 MPa
Stress YZ	-1.12062 MPa	0.860707 MPa
Stress ZZ	-1.55821 MPa	1.40445 MPa
X Displacement	-0.0000243235 mm	0.000275712 mm
Y Displacement	-0.00520994 mm	0.000155043 mm
Z Displacement	-0.00157904 mm	0.0015183 mm
Equivalent Strain	0 ul	0.00000889666 ul
1st Principal Strain	-0.000000226971 ul	0.00000806199 ul
3rd Principal Strain	-0.00000860313 ul	0.0000000609734 ul
Strain XX	-0.00000138236 ul	0.00000169853 ul
Strain XY	-0.00000149392 ul	0.00000156285 ul
Strain XZ	-0.00000430387 ul	0.00000468683 ul
Strain YY	-0.00000424461 ul	0.00000373736 ul
Strain YZ	-0.00000714247 ul	0.00000545814 ul
Strain ZZ	-0.00000637501 ul	0.00000666883 ul
Contact Pressure	0 MPa	68.6302 MPa
Contact Pressure X	-3.07107 MPa	3.34292 MPa
Contact Pressure Y	-4.51131 MPa	48.9527 MPa
Contact Pressure Z	-9.33883 MPa	48.0746 MPa