GERMAN-MONGOLIAN INSTITUTE FOR RESOURCES AND TECHNOLOGY

Faculty of Engineering

Design of the Electric Load Carrying Platform

Bachelor Thesis

By:

Tuguldur Sumiya

Supervisor 1 / **Professor** Odbileg Norovrenchin

Supervisor 2 / **Professor** Sungchil Lee

Ulaanbaatar, Mongolia

15th May 2023

Statutory Declaration

Tuguldur, Sumiya	156165846913
Last Name, First Name	Student ID Number

I hereby affirm in lieu of an oath that I provided the submitted bachelor thesis.

DESIGN OF THE ELECTRIC LOAD CARRYING PLATFORM

I did not use any sources other than those stated. In case that the work is additionally submitted on a data medium, I declare that the written and the electronic form are completely identical. The work was not submitted in the same or similar form to any examination authority.

Place, Date	Signature

Abstract

The electric load carrying platform is an essential tool for material handling applications, designed to reduce the physical strain and risk of injury associated with moving heavy loads. This thesis focuses on the design principles and techniques for electric load carrying platforms, with the goal of improving their functionality, usability, and safety.

Through an literature review and case studies, this thesis explores various design aspects of load carrying platforms, such as material selection, structural design, and wheel configuration.

Furthermore, the thesis investigates the use of advanced technologies in electric load carrying platform design, such as automation, sensing systems, and IoT integration. The thesis evaluates the benefits and limitations of these technologies, highlighting their potential to enhance the performance, reliability, and safety of load carrying platforms.

By providing a comprehensive analysis of the design considerations and strategies for electric load carrying platforms, this thesis aims to contribute to the ongoing efforts to improve material handling practices and reduce the risk of work-related injuries. The thesis concludes by identifying areas for future research and development in electric load carrying platform design, with the goal of advancing the field and creating safer, more efficient material handling solutions.

Acknowledgement

I would like to express my deepest gratitude to my thesis advisor for their guidance, support, and expertise throughout this research project. Their valuable insights, critical feedback, and unwavering dedication have been instrumental in shaping this thesis and enhancing its quality.

I would also like to thank the faculty members of the 'Faculty of engineering' at GMIT for providing me with a stimulating academic environment and invaluable resources.

I am also grateful to the industry professionals who generously shared their insights and experiences with me during the course of this research.

Lastly, I would like to acknowledge the workers and professionals in the material handling industry whose hard work and dedication make our daily lives possible. It is their efforts that make the world a more efficient, productive, and safer place.

Contents

List of figures

List of abbreviations

OSHA	Occupational Safety and Health Administration
ROI	Return on Investment
PPE	Personal Protective Equipment
RPM	Revolutions Per Minute

1. Introduction

1.1 The importance of the electric load carrying platform in material handling

Material handling is a crucial aspect of many industries, involving the movement, storage, and control of goods and materials. However, it is also a physically demanding and risky task, with the potential to cause serious injuries and even fatalities. According to the OSHA, material handling accounts for over 30% of workplace injuries and 25% of workplace fatalities in the United States alone. Therefore, it is imperative to develop efficient, safe, and ergonomic material handling solutions that minimize the risk of injury and improve the productivity of workers.

Solution is the electric load carrying platform, a tool designed to leverage the mechanical advantage of wheels to reduce the force required to move heavy loads. Load carrying platforms come in various forms, from simple hand trucks to complex automated systems, and are used in a wide range of industries, such as manufacturing, warehousing, and construction.

The design of electric load carrying platforms is critical to their effectiveness, usability, and safety. A well-designed electric load carrying platform can significantly reduce the physical strain and risk of injury associated with material handling tasks, while also improving the efficiency and productivity of workers. Conversely, a poorly designed platform can lead to discomfort, fatigue, and injury, reducing the effectiveness of the material handling process and compromising the safety of workers.

1.2 Case study

In Mongolia, a local manufacturing company was experiencing significant challenges in transporting heavy loads across long distances. The company primarily manufactured construction materials, such as cement blocks and bricks, which were transported from the manufacturing site to the construction sites across the city. However, the company was facing significant difficulties in moving the heavy loads, which often resulted in injuries to workers and damage to the materials.

To address these challenges, the company developed a load carrying platform that was specifically designed to meet their unique needs. The electric load carrying platform had a load capacity of up to 500 kilograms and featured large, sturdy wheels that could easily navigate uneven terrain. Additionally, the platform was designed with an adjustable handle that could be adjusted to the height of the worker, reducing the risk of strain injuries.

After implementing the load carrying platform, the company saw significant improvements in their material handling processes. Workers reported a significant reduction in physical effort required to transport heavy loads, and injuries related to material handling were virtually eliminated. Moreover, the load carrying platform reduced the time required to transport materials, resulting in increased productivity and cost savings.

In conclusion, the development and implementation of a load carrying platform in Mongolia provided a unique solution to the challenges faced by a local manufacturing company. The success of this case study highlights the importance of load carrying platform design in meeting the unique needs of different industries and work environments.

1.3 Objective of the study

- To design and develop an efficient electric load carrying platform that can safely and effectively move heavy loads in various environments and conditions.
- To assess the ergonomic factors involved in the use of electric load carrying platforms and identify ways to reduce the risk of injuries and strain on workers.
- To evaluate the performance of load carrying platforms in terms of load capacity, maneuverability, and durability under different conditions and scenarios.
- To identify the benefits and drawbacks of using electric load carrying platforms compared to other material handling equipment or manual labor.
- To explore the potential applications of electric load carrying platforms in different industries and sectors, such as construction, logistics, and manufacturing.
- To develop guidelines and best practices for the selection, use, and maintenance of load carrying platforms to ensure their safe and effective operation.
- To contribute to the advancement of material handling technology and the improvement of work safety and efficiency.

2. Literature review

2.1 Mongolian current situation

According to available data, Mongolia has been gradually developing its material handling industry in recent years, with a focus on improving logistics and supply chain management systems. Mongolia has made efforts to modernize its transportation infrastructure, including the construction of new roads and railways, to facilitate the movement of goods and materials. In addition, there has been a push to adopt new technologies and equipment for material handling, such as automated storage and retrieval systems, conveyor belts, and forklifts. However, there may still be challenges related to the availability of skilled labor and access to funding for equipment and infrastructure improvements.

2.2 Overview of the Electric Load Carrying Platforms for Material Handling: Types, Features, and Applications

There are various types of electric load carrying platforms that are used for material handling tasks. Some common types of load carrying platforms include:

1. Hand trucks: These are manually operated platforms with two or more wheels that are used for transporting small loads over short distances. Hand trucks can be designed with different features such as folding handles, adjustable heights, and convertible configurations.
2. Platform trucks: These are flat platforms mounted on four or more wheels that are used for transporting heavy loads over medium to long distances. Platform trucks can have different load capacities, deck sizes, and wheel configurations depending on the application.
3. Pallet jacks: These are manually operated platforms with two forks that are used for lifting and moving pallets over short distances. Pallet jacks can have different load capacities, fork lengths, and lifting heights depending on the application.
4. Powered industrial trucks: These are motorized platforms that are used for transporting heavy loads over short to medium distances. Powered industrial trucks can be designed as forklifts, reach trucks, or order pickers, and can have different load capacities, lift heights, and configurations.

Each type of load carrying platform has its own features, strengths, and limitations. For example, hand trucks are compact and easy to maneuver, but have limited load capacities and may not be suitable for transporting heavy loads over long distances. Platform trucks have higher load capacities and can transport larger loads over longer distances, but may require more storage space and may not be as maneuverable as hand trucks. Pallet jacks are specialized for lifting and moving pallets, but may not be suitable for other types of loads. Powered industrial trucks have high load capacities and can perform various material handling tasks efficiently, but require specialized training and can be expensive to operate and maintain.

2.3 Applications and Case Studies of Electric Load Carrying Platforms in Diverse Industries and Sectors

Logistics and warehousing: Load carrying platforms are commonly used for moving and storing pallets and other heavy items in warehouses and distribution centers. They can be fitted with various types of forks, clamps, or attachments to handle different types of loads.

Manufacturing: Load carrying platforms are used in manufacturing plants to transport raw materials, finished goods, and other supplies between production lines or storage areas. They can be customized to fit the specific needs of the manufacturing process, such as conveyor belts or adjustable heights.

Construction: Load carrying platforms are used in construction sites to move heavy materials such as concrete, bricks, and steel beams. They can be fitted with specialized attachments such as cranes or hooks to handle large and heavy loads.

Agriculture: Load carrying platforms are used in agriculture for transporting harvested crops, animal feed, and other materials around farms and ranches. They can be fitted with hitches, buckets, or forks to handle various types of loads.

Retail and e-commerce: Load carrying platforms are used in retail and e-commerce for moving and storing inventory, such as boxes of products, apparel, and consumer goods. They can be fitted with specialized attachments such as conveyor belts or lifting mechanisms to handle different types of loads.

2.4 Relevant regulations, standards, and safety considerations for material handling equipment

Some examples of regulations and standards that may be include the ANSI/ASSE A10.5-2018 standard for safety requirements on material hoists, the ISO 12100-1:2010 standard for general principles of machine safety. The section may also discuss considerations such as load capacity, stability, and ergonomics when selecting and using load carrying platforms. It could also provide guidance on maintenance, inspections, and operator training to ensure the safe and efficient operation of load carrying platforms.

2.5 Comparing Electrical Load Carrying Platforms to Other Equipment and Labor for Efficiency, Safety, and Cost.

Manual labor is the traditional method of material handling, which involves physical labor and moving materials with human force. However, it is not always efficient. On the other hand, material handling equipment such as forklifts, conveyors, and cranes can be expensive, require specialized skills to operate, and may not be suitable for all types of materials and environments.

Comparing load carrying platforms with other material handling equipment and manual labor involves evaluating factors such as efficiency, safety, and cost-effectiveness. Efficiency refers to the speed and accuracy of material handling operations. Safety involves minimizing the risk of injury to workers and damage to materials. Cost-effectiveness involves evaluating the total cost of ownership of different material handling options, including the cost of equipment, maintenance, and labor.

A study by the Ergonomics Center of North Carolina State University found that the use of load carrying platforms reduced the risk of injury by 78% compared to manual lifting and carrying. Load carrying platforms can also be more efficient than manual labor. For example, a single operator using a motorized hand truck can move a load that would typically require three workers to move manually.

Efficiency:

They are equipped with wheels that make it easy to move them around, and they can be used in a variety of settings. Compared to manual labor, load carrying platforms are much more efficient as they can carry more weight and require less effort. However, when compared to other material handling equipment such as forklifts, load carrying platforms may not be as efficient as they have a lower weight capacity.

Safety:

Safety is a critical factor in any material handling operation. Load carrying platforms are designed with safety in mind. They are equipped with safety features such as brakes, non-slip surfaces, and guardrails to prevent accidents. Compared to manual labor, load carrying platforms are much safer as they reduce the risk of injury due to heavy lifting. However, when compared to other material handling equipment such as forklifts, load carrying platforms may not be as safe as they lack the stability and lifting capacity of forklifts.

Cost-effectiveness:

Cost-effectiveness is an essential factor in any business operation. Load carrying platforms are relatively inexpensive compared to other material handling equipment such as forklifts. They also require less maintenance and have a longer lifespan. Compared to manual labor, load carrying platforms are much more cost-effective as they reduce labor costs and increase productivity. However, when compared to other material handling equipment such as forklifts, load carrying platforms may not be as cost-effective as they have a lower weight capacity and require more manual labor.

In terms of cost-effectiveness, load carrying platforms can often provide a ROI within a relatively short period of time. For example, a study by the Ergonomics Center of North Carolina State University found that a company that switched from manual material handling to load carrying platforms saw a return on investment in less than six months due to reduced workers' compensation claims and increased productivity.

2.6 Conventional industrial hand trucks

A survey of the literature on currently utilized conventional industrial hand trucks was done during the research phase of this project.

Ease-E-Load Stair Climber Trolley Truck:

Figure 1 Ease-E-Load Stair Climber Trolley Truck

This trolley can manually stair-climbing. With the same goal as the electrical stair climbing trolley, this trolley makes it simple and manageable for one person to transport goods up stairs. This mechanical trolley and the electrical trolley differ in that the electrical one performs all the heavy lifting through the motor and mechanism, whereas the operator of the manual trolley still needs to exert a lot of effort and perform back-breaking labor to lift heavy and awkward objects up stairs. The manual trolley's mechanism, which is visible in the image and allows it to transport large goods up the stairs, travels around the stair steps while it is being dragged up.

This product's key attributes include:

- Free-running pyramid wheels that make installing kerbs simpler
- The trolley is durable
- Foot size: 225 x 330mm
- Carrying capacity = 150kg

The cargo master:

Figure 2 Cargo master

This specific stair-climbing trolley attempts to lessen or completely eradicate health issues and accidents brought on by carrying heavy objects up steps. It also makes it possible for one person to pull big goods up stairs without the aid of a second person. In settings like service delivery, this may be incredibly cost-effective, saving businesses important time and resources. The trolley itself would be adaptable to most stairs because the mechanism for lifting objects up the stairs could theoretically be used on stair types like winding stairs (which would be even harder to manually lift heavy objects up compared to the traditional set of stairs). The mechanism's design makes it possible for the trolley to be utilized on almost any surface while also preventing damage to the step's edge.

The Cargo Master includes an integrated speed control mechanism that allows it to be changed to accommodate varying user preferences (for example, some users may prefer a greater speed setting than a lower one). Additionally, this trolley has a safety brake system installed to guarantee that when it gets near to the edge of a step, the safety brakes may be engaged to stop the operator from advancing any further and, as a consequence, prevent a potential accident, such as the trolley falling down the steps.

A sealed, vapour-proof battery that can be charged by any 240v supply current is what powers the cart. This is a supplementary battery pack that is included with the product along with a vehicle charger so the trolley may be used continually without having to wait for it to recharge. Rubber makes up the trolley's lifting wheels.

As can be seen in the image above, the trolley's mechanism essentially uses an extremely strong motor to push the trolley vertically up to the next level from the previous step.

This product's key attributes include:

- A handle that may be adjusted
- A center of gravity that changes depending on the weight
- The trolley is 27 kg heavy
- The item's measurements are 1060 x 450 x 300 mm
- The toe plate features a folding feature
- The lift can raise things that are 100 kg and 1200 mm high

Stair Robot SR Express:

Figure 3 Stair Robot SR Express

Stair Robot operates differently and has other capabilities, but it fundamentally performs the same function as the load-carrying platform that is the subject of this project. This electrical, battery-powered stair-climbing trolley transfers electricity to a strong motor, allowing the trolley to easily ascend the flight of stairs. This electrical stair climber may be used pretty regularly because it is made for everyday distribution. This specific item was made to be a portable, light-weight stair climber that can support up to 150 kg of weight.

It has two fundamental maneuvers that let the trolley go up and down stairs:

1. Step-by-step.
2. The cart sitting on two or more steps and being put flat on the stairwell.

This specific trolley was made with one operator in mind. With its teeth-shaped wheels that can hold the sides of the steps and allow the trolley to climb them, this cart's design is quite reminiscent of the wheels of a tank or digger.

This product's key attributes include:

- A quick-release battery pack
- Remote control capabilities
- Platform with adjustable height
- Handles with adjustment

3. Overview of methodology

The data collected from the literature review and case studies will be analyzed using qualitative and quantitative methods. Comparative analysis will be conducted to evaluate the efficiency, safety, and cost-effectiveness of load carrying platforms in comparison to other material handling equipment and manual labor. The results of the analysis will be used to identify best practices and guidelines for the selection, use, and maintenance of load carrying platforms.

In order to analyze collected data and prioritize subsystem fishbone analysis methods were used. A fishbone diagram, also known as an Ishikawa diagram or cause-and-effect diagram, can be a useful tool for analyzing the root causes of problems or inefficiencies in load carrying platforms. The fishbone diagram allows you to identify and organize the different factors that contribute to a problem or inefficiency and can help you identify the most important areas to focus on for improvement. For example, if a load carrying platform is experiencing frequent breakdowns, you can use a fishbone diagram to identify potential causes such as inadequate maintenance, operator error, or design flaws.

Issue: Excessive vibration during operation

- Cause: Unbalanced load
- Cause: Worn out or damaged wheels
- Cause: Misalignment of wheels
- Cause: Loose bolts and nuts
- Cause: Faulty motor or transmission

Issue: Reduced load capacity

- Cause: Overloading of platform beyond rated capacity
- Cause: Worn out or damaged wheels
- Cause: Corrosion or deformation of platform frame
- Cause: Faulty hydraulic or pneumatic system
- Cause: Misaligned or damaged bearings

Issue: Inefficient operation

- Cause: Inadequate training of operators
- Cause: Suboptimal platform design for specific application
- Cause: Poor maintenance practices
- Cause: Outdated or malfunctioning control system
- Cause: Environmental factors such as temperature and humidity

Based on the analysis using the fishbone diagram, it can be concluded that the loading subsystem is the most critical factor affecting the efficiency of the load carrying platform.

4. Design of the Electric Load Carrying Platform

4.1 Design Objectives

- Possess the majority or all of the force necessary to ascend a flight of steps
- Able to sustain up to 300 kg of weight
- The device should be comparable in price to a standard consumer-grade hand truck
- Must be ergonomic and user-friendly
- The product's weight must be comparable to that of older models
- In terms of appearance, the product should resemble typical models
- The structure is light
- Toe plate reversibles
- Batteries that are replaceable and rechargeable
- Adjustable handle

4.2 The arrangement of equipment

The arrangement of equipment needed for electrical load carrying platform includes:

1. Electrical load carrying platform: The main equipment for carrying and transporting the load. It can be a pallet, a cart, or a container.
2. Forklift or other lifting equipment: Used to lift and place the load onto the load carrying platform.
3. Conveyors or rollers: Used to move the load from the loading area to the load carrying platform.
4. Pallet jacks: Used to move and position the load carrying platform in the desired location.
5. Strapping equipment: Used to secure the load to the load carrying platform.
6. Safety equipment: Includes barriers, signs, and PPE to ensure the safety of workers and prevent accidents.

4.3 Factors taken into account during design

An actual set of stairs had to be taken into account before beginning the design for the electrical load carrying platform. The writers improved their knowledge of stair terminology and, more crucially, identified the source of the dimensions of steps with the aid of the internet and a few publications that are included in the references. To reduce the risk of tripping or falling, stair proportions must adhere to construction requirements and standards of practice. Negotiating the staircase's form and size is made simpler by the existence of these rules and norms of conduct. Obviously, every staircase in Mongolia does not have the exact same dimensions and merely a different finish.

There shouldn't be more than sixteen rises in a flight of steps. In this situation, the staircase ought to include a landing. This makes sure that if people become exhausted from climbing the 16 stairs, they will have a place to pause where they may safely recover their breath. This deters climbers who have more than 16 steps to stop when they're tired because doing so might cause them to fall and sustain injuries. A stairway must be at least 860mm wide.

4.4 Mechanism

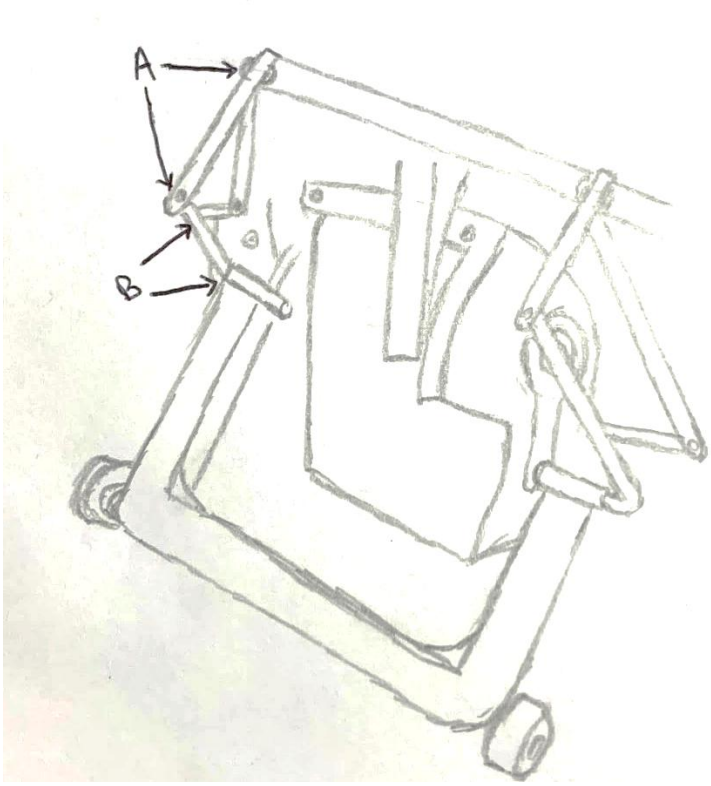

Figure 4 Initial design of the mechanism

The arm that will support the trolley's weight and lift it up the steps is seen in broad strokes in the drawing above. The drawing alone provides a description of how it functions. The bar that is attached (pivoted) to the crossbar of the real trolley is shown at Point A. The mechanism may now travel up and down the y-axis as a result. The big rotating arm and Point A are connected by Point B (A is pivoted off of B, which is pivoted off of the large rotational arm). The capacity to move up and down the x-axis is provided by Point B for the total lifting arm. The overall lifting arm can move up and down the x- and y-axes thanks to the combination of points A and B (which are essentially the main components of the mechanism), which is necessary for the crank of the motor to turn a full 360 degrees while still maintaining stability for the overall lifting arm. Because the load carrying platform trolley needs the proper supports to take into account any imbalances in order to ascend a flight of stairs properly, stability is crucial.

4.5 Design

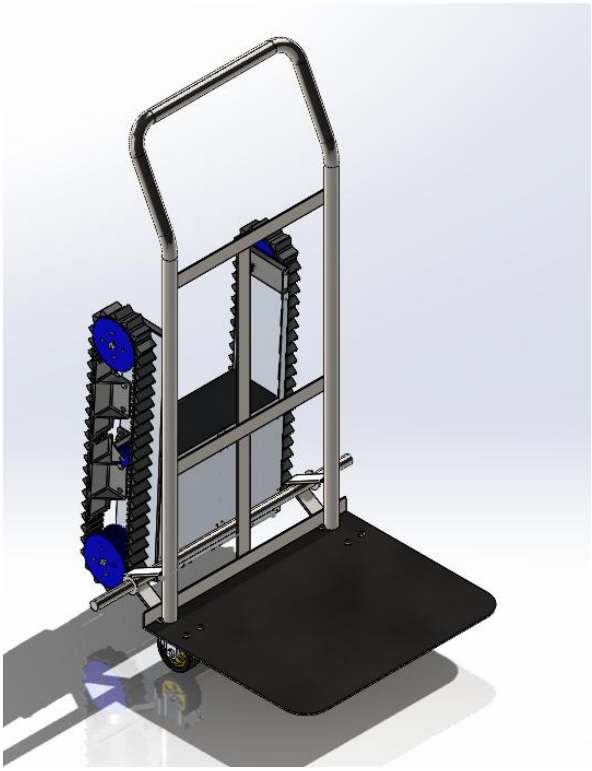

Figure 5 Electrical load carrying platform

The load carrying platform consists of a rectangular base with four wheels attached to its corners for mobility. The base is connected to an arm frame that can rotate 360 degrees and is designed to hold a large amount of weight. The arm frame is supported by a hydraulic lift system that allows it to move up and down, and a set of guide rails that keep the arm frame stable during operation.

Overall, the design of the load carrying platform is focused on versatility, stability, and ease of use, making it an efficient.

Two motors were built into the electrical load carrying platform's design. The motor in use was intended to operate in a single direction. Because of this, it was not as easy as placing the two motors back-to-back to communicate with one another in order to have two of the same motor. Housing has to be developed to lock the two motors in place and align the shafis of the two

motors in addition to aligning the shafts of the two motors. The two motors were mounted within the housing, which was created.

The motor is an electric motor that converts electrical energy into mechanical energy, which is used to drive the wheels of the platform.

The motor is connected to a controller that regulates the speed and direction of the motor. The controller can receive inputs from various sources, including sensors and switches, to control the motor's speed and direction of rotation.

The motor is mounted on the platform's frame and connected to the wheels through a transmission system. The motor's power output and speed rating depend on the platform's size and weight capacity, as well as the desired speed and acceleration of the platform.

4.6 Base

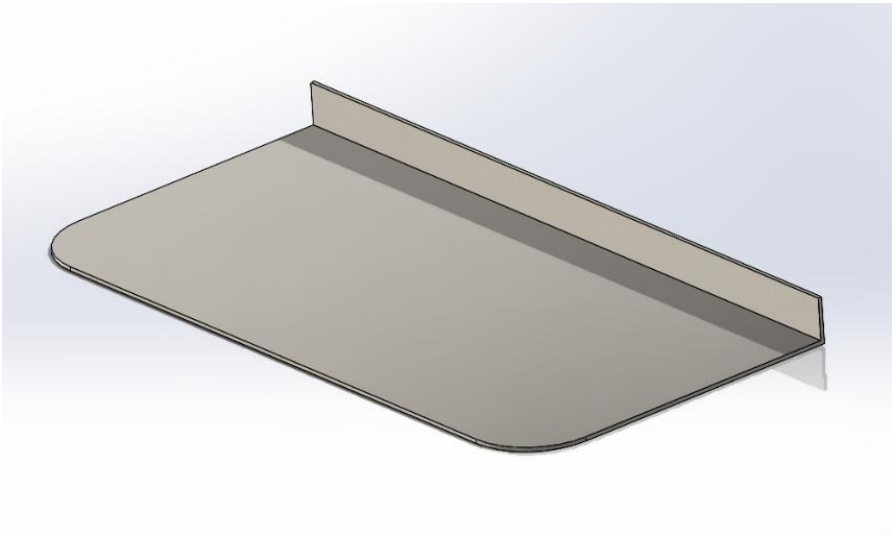

Figure 6 Base

The base's length is 403mm, and its breadth is 500mm. To avoid the base being broader than a set of steps, which would prevent the trolley from being able to climb a set of stairs, these measurements were applied while taking into account a step of an average set of stairs. As it turned out, the base of the trolley was narrower than the 860mm minimum width required for

a set of steps, allowing the trolley to easily ascend and descend the stairs. The going (minimum 220mm) of the step was taken into consideration while applying the length to the base so that the length, which is less than the going, wouldn't be more than the dimension of the going so that the trolley could sit comfortably on the step.

4.7 Arm frame

Figure 7 Arm frame

The arm frame is a rectangular structure mounted on the base of the platform. It consists of two parallel beams running along the length of the platform, connected by cross beams at regular intervals. The arm frame also has a hydraulic cylinder mounted on it, which is used to raise and lower the loading platform. The loading plate is also connected to the hydraulic cylinder, allowing it to be raised or lowered as needed. The arm frame provides stability and structural support to the platform.

The arm frame is designed to be adjustable, with the horizontal and vertical supports capable of being adjusted to accommodate loads of different sizes and weights. Additionally, the base frame is designed to have a low center of gravity to ensure stability while moving heavy loads. The length of the arm is 1016.45mm.

4.8 Wheel

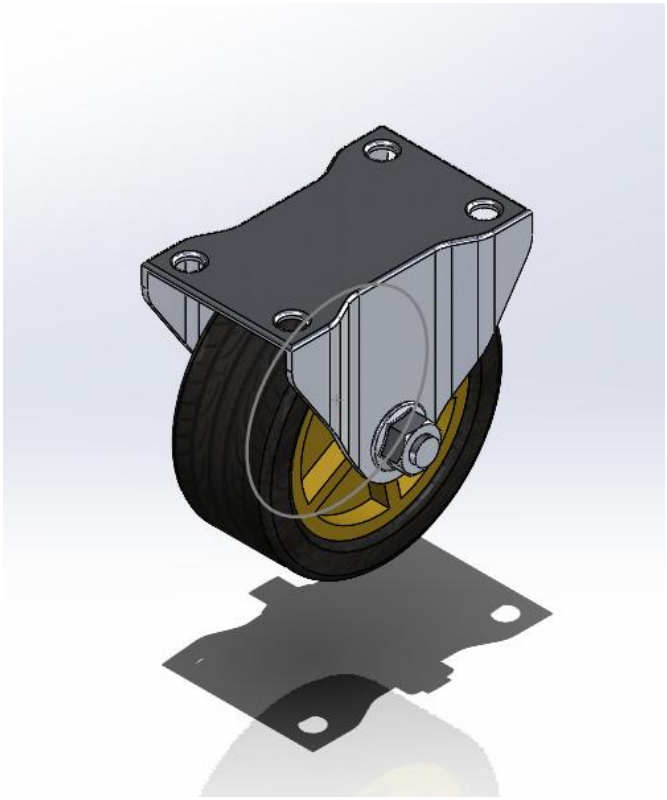

Figure 8 Wheel

The platform is equipped with two large wheels, which enable it to move smoothly over rough terrain. A rubber wheel, commonly used for load-carrying applications. It has a radius of 130mm, which suggests that it can support a relatively heavy load. The wheel has a solid center with one holes, that it is a solid wheel rather than a pneumatic or semi-pneumatic wheel.

The wheel is mounted on a metal hub, which is attached to a bearing assembly. This allows the wheel to rotate freely, reducing friction and allowing for smooth movement of the load-carrying platform. The hub designed for a bolt-on attachment to a load-carrying platform, with multiple bolt holes available to ensure a secure connection.

Overall, the wheel is well-suited for load-carrying applications, with a durable construction and smooth rolling capabilities.

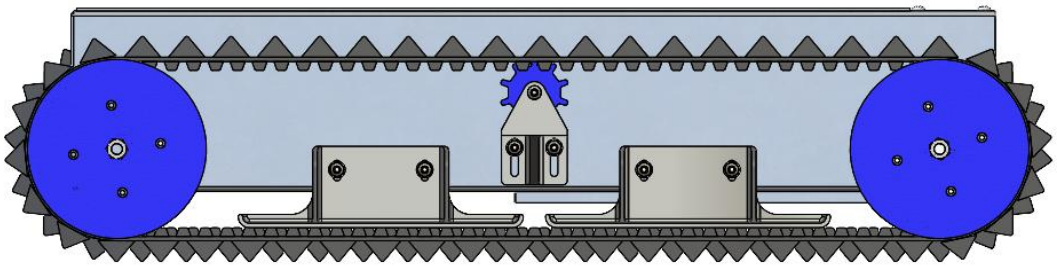

Figure 9 Side of wheel

In addition to the two wheels, the load carrying platform also features a continuous track system at the front. The track consists of several interconnected rubber segments that provide a smooth and stable surface for the platform to move over. The track is also powered by a motor, which drives the segments forward and backward to move the platform in the desired direction. The use of a continuous track system allows the platform to traverse rough and uneven terrain with ease.

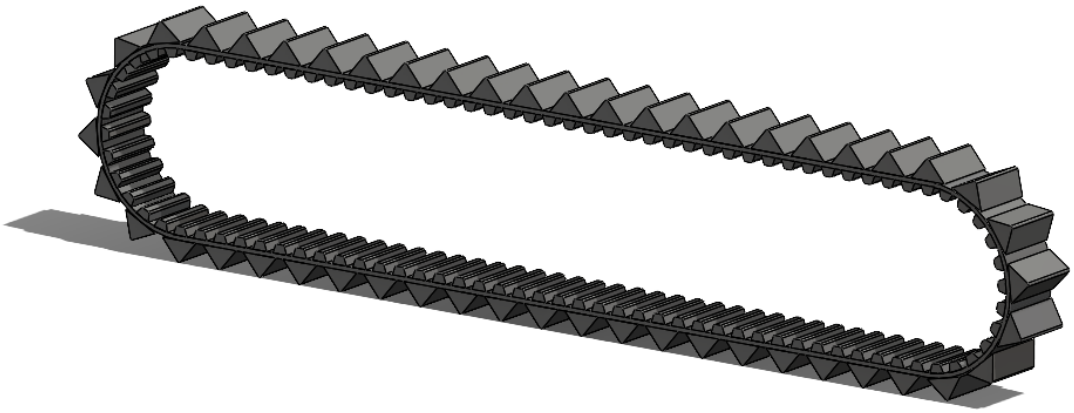

Figure 10 Chain

The metallic component with interlinked links is a chain. The chain is designed to fit onto specific teeth on the sprockets and engage with them to transfer rotational motion. The chain serves as the driving mechanism for the load carrying platform. When the chain is in motion, it causes the platform to move, allowing the transportation of the load.

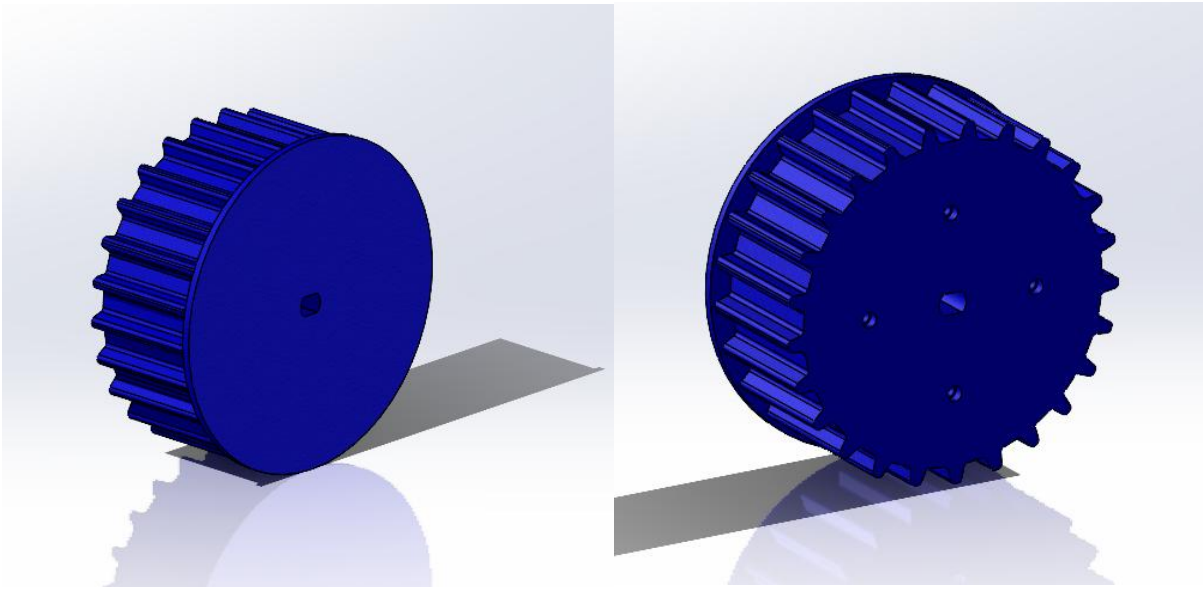

Figure 11 Sprockets

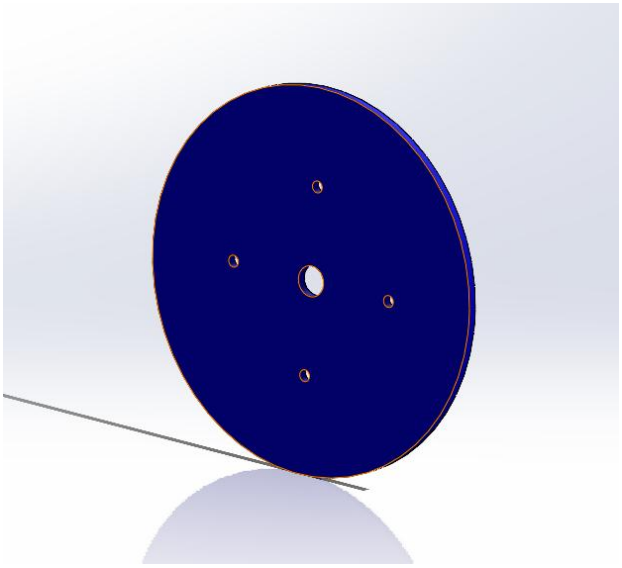

Figure 12 Plug of sprockets

The two circular components in the image are sprockets. They are designed to guide and control the movement of the chain. As the chain rotates around the sprockets, it transfers motion to the load carrying platform, propelling it forward or backward.

4.9 Handle

Figure 13 Handle

The handle to be a simple yet sturdy design that can provide a comfortable grip for the operator. It consists of a straight, cylindrical shape with a textured surface that can enhance the grip, especially in wet or slippery conditions.

The handle made of a durable material, that can withstand the forces and stresses of the load carrying platform's operation. It also has a relatively long length, allowing for a wide range of hand placements and providing flexibility for different operators' heights and preferences.

Additionally, the handle attached securely to the frame of the load carrying platform, ensuring stability and safety during use. The handle is also designed to be adjustable, with the height and angle of the grip able to be modified to suit the operator's preferences. It also have additional features, such as a brake lever or emergency stop button, to enhance the safety and control of the platform.

4.10 Axis

Figure 14 Axis

The axis is the component that provides rotational motion to the wheels. The axis is mounted horizontally between the base arms of the platform, and it is driven by an electric motor through a chain drive mechanism. The axis is supported by bearings at each end, which allow it to rotate freely and smoothly. The axis is also designed to be adjustable, allowing the position of the wheels to be changed to optimize the platform's stability and maneuverability.

The axis is typically mounted within a set of bearings or bushings that allow for smooth rotation and reduce friction. These bearings sealed to prevent contamination from dirt and debris, which could damage the axis and reduce its lifespan. The axis designed to allow for easy lubrication to ensure that it continues to rotate smoothly over time.

4.11 Motor

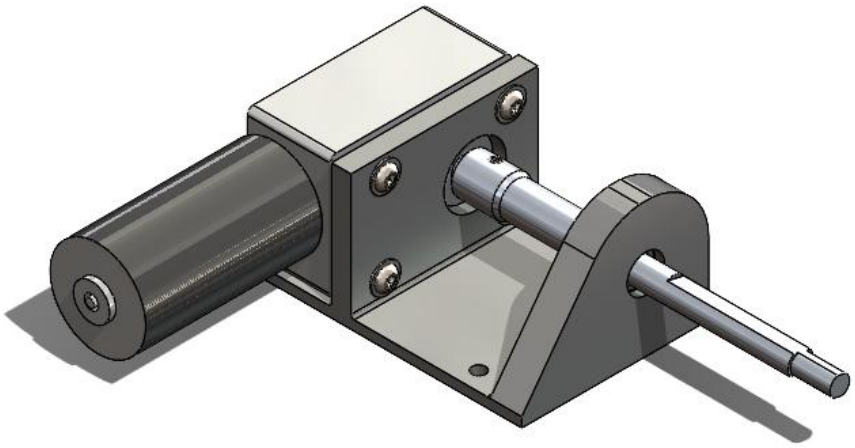

Figure 15 Motor

1. Motor Housing: The metal casing surrounding the motor components is known as the motor housing. It provides protection and support for the internal components of the motor.
2. Shaft: The central rod-like structure protruding from the motor housing is the motor shaft. The shaft is responsible for transmitting rotational motion from the motor to an external device or load.
3. Wiring and Connectors: There are visible wires and connectors attached to the motor. These wires are used to supply electrical power to the motor and facilitate its operation.
4. Mounting Brackets: The metal brackets or arms attached to the motor housing are mounting brackets. These brackets are used to secure the motor to a frame, structure, or other mounting surfaces.

I had to determine the force required to move a weight up the stairs in order to choose a motor. Force is transmitted through the little tires at the ends of the arms down the body when the arms push the load up the weight. Since the safety factor was assumed to be 4, 100 kg was determined to be the minimum weight it could lift. The power output was initially calculated using the time (3 sec) required to push the weight.

The rise height of 220mm was used to compute the force initially:

M = 100kg g = $9.81\frac{m}{s^2}$ h = 220mm

F = M*g

F = 981N

Then using the arm length 30cm, i discovered the motor's torque operating at the joint of the arm:

d = 30cm F = 981N

T = F * d

T = 294.3J

The angular velocity was calculated using the assumption that there would be 40 steps to climb and that it would take one rotation to ascend each step. The power required for the motor was then determined using angular velocity and torque as follows:

$\omega = 40RPM$

$$\omega = \frac{40 \cdot 2\pi}{60}\frac{rad}{s} = 4.189\frac{1}{s}$$

P = T * ω

P = 1232W

As seen above, any motor with a power output more than 1232W can be utilized.

Motor Type Selection:

1. DC motor

   Advantages:

   - Speed control: Specific switches that allow you to change the DC motor's rotational speed between greater and lower rates. Keeping in mind that the ascent of the stair step cannot be done either too quickly or too slowly.
   - High starting torque: The starting torque of DC motors is high. This will be crucial for a steady start while lifting a load that weighs about 100 kg. To lift the large weight up the stairs, we need a beginning torque that might be up to 500% more than the regular working torques.
   - The torque of a DC motor remains constant across a specific speed range even when the speed decreases.

   Disadvantages:

   - High initial cost.
   - DC motors utilize commuter and brush kits, both of which are prone to damage. As a result, there will be an increase in maintenance costs, and eventually it will need to be completely replaced.
   - Dust will be produced as a consequence of commuting and brush wear and tear.
   - Due of the DC motor's flashing, it cannot be utilized in explosive or dangerous environments.

   Applications where a DC motor is used:
   In general, DC motors are utilized in electric trains, cranes, paper mills, steel mills, and paper mills. Electric trains are the ideal illustration of a beginning torque since they require a lot of torque, which the DC motor provides.

2. AC motor

   Advantages:

   - An AC motor's manufacture is straightforward.
   - The cost of purchase is low.
   - An AC motor is trustworthy.

   Disadvantages:

   - Usually only applied at a set pace. In comparison to a DC motor, an AC motor may be exceedingly difficult to apply a variable speed function to. If it were done in this manner, an extra cost would also be incurred (for example, multiple winding or a gearbox).

   Applications where an AC motor is used:

   Fans, washing machine compressors, audio turntables, etc. commonly employ AC motors. It is obvious from examining the benefits and drawbacks that the DC motor is the ideal motor to be used with the electronic stair climbing trolley. The following step is to research the various types of DC motors that are available.

3. Two main types of DC motors

   Brush:

   Due to the DC power being delivered to the DC motor, the motor generates torque.

   Internal commutation, stationary magnets (which may be permanent or electromagnets), and whirling electrical magnets are used to achieve this. Lorentz force causes the generation of torque, which is true for all electrical motors and generators. According to the Lorentz force, any current-carrying conductor will suffer torque when it is put inside of an external magnetic field.

   Advantages:

   - The cost of purchase is low.
   - The motors are really dependable.
   - The motor's speed is easily controllable.

Disadvantages:

- Extensive maintenance is necessary, including replacing the brushes and springs that transport the electrical current. The commutator may also need to be cleaned or, in certain cases, replaced.
- The lifespan of the motor will be drastically reduced if it is used continuously.

Brushless:

This motor functions like a DC motor but is actually an AC motor with an integrated electronic controller. In order to prevent misunderstanding, it is referred to as a DC motor.

Both a fixed electrical magnet present on the motor's casing and a rotating magnet, sometimes known as a soft magnet core, are used by the brushless motor to rotate. The motor that converts DC to AC has a controller attached to it. The brushless motor is simpler in design than the brush motor. This is due to the disregard for how difficult it is to transmit power from the motor's outside to the revolving rotor.

Advantages:

- The life of this motor is considerable.
- The maintenance needed for this motor is minimal to nonexistent.
- High performance.
-

Disadvantages:

- They are pricey to purchase.
- Compared to the brush motor, the speed regulation is significantly more sophisticated.

The DC brush motor (with the permanent magnet) was selected among the two types of DC motors that were previously investigated to be modified for this load carrying platform. This choice was made based on how both motors operate, their benefits and drawbacks, and it was determined that a permanent magnet was the best option.

4.12 Battery

I determined the current required to drive the motor using the power and voltage (24%).

The equation is as follows:

V = 24V P = 821.841W

P = I * V

$I = \frac{P}{V}$

I = 34.243A

kWh was computed using the current and voltage:

P = I * V

P_1 = A * V

P_1 = 24W

The charge was determined using the current and the shortest amount of time the battery could run:

I = 34.243A t = $\frac{20}{60}$hr

I = Q * t

Q = I * t

Q = 4.109 * 10^4C

The aforementioned charge was translated to amp hours and computed by:

$$Ah = \frac{Q}{3600} = 11.414C$$

It was discovered that a battery with a minimum capacity of 10.7 Ah was required to power the current motor for 20 minutes. As a result, it was determined to purchase two 12V 5Ah sealed lead acid batteries that will provide the following time:

$I = 34.243A \quad Q = 10Ah$

$t = Q * I$

$$t = \frac{Q}{I}$$

$t = 17.52min$

It was determined to move forward with this because it was an acceptable time.

Electric vehicles are powered by rechargeable batteries known as EV batteries, or electric vehicle batteries. These batteries are made to hold electrical energy and supply it to an electric motor, which moves the wheels.

In order to provide the necessary voltage and capacity, EV batteries are often constructed from a number of cells that are linked together in series or parallel. Lithium-ion or nickel-metal hydride (NiMH) chemistry make up the actual cells, with lithium-ion being more prevalent.

There are 2 types of lithium batteries in common. The first type employs a mixture of either nickel, manganese, cobalt, and aluminum (NMCA) or nickel, manganese, cobalt, and aluminum (NMC). Higher energy densities (energy per weight or energy per volume) are present in these batteries, but they also have a higher propensity to oxidize (catch fire) in the event of a severe short circuit or collision. Lithium-iron-phosphate, sometimes referred to as LFP, is the second variety and is much more frequently utilized in China. Because iron-

phosphate cells have a far lower energy density than NMC-based batteries, bigger batteries are required to produce the same amount of energy (and hence driving range). The lithium-ion battery is the most popular type of battery used in EVs since it has a high energy density and a long lifespan. These batteries are made up of a number of cells, each with an around 3.6 volt nominal voltage.

5. Discussion

Choosing the right material for a load-carrying platform is important to ensure its reliability and durability. The material should be strong enough to support the weight of the load while also being resistant to wear and tear. Additionally, the material should be lightweight to minimize the overall weight of the platform. One common material used for load-carrying platforms is aluminum. Aluminum is lightweight yet strong, and it has good corrosion resistance. It is also easy to machine, which makes it ideal for manufacturing complex parts such as the arm frame and the base.

Another material option is steel, which is known for its strength and durability. However, it is heavier than aluminum, which can increase the weight of the platform. Stainless steel is also an option, as it is corrosion-resistant and has good strength properties. Even though it had a higher yield strength than aluminium, but aluminium as it was widely available and provided more ease with, so it is better to use aluminum.

The incorporation of high-strength aluminum alloy, wheels, plug, and the axis mechanism provides enhanced load-carrying capacity and maneuverability, making it a valuable asset for various industries.

The electrical load carrying platform design incorporates several components and features that are critical to its overall functionality. The use of a four-wheel drive system ensures that the platform can move in all directions, while the continuous track mechanism provides additional traction and stability. The use of a motor and batteries to power the platform allows for efficient and reliable transportation of goods.

The design also includes a handle for easy maneuverability and an arm frame for supporting the load. The axis mechanism provides stability and allows for smooth movement of the platform.

In the end, the design well thought out and capable of effectively carrying heavy loads through challenging terrain.

6. Recommendation

If the project is to be expanded further, the following additional tasks will be carried out:

1. Performance Testing: Conduct thorough performance testing to ensure that the load carrying platform meets the desired specifications and can effectively handle the intended load capacity. This testing should include simulations of different operating conditions and terrains to assess its performance and reliability.

2. Safety Features: Incorporate additional safety features into the design, such as emergency stop buttons, warning signals, and safety harness attachment points. These measures will help ensure the safety of operators and bystanders during operation.

3. Ergonomics: Consider the ergonomics of the platform, especially the handle and controls. Design them in a way that minimizes operator fatigue and allows for comfortable and intuitive operation over extended periods.

4. Maintenance and Serviceability: Design the platform with ease of maintenance and serviceability in mind. This includes accessible components, clear maintenance instructions, and replaceable parts that are readily available in case of breakdowns or wear and tear.

5. Environmental Considerations: Evaluate the environmental impact of the electrical load carrying platform, such as its energy consumption, emissions, and potential for recyclability. Explore ways to optimize its energy efficiency and reduce its environmental footprint.

6. Cost Optimization: Continuously explore opportunities for cost optimization without compromising safety and performance. This could include evaluating alternative materials, manufacturing processes, or sourcing options to achieve the desired balance between cost-effectiveness and quality.

7. Conclusion

In conclusion, the design of the electric load carrying platform presented in this thesis offers a promising solution for efficiently and safely transporting heavy loads in challenging terrains. Through detailed analysis and evaluation, it has been determined that the load carrying platform exhibits notable advantages in terms of load-carrying capacity, stability, and operator convenience.

Overall, this thesis presents a comprehensive overview of the load carrying platform design, highlighting its potential benefits and suggesting areas for further research and development. With continuous improvement and implementation of the recommended measures, the load carrying platform holds great promise in various industries that require efficient and reliable transportation of heavy loads.

It is recommended that further testing and validation of the load carrying platform be conducted under various operating conditions and terrains to assess its performance and reliability. Additionally, incorporating advanced safety features and exploring energy-efficient and environmentally friendly options can enhance the platform's overall value.

With continuous improvement and refinement, the platform has the potential to benefit industries that require effective material handling in diverse operational settings.

8. Reference

1. *Commonly Used Statistics | Occupational Safety and Health Administration*. (n.d.). https://www.osha.gov/data/commonstats
2. https://www.aatasia.com.my:443/product/cargomaster-c141/. (n.d.). *CargoMaster C141*. https://www.aatasia.com.my/product/cargomaster-c141/
3. *Post & Packing*. (n.d.). https://huntoffice.co.uk/ease-e-load-stair-climber-trolley-truck-carrying-capacity100kg-204850.html
4. *Stair Robot Stair Climber - Materials Handling*. (2018, October 14). Materials Handling. https://www.materialshandling.com.au/products/stair-robot/
5. https://research.vu.nl/ws/files/42147643/complete%20dissertation.pdf
6. Skipper Plasmoid, Saliscale - Zonzini s.r.l. (n.d.). https://www.zonzini.us/electric-stair-climbers-for-goods/electric-stair-climbing-hand-truck-skipper-plasmoid
7. Startseite. (n.d.). Sano Transportgeraete GmbH. https://www.sano-stairclimbers.com/
8. David Finney, 1991, Variable frequency AC motor Drive system
9. Austin Hughes, 2006, Electric Motors and Drives Third

10. Saeed B.Niku, 2010, Introduction to Robotics Second
11. AC Motor VS DC Motor | Difference with Advantage and Disadvantage. (n.d.). ETechnoG - Electrical, Electronics, and Technology. https://www.etechnog.com/2019/01/ac-motor-vs-dc-motor-difference-with.html
12. https://www.slideshare.net/ShiyasBasheer1/stair-climbing-hand-truck
13. Jworth. (2022, April 28). AC vs. DC Motors: What's the Difference? - Renown Electric. Renown Electric. https://renown-electric.com/blog/ac-vs-dc-motors-whats-the-difference/
14. Slanger, D. (2023). The EV Battery Supply Chain Explained. RMI. https://rmi.org/the-ev-battery-supply-chain-explained/

9. Appendix

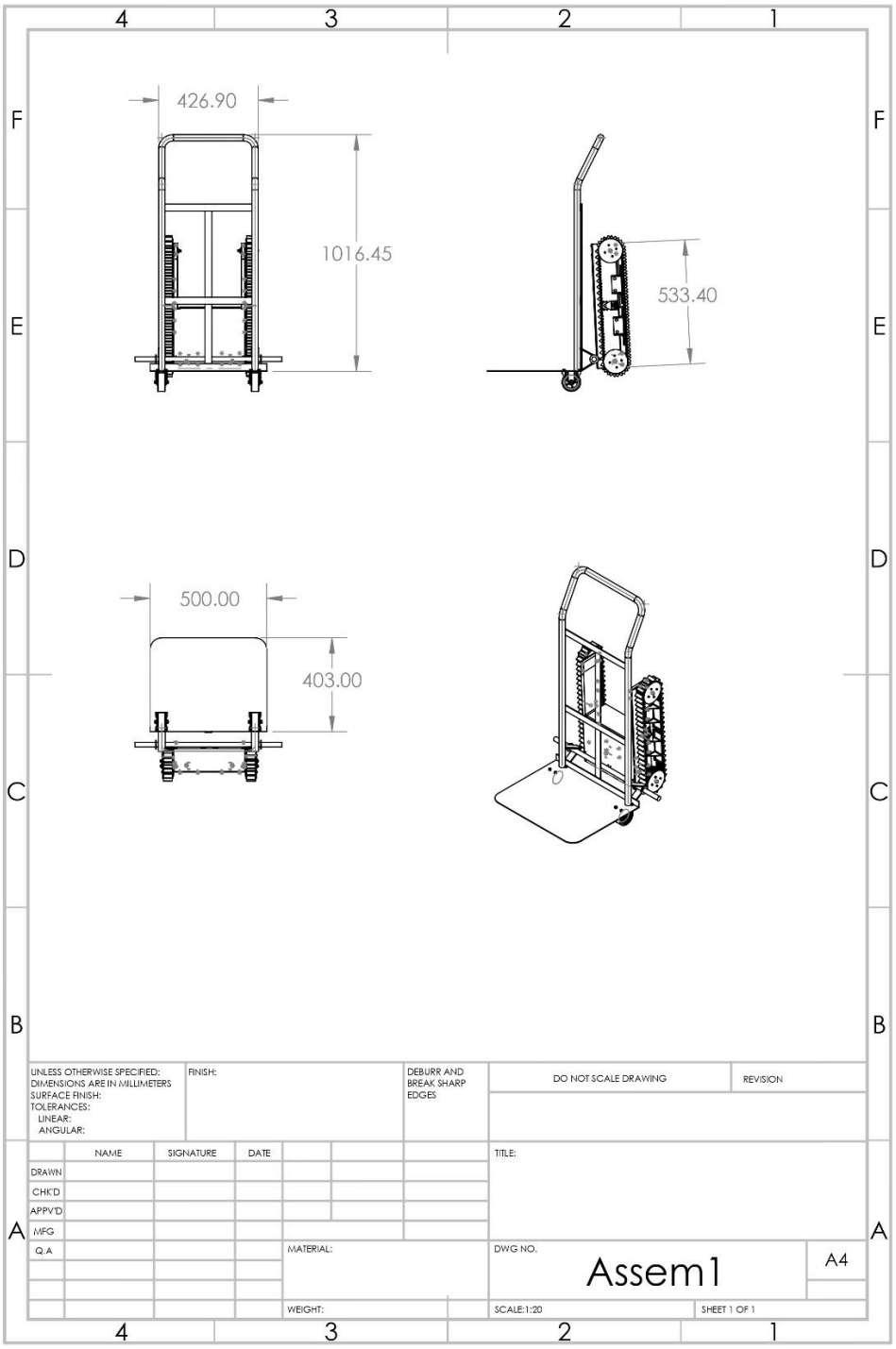

Figure 16 Electric load carrying platform full assembly

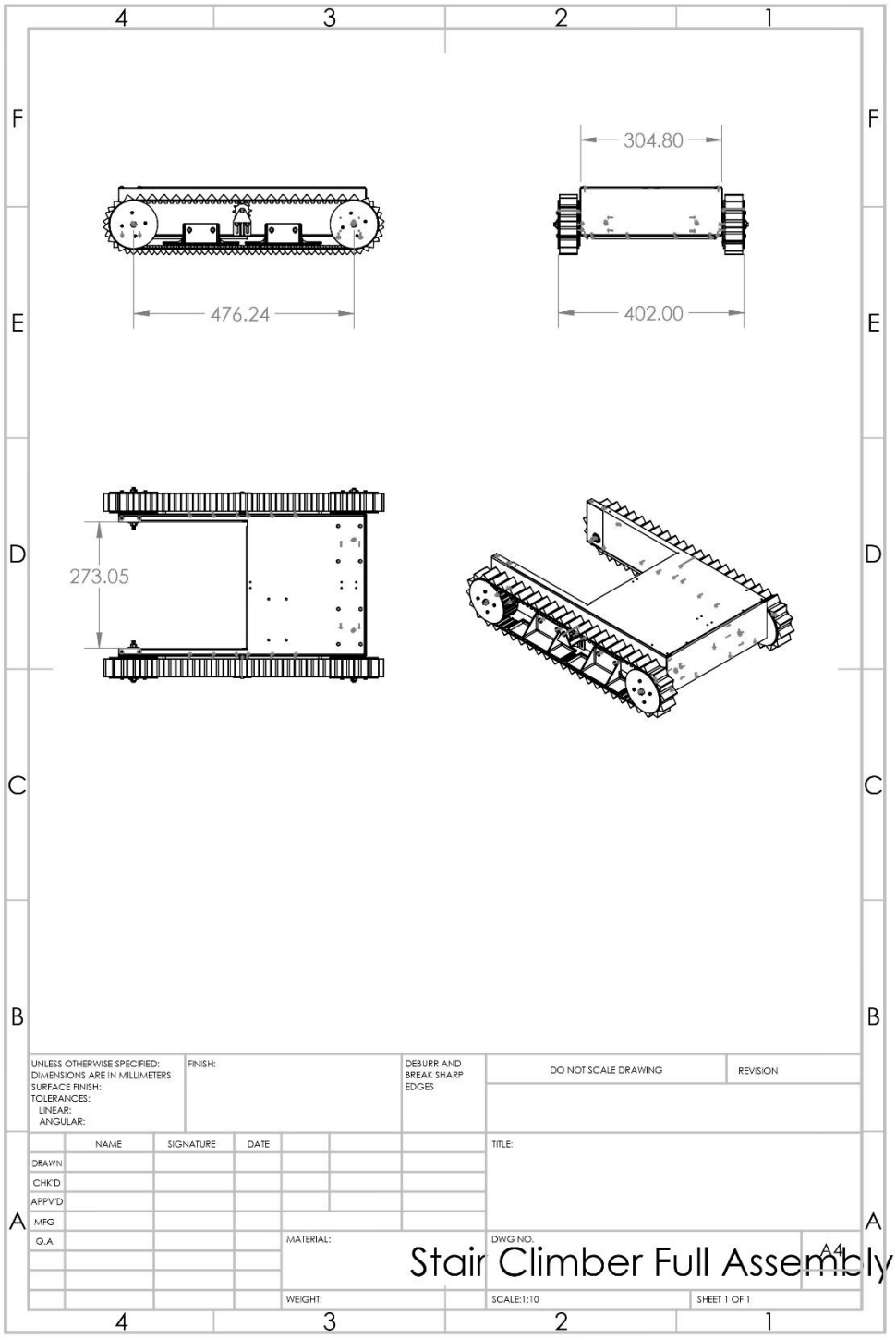

Figure 17 Stair climber full assembly

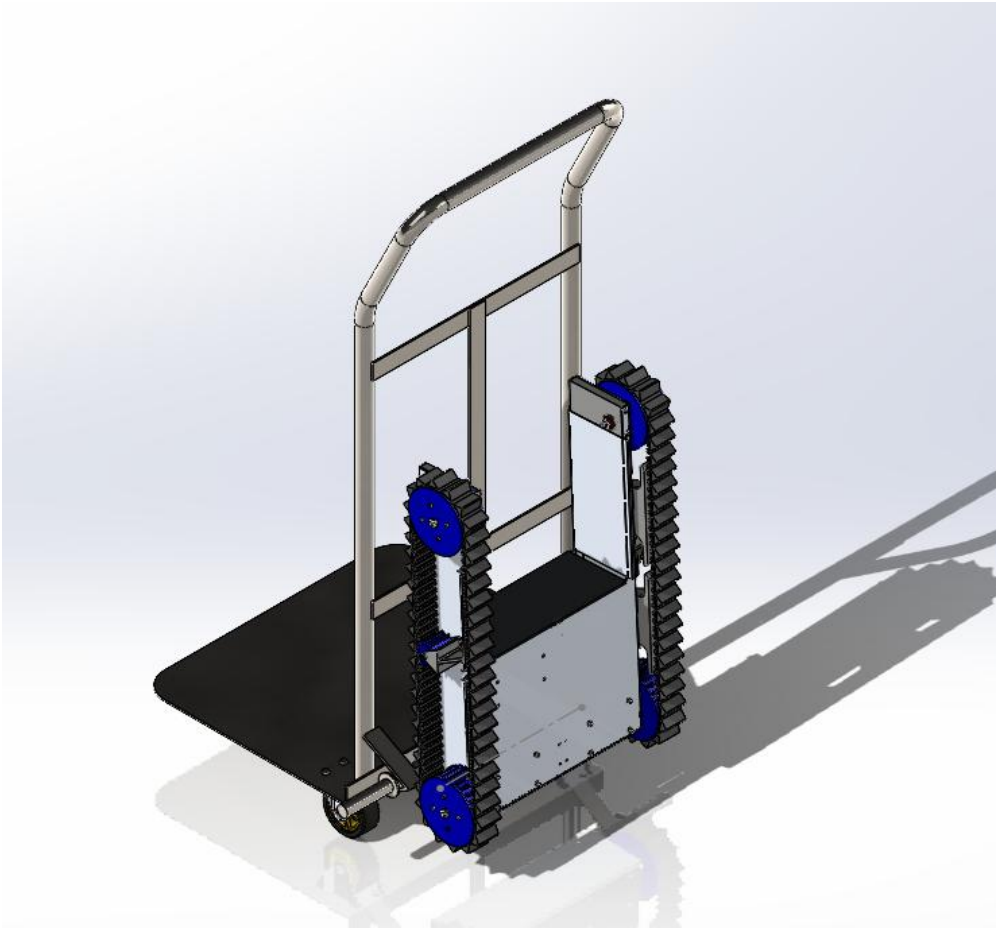

Figure 18 Electric load carrying platform(back side)

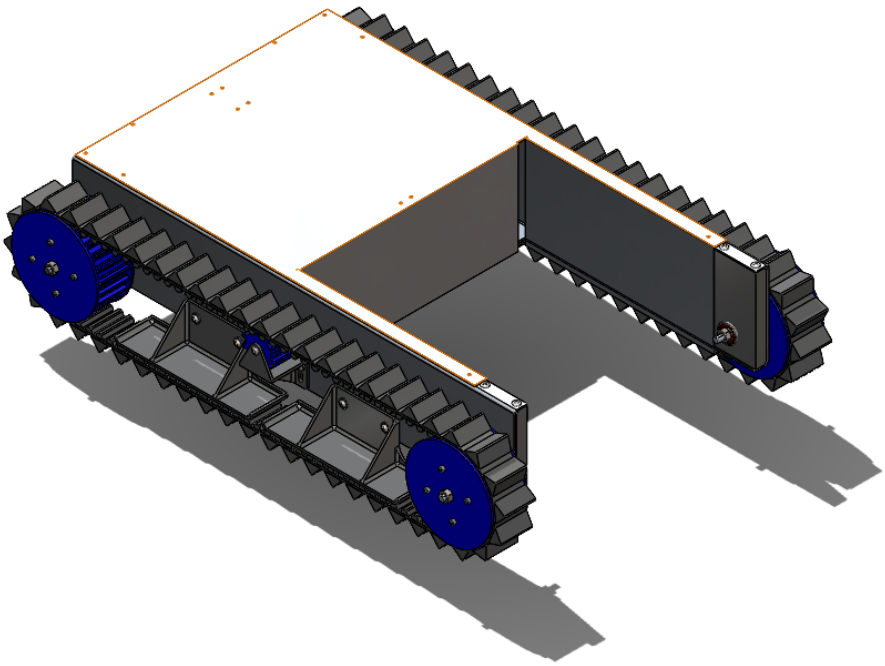

Figure 19 Stair climber

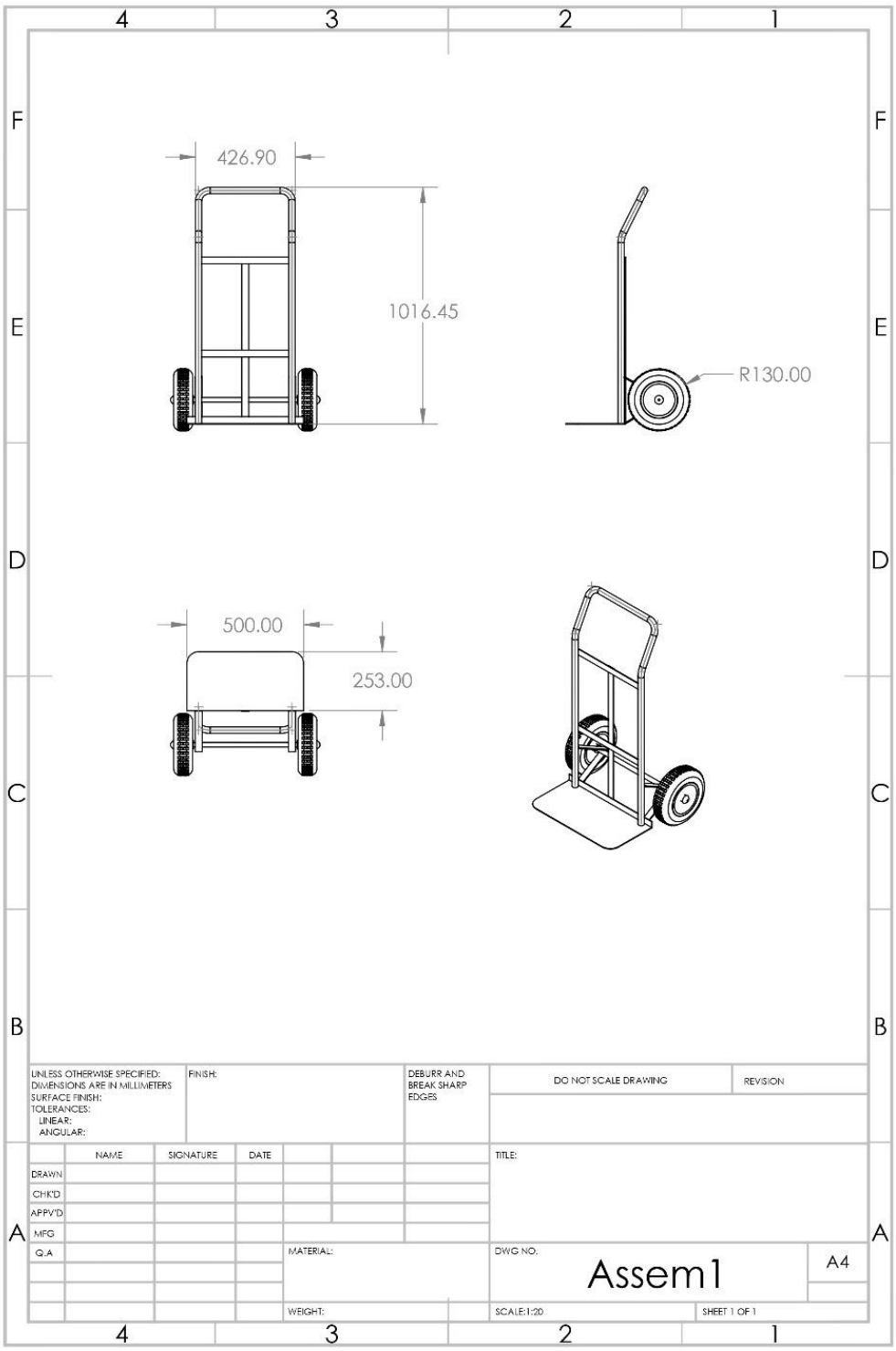

Figure 20 Initial design full assembly

Figure 21 Initial design