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Design and Fabrication of Portable Cableway System for Efficient Transportation of Agricultural Commodities

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Abstract: In order to enhance productivity on the farms and reduce post-harvest losses, agricultural commodities must be transported efficiently. In order to overcome the difficulties of manual transport in various agricultural commodities like Banana, Tender Coconut, Jack fruit this project proposes the creation of a portable cableway system. The implementation of a reinforced tripod stand, which improves stability and load-bearing capacity over conventional frame structures, is a significant feature of this system. This design greatly increases the system's adaptability by enabling dependable operation on uneven terrain. High-tensile cables, pulleys, a motorized or manual hauling mechanism, and a lightweight yet robust frame make up the system. The tripod structure ensures dependability and durability by preventing structural deformation under various loads. By lowering labour dependency and increasing transportation efficiency, this innovation seeks to assist small and medium-sized farmers.
Keywords: Portable cableway system, agricultural commodities, post-harvest losses, reinforced tripod stand, load-bearing capacity, uneven terrain, stability, transportation efficiency, small and medium-sized farmers.

I. INTRODUCTION

A. Overview of the system

Optimizing farm productivity and reducing post-harvest losses depend critically on the effective transportation of agricultural products, especially for small and medium-sized farmers working over varied landscapes. Often labour-intensive, time-consuming, and prone to loss from spillage or spoilage, traditional manual transportation techniques are This project presents a portable cableway system meant for the effective movement of harvested crops, fertilizers, and other agricultural products in order to handle these difficulties. The structural design of the system is a major innovation; it has a reinforced tripod stand that greatly improves load-bearing capacity and stability over traditional frame construction. Overcoming the constraints of conventional systems, this tripod configuration guarantees dependability on sloped or uneven fields. Supported by a lightweight yet strong frame, the cableway system combines high-tensile cables, pulleys, and a motorized or manual hauling mechanism to ensure both portability and durability. Particularly in areas with inadequate infrastructure, this system seeks to increase general farm efficiency and support the economic sustainability of agricultural operations by lowering labour dependency and streamlining transportation systems.

B. Objectives

1) To Design and develop a portable cableway for efficient agricultural transport.
2) To Integrate a tripod stand to enhance stability and strength.
3) To Reduce manual labor and minimize post-harvest losses.
4) To Ensure adaptability with an easy-to-assemble and scalable design.
5) To enhance farmer accessibility by developing an affordable and user-friendly transportation solution for small and medium-scale farmers.
6) To contribute to agricultural innovation by integrating modern engineering principles into farm logistics for better productivity.

II. LITERATURE SURVEY

The study examines the difficulties Indian farmers face in the twenty-first century, especially the lack of labor, and how cableway systems are used for transportation and material handling. In order to ensure successful use for numerous farmers, it employs a bi-cable system for sugarcane producers in Tamilnadu State and emphasizes the advantages of both mono- and bi-cable systems [11]. In order to optimize crop handling logistics, the study creates a classical mechanics model for the effective transportation of banana bunches via a cableway system and assesses its real-world applications in Trujillo, Venezuela [9]. The study emphasizes sustainable mechanization as a workable, cost-effective, and farmer-friendly substitute by highlighting the benefits of automation and mechanized equipment in raising productivity, lowering labor costs, and preventing losses [7].

Despite advancements in food production over the past 50 years, the article addresses the difficulties in ensuring long-term food security in developing nations, especially Nigeria. In order to connect producers and consumers, lower costs, and increase agricultural productivity, it highlights the significance of agricultural output to GDP and labor force employment as well as the necessity of efficient transportation systems [1]. Highlights international initiatives to minimize food waste in the fresh fruit and vegetable sector. It draws attention to the ethical, social, environmental, and greenhouse gas emissions caused by food losses. Additionally, specific causes of food losses are identified in the paper, including problems with handling, storage, and transportation [6]. Describes how to properly handle, store, and transport bananas after harvest in order to preserve their freshness and food safety. It draws attention to the necessity of appropriate infrastructure and minimal handling in order to stop deterioration. By using weight sensors and motorized pulleys, the project seeks to increase the efficiency, quality, and safety of banana transportation [5]. The review highlights aerial ropeways as a workable solution to the problems associated with moving building materials over steep terrain. The history of ropeway systems, their application in both passenger and freight transportation, design methodologies, and the influence of tonnage on cable selection for stability and wear reduction are all covered [2]. Aerial ropeways offer social, technological, and financial benefits for urban transportation infrastructure, with minimal environmental impact. They require continuous improvement for full potential. Mobile aerial rope systems are being developed for rapid deployment. However, construction costs can be expensive due to budget constraints and regulations [8]. Examines the dynamic properties of soil, emphasizing its importance in geotechnical engineering, foundation design, seismic design, site response analysis, earthquake liquefaction risk assessment, and soil modelling. Using studies and tests such as the Resonant Column Test and the Cyclic Triaxial Test, it investigates shear modulus and damping ratio [4]. For the infrastructure of urban transportation, passenger ropeways provide social, technological, and financial advantages. They minimize their impact on the environment and use electric energy. To reach their full potential, however, new designs incorporating automatic control systems and mechatronic movement modules are required [3]. explains the difficulties in constructing and maintaining overhead transmission lines, especially in areas with difficult topography. For greater efficiency, it recommends using cableway transportation systems, which just need ropes to be installed [10].

III. METHODOLOGY

A. *Materials:*

1) Rope – The **10mm wire rope** used in the cableway system is a **6×19 stranded steel rope**, providing **high strength and flexibility** for efficient load transportation. It ensures **durability and stability**, handling **shock loads and dynamic stresses** during movement.
2) Trolley **-** The cableway system's hook-equipped trolley makes it possible to transport agricultural products safely and smoothly. Its ball-bearing wheels guarantee smooth travel along the steel rope. In order to prevent load slippage during transit, the heavy-duty hook offers a firm grip.
3) Tripod Frame **-** Stability and strength are guaranteed for effective load transportation by the tripod frame with support in the cableway system. Its three-legged design prevents tilting and structural failure by distributing weight evenly. Constructed from aluminum or high strength steel, it can endure harsh conditions and heavy loads.
4) Nylon rope **-** In the cableway system, the nylon rope rotates to move the pulley effectively and smoothly. Its strong yet lightweight design guarantees flexibility and durability while in use. It improves system efficiency and lowers energy loss due to its high wear resistance and low friction. The trolley can move continuously and precisely along the cableway thanks to the rotating motion.
5) Pulley **-** Both the nylon and wire ropes are supported and move smoothly because of the cableway's pulleys system. One pulley holds the wire rope securely, ensuring stability and load-bearing capacity. Another rotating pulley guides the nylon rope, enabling continuous motion for efficient transportation. These pulleys, which are made of sturdy materials like nylon or steel, lessen wear and friction.

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6) Motor - The **DC motor** in the cableway system provides efficient and controlled power **for** smooth load transportation. With high torque output, it ensures steady movement of the trolley along the wire rope. Its energy efficient operation reduces power consumption while maintaining reliable performance. The motor's speed control feature allows precise adjustments for different load conditions**.**

B. Methods:

1) Construction:

Based on its high tensile strength and corrosion resistance, galvanized mild steel (MS), which has a diameter of 10 mm, the steel wire rope used in the cableway system. The rope is made of six by nineteen strands. To guarantee consistent load-bearing capacity and decreased elongation, the rope is pre-stretched and heat-treated. The trolley's rigid frame is created by shaping and welding mild steel plates and rods. It can roll along the steel wire rope with the help of two pulley wheels with grooves at the top. For hanging agricultural loads, a detachable hook (length: 345 mm, top diameter: 40 mm, shank diameter: 20 mm) is either bolted or attached at the bottom.

Despite its small size, the trolley is sturdy enough to hold up to 150 kg of weight. Ball bearings are installed on the pulleys to lessen rolling friction. The system uses high-strength synthetic nylon rope, which has a diameter of roughly 8 to 10 mm. It is selected due to its flexibility, abrasion resistance, and high tensile load capacity. The motor-controlled forward and backward motion can be handled by the rope. It can tolerate weather and UV rays in agricultural fields. MS hollow circular pipes are used to construct the tripod frames of 1800 mm on either end of the system. These pipes are then welded together to create a sturdy triangular structure that is five feet which is roughly 1.5 meters high.

To support pulleys and motor mounting, each tripod has three 800mm legs: two for the front and one for the back. The legs are joined at the top with a horizontal bar. To keep it from falling over while in use, the tripod's base is equipped with plates for weighting or ground anchoring. There are two kinds of pulleys in use: Steel Rope Support Pulleys These have ball bearings in the middle and grooved rims, and they are constructed from mild steel or cast iron.

To support and direct the steel wire rope, they are placed at the top of each tripod stand. Nylon Rope Pulleys are used to route the driving nylon rope, these pulleys are lighter and composed of aluminium or nylon-reinforced plastic. These are mounted and connected to the motor in a way that keeps the loop aligned for fluid motion. The nylon rope is driven by a DC motor (12V–24V) connected to a pulley. The motor can run forward or backwards thanks to an H-Bridge driver circuit constructed with MOSFETs. The STM32 microcontroller that powers the H-Bridge controls the current direction by sending GPIO signals. To prevent rope misalignment, the motor is positioned with the pulley and fastened to the tripod frame using bolted brackets. An M32 mild steel bolt and nut with a 2 mm pitch, custom-made using lathe operations like turning, threading, and tapping, make up the ratchet system.

The steel wire rope can be manually tightened because of this mechanism. The rope goes through a clamp that is attached to the nut, and the bolt is fastened to the tripod structure. The tension in the steel rope gradually increases as the nut is tightened. The middle support pole, which is about five feet tall and marginally shorter than the tripods, is constructed of MS pipe. It has a U-shaped saddle or groove on top to support the steel rope, and it is positioned in the middle of the span, three meters from each tripod. For rigidity, bolts and mechanical anchors are used to secure the base to the ground. This pole keeps the wire rope from sagging too much and keeps it aligned while being loaded.

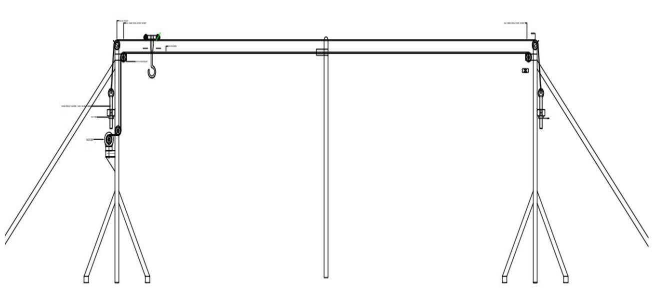

Fig. 1 CAD Design of Cableway system

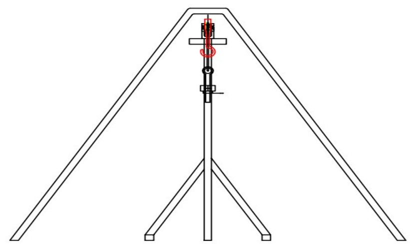

Fig. 2 CAD Design of Tripod frame

Problem Identification

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Designing and CAD Modelling

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Material Selection

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Fabrication of Components

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System Assembly and Installation

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Testing Under Various Loads

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Performance Evaluation

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Conclusion

Fig. 3 Methodology

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2) Working:

By combining steel wire rope, nylon rope, pulley systems, and a motorized drive mechanism, the cableway transportation system uses a straightforward but incredibly efficient mechanical motion principle. The steel wire rope, which serves as the pulley trolley's main load-bearing track, is the essential functional component. This rope is tensioned over a 6-meter span between two sturdy tripod support frames, each about 5 feet high, and is composed of high-tensile galvanized steel with a 10 mm diameter and a 6x19 strand configuration.

A ratchet-based tightening mechanism is fixed at one end of the cable, allowing for fine tension adjustments to guarantee constant tautness and reduce sag. The trolley system travels along the steel wire rope with the help of a detachable MS hook and grooved pulleys set on ball bearings. This hook is made to safely transport heavy and bulky agricultural products like bananas, and jackfruits. A closed-loop nylon rope that is attached to both ends of the trolley and passes through guide pulleys mounted on the tripods controls the movement of the vehicle. To enable the trolley to move forward or backward along the cableway, a DC motor powered by an H-Bridge motor driver circuit with MOSFETs rotates the nylon rope in either direction.

Digital control over trolley movement is made possible by the H-Bridge, which allows bidirectional current flow to the motor in response to commands from an STM32 microcontroller. While retaining enough tensile strength for controlled movement, the use of nylon rope as the driving medium guarantees flexibility, decreased weight, and resistance to corrosion. In order to prevent cable sag and preserve alignment under dynamic loads, a middle support pole is also placed strategically at the middle of the span. The trolley is pulled along the tensioned steel cable by the nylon rope, which is driven by the motor through a pulley system. The weight distribution across the wire rope and the aligned pulley grooves provides for a smooth motion.

In situations where traditional road-based logistics are impractical, this system offers a practical and energy-efficient way to transport harvested agricultural produce over uneven or hilly terrain. It is a practical solution for rural and isolated agricultural areas because of its mechanical design and embedded control, which guarantee dependable operation with minimal energy consumption. The system's practicality and long-term usability in actual farming environments are further enhanced by the modular design's scalability and ease of maintenance.

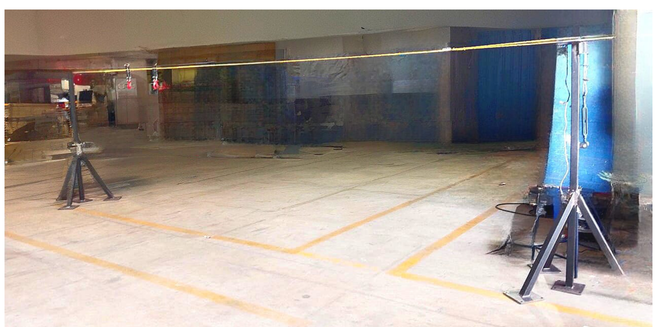

Fig. 4 Cableway system

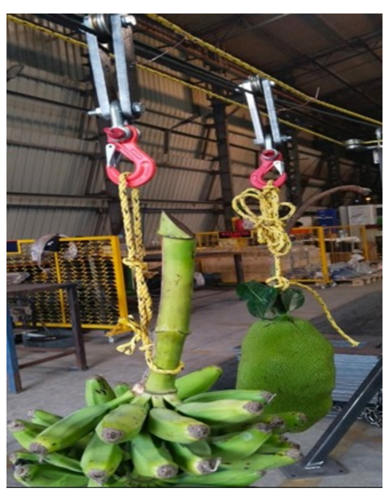

Fig. 5 Load Carrying

IV. RESULT AND DISCUSSION

Transporting several types of agricultural products under various load conditions allowed for an evaluation of the portable cableway system's performance. Tender coconuts, jackfruit, and banana bunches all typical heavy farm products were included in the test loads. Transport time, cable sag, and trolley stability tests were performed on each commodity. The assessment helped in identifying the impact of load fluctuations on system performance. The analysis observed that slower cable way movement and longer transport times were caused by heavier products. Additionally, the steel rope sagged under heavier weights. The system continued to function even after the tensioning mechanism was slightly modified. The findings imply that concentrating on speed, tensioning mechanism could increase the effectiveness of the system.

Table 5.1 For Banana Bunch

S.NO	WEIGHT (Kg)	TIME TAKEN (S)
1.	5.8	20
2.	7	22.3
3.	6.2	21.8
4.	14	35

Table 5.2 For Jack Fruit

S.NO	WEIGHT (Kg)	TIME TAKEN (S)
1.	4.48	18
2.	6.57	22
3.	8.53	26
4.	12	31.4

Table 5.3 For Tender Coconut

S.NO	WEIGHT (Kg)	TIME TAKEN (S)
1.	6.5	23.8
2.	8	29.4
3.	11.7	32
4.	16	39.7

V. CONCLUSION

Throughout several trials, the system operated consistently and effectively while transporting loads. Heavy loads caused some sag and decreased speed, but modifications to the tensioning mechanism allowed for safe operation to continue. The trolley's controlled and energy-efficient movement was made possible by the use of a brushed DC motor. Additionally, testing verified that the system is lightweight, terrain-adaptable, and simple to assemble. All things considered, the cableway system provides a dependable and farmer-friendly solution that lowers manual labour, minimizes losses after harvest, and improves transportation efficiency. The system has the potential to be widely used in small and medium-sized agricultural operations with additional optimization in automation, structural design, and speed control.

VI. FUTURE SCOPE

1) Use a mobile app or remote device to start, stop, and reverse the trolley remotely by integrating wireless or Internet of Things-based controls.
2) To increase the cableway's sustainability and usability in remote, off-grid locations, a solar-powered charging system can be added.
3) Adding safety features like overload sensors, automatic slack detection systems, and emergency stop mechanisms would improve the cableway system's dependability and security, particularly when moving heavy produce in big quantities.
4) The process could be further streamlined by integrating robotics or AI-based automation for product loading and unloading, which would decrease manual labor and increase overall operational efficiency.
5) Create a standardized hook or latch system that works with different kinds of crates or baskets for different kinds of crops.

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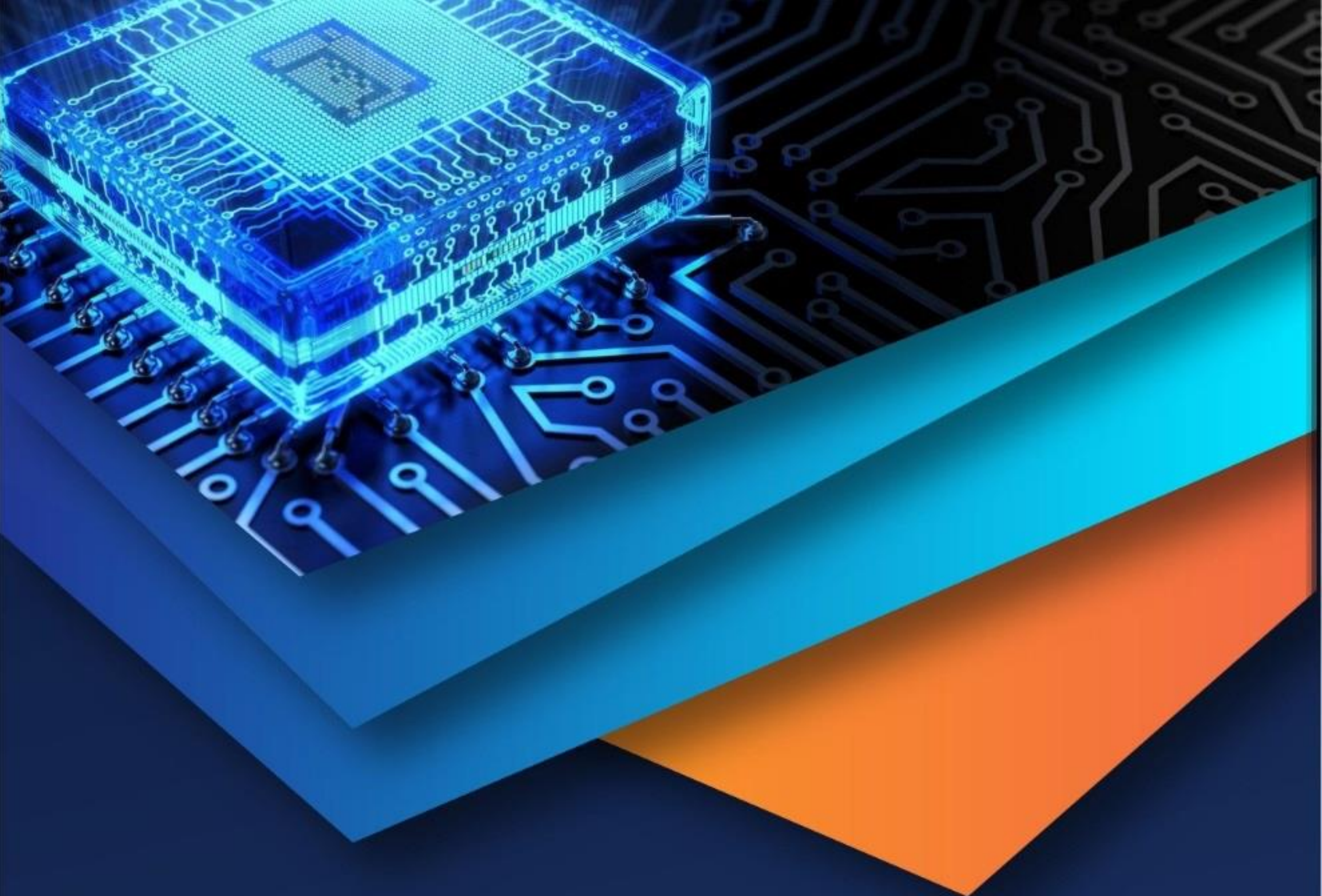

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