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Design And Analysis Of Hanger Irrigation System

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ABSTRACT— The goal of the research is to gauge how well the hanger irrigation system works. The major objective of developing the hanger irrigation system was to balance the continual supply of water. Regardless of the size of the holding, irrigation is the foundation of agriculture. Since the first five-year plan, enormous efforts have been undertaken to extend the irrigated area through the building of several surface irrigation projects and through ground water resources. Utilising SolidWorks software, the hanger irrigation system's CAD design will involve the assembling of many pieces. ANSYS 19 software will be used for pivot spray irrigation system vibration analysis. The model is well-fitted and able to withstand vibrations, according to the findings of the modal analysis, which were favourable.

KEYWORDS— IRRIGATION, SOLIDWORKS, ANSYS 19.

I. INTRODUCTION

Irrigation is a critical component of agriculture, especially in arid in dry regions with little to no rainfall, inadequate to support crop growth. Irrigation helps to provide the necessary water for crop growth, ensuring higher yields and greater food security. In addition to increasing crop yields, irrigation can also improve the overall quality of crops, as water stress can result in poor quality and lower market value .[1]

Inefficient irrigation practices, however, can lead to water wastage, soil degradation, and reduced crop yields .[2] Hence, there is a need for sustainable irrigation practices that can efficiently utilize the available water resources while maximizing crop yields. Sustainable irrigation techniques can lessen agricultural systems' vulnerability to the damaging consequences and climate change of agriculture on the environment. [3]

One approach to sustainable irrigation practices is through the use of modern irrigation techniques, such drip irrigation, both center pivot irrigation and sprinkler irrigation. These systems can help to reduce water wastage, improve the efficiency of water use, and maximize crop yields. [4] However, there is still a need for further research to optimize the design and performance of these irrigation systems. Therefore there is a need to develop irrigation techniques that use water more efficiently and reduce water wastage, which is critical in areas where water resources are limited. The necessity of irrigation methods is crucial to achieve sustainable agriculture as well as food safety. Innovative irrigation techniques can help to increase crop yields, conserve water resources, and minimize environmental impact.

The design and analysis of hanger irrigation systems are one of such innovative techniques that can contribute to achieving these goals. So there is need for further research to improve its efficiency, reduce cost, and develop an optimal design.

Previous studies have focused on the emergence of drip as well as center pivot irrigation systems for specific crops and soil types, such as cotton and sandy soils.[5] However, there is a lack of research on the modal analysis of hanger irrigation systems, which can help to improve their durability and sustainability. Using the powerful technique of modal analysis, structural engineers may analyse a structure's dynamic behaviour to identify its inherent frequencies and mode shapes.[6]

It is required to determine the optimal distance between the hangers and the irrigation pipes, the optimal size of the irrigation pipes, and the optimal spacing between the irrigation pipes. Such a model can help to reduce water wastage, improve crop yields, and increase the overall efficiency of the hanger irrigation system.

Therefore, the research on the design and analysis of the hanger irrigation system is important to address these research gaps and optimize the design and performance of this irrigation system. In this research paper, we aim to develop the design of a hanger irrigation system and conduct a modal analysis of the system to assess its performance and sustainability.

The hanger irrigation system is a relatively new technology that involves hanging irrigation pipes or hoses from a horizontal support structure. This allows for a uniform distribution of water to crops while reducing water loss due to evaporation and runoff. However, the design of the hanger irrigation system is critical to ensuring proper water distribution and maximizing crop yield.

The first part of this study involves the design of the hanger irrigation system. The design process includes selecting the appropriate materials for the irrigation pipes or hoses, determining the spacing and height of the horizontal support structure.

The second part of the study involves the modal analysis of the hanger irrigation system. By determining a system's inherent frequencies and modes of vibration, the dynamic behaviour of the system is assessed using the modal analysis technique. Through modal analysis, we can identify potential structural weaknesses and assess the sustainability of the hanger irrigation system.

The findings of this study will offer insightful knowledge into the planning and evaluation of hanger irrigation systems, with possible uses in sustainable agriculture. The hanger irrigation system has the potential to increase the economic viability of agriculture while minimising its environmental effect by using less water and producing more crops.

II. LITERATURE REVIEW

S. Garrido et al. [7]. Author of this literature review discusses pivot sprinklers. In this study, a two Rotating Spray Plate Sprinklers and Fixed Spray Plate Sprinkler were examined for their wind drift, wetted diameter and dynamic water application profile, static water precipitation pattern and evaporation losses (WDEL). An experimental irrigation system resembling a pivot section was constructed in order to conduct research in both dynamic and static modes. While RSPS produced triangular patterns or bell-shaped, FSPS typically produced bi-modal patterns when water was applied. At 2.4 m nozzle height and 140 kPa operating pressure, the wetted diameter of RSPS was 1.6 m greater than the FSPS's. There were 0.5 Mon the variations between the two RSPS.

Emanuele Baifus Mankea et al. [8] When operated correctly, the mechanical lateral-move irrigation system may achieve a high irrigation efficiency. However, operational and environmental conditions may cause WDEL, or wind drift and evaporation losses, during irrigation. It was necessary to determine the WDEL under various climatic conditions for a mechanical lateral-move irrigation system (I-Wob) fully equipped with oscillating plate sprinklers. Create a model to calculate the WDEL of a mechanical lateral-move irrigation system with an oscillating plate, and assess how well eight known WDEL models predict WDEL when compared to field data for the entire mechanical lateral-move irrigation system.

R. Delirhasannia et al. [9] To imitate the pattern of water application on a field irrigated with a centre pivot, a single stationary spray sprinkler exposed to the wind was calculated. A dynamic square grid of cells for applying water and a static square grid of cells for collecting it were both specified in the model. The dynamic grid tracked the movement of the centre pivot lateral and held data on the water application pattern of a lone spray sprinkler. The dynamic grid delivered water at predetermined intervals to the static grid, which represented the whole field. The irrigation uniformity measurements (travelling route, global and radial) and applied water distribution pattern were model outputs. Simultaneously, a number of tests were carried out utilising pivoting and single spray sprinklers.

Momtanu Chakraborty et al. [10] In this essay, the author discusses how maize cultivation uses a centre irrigation system. Both agricultural yield and irrigation effectiveness may be increased by using irrigation management and related precision technology. To assist farmers make an educated choice about investing in the system, several aspects must be taken into account when selecting an irrigation system. Understanding the impacts of irrigation treatment using multispectral and thermal images data from small UAS was successful. MESA watered regions showed stronger growth and cooler canopies throughout the season than LESA. The agricultural damage caused by sprinkler heads in LESA was also able to be found using the tiny UAS footage. These strips showed greater temperature gradients and lesser vigour (lower NDVI). If not discovered, such damage would be undetectable by ground reconnaissance techniques. This clarifies the usage of pictures produced by small UAS in the assessment of field research techniques. Based on the results of the study, we encourage further investigation into the best centre pivot irrigation system for producing maize in the state of Washington utilising a variety of sprinkler head designs.

M. SHIVA SHANKAR et al. [11] Regardless of the size of the holding, irrigation is the foundation of agriculture. Since the first five-year plan, enormous efforts have been undertaken to extend the irrigated area through the building of several surface irrigation projects and through ground water resources. As a result, the area that is irrigated has virtually doubled during 1950–1951. Currently, of the 139.9 M ha of net seeded land, about 45.2% (63.2 M ha) is irrigated, and the remaining 54.8% is sown under the conditions of rainfed sowing (MoA, 2009–10). Only 40% of water can be used efficiently using the current methods. Agriculture's long-term viability is under danger due to the indiscriminate, unscientific, and wasteful use of water throughout the years. Due to a growing population, unusual weather patterns, the depletion of groundwater supplies, and increased competition from the household and industrial sectors, utilisable water resources for agriculture are becoming increasingly scarce.

Nezar A. Mostafa et al. [12] This study aimed to evaluate the performance of three center pivot sprinkler irrigation systems, P, Q, and R, on the high terrace soil of a farm in River Nile State and Atbara. Catch-can studies were brought out to assess the efficacy of irrigation provided using center pivot sprinkler irrigation systems in agricultural contexts. The coefficient of application efficiency (AE), distribution uniformity (DU) and uniformity (CU) were chosen as performance indicators. The performance metrics DU, AE and CU were calculated using the Centre Pivot irrigation Model (CPM) and the average application depth (AgD). According to the findings of the field assessment, the three systems, P, Q, and R, had AEs of 79.7, 92.1, and 92.9%, DUs of 49.1, 71.6, and 87.1%, and CUs of 77.7, 84.1, and 92.5%, respectively.

III. DESIGN OF SYSTEM

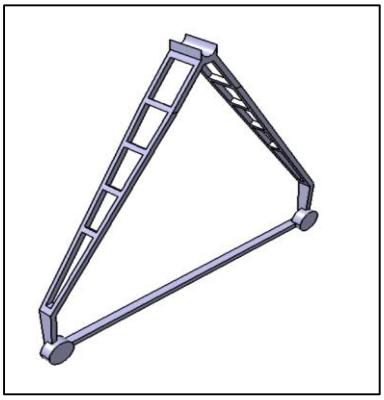


Fig.1 Frame

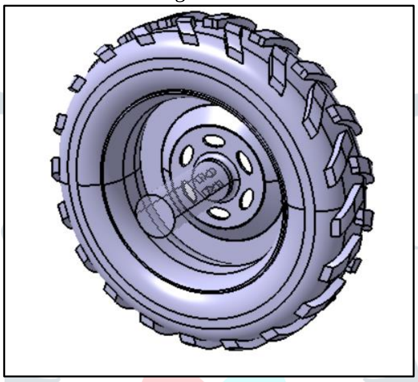


Fig.2 Wheel

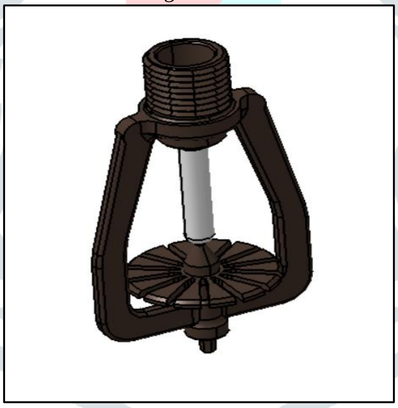


Fig.3 Water Sprinkle

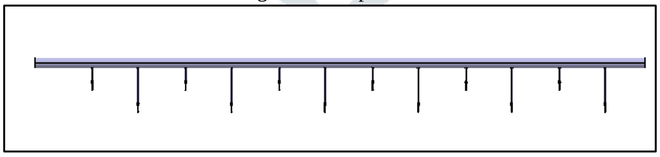
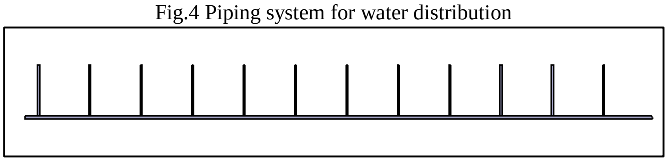
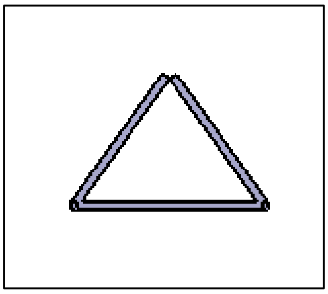


Fig.4 Piping system for water distribution





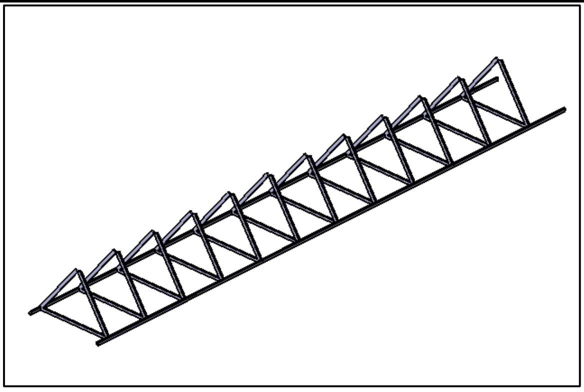


Fig.5 Supporting members

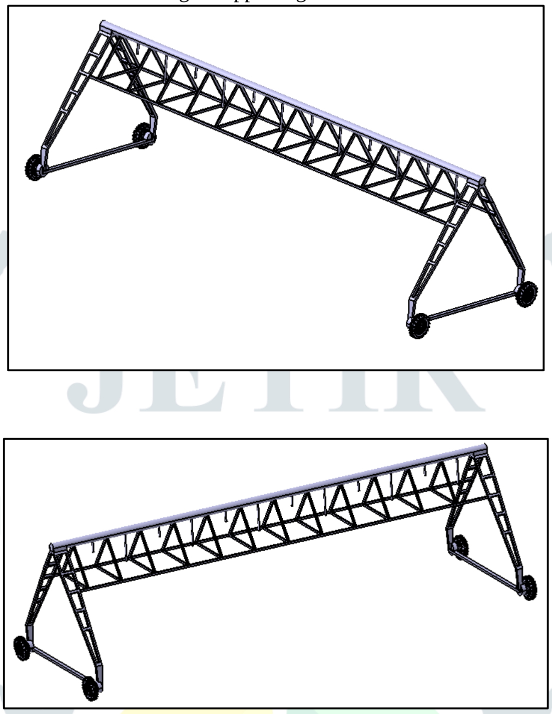


Fig.6 CAD model assembly for hanger irrigation system

A. Basic Calculation

Water Pump Calculation:
For Hanger Irrigation System,
Force acting on wheel = 3000N
Radius of wheel = 450mm = 0.45 m
Required Torque is,
T = Force * Radius
T = 3000 * 0.45
T = 1350 N-m
Required energy – 0.75kW
Motor torque calculated -- 3000 rpm
On the basic of above calculation, energy required to move the system is 0.75 kW. Therefore, a 1 HP electric motor was selected to provide the necessary power for the system.

Pipe size – 12.25 inch
Water flow rate – 972222 mm3 / s
The following formula is used to determine the power directly used for gearbox of pumped fluid energy:
$Pn = \rho * g * Q$
$= 1000 \times 9.81 \times 0.036 \times 5.5$
Pn = 1942.38 Watts

Where,
Pn – power,
Q – flow rate in m3/s,
H – overall head
g – acceleration due to gravity, m/s2,
ρ – pumped medium's density, in kg/m3

IV. MODAL ANALYSIS OF EXISTING MODEL

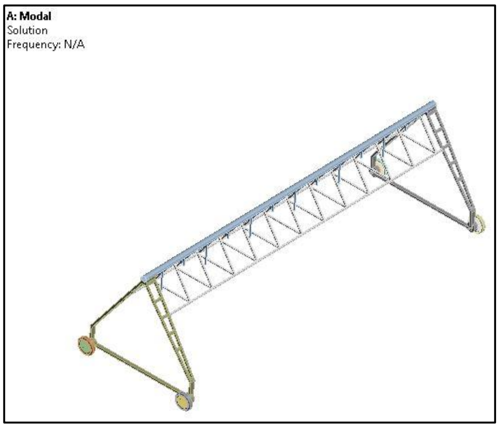


Fig.7 Geometry imported in ANSYS

A. Mesh

ANSYS A high-performance, adaptable, intelligent, automated product is coming together. In order to produce accurate, efficient multi-physics solutions, it produces the best mesh available. A mesh that is ideal for a certain study may be built for any portion of a model with only one mouse click. Full control over the settings used to create the mesh is offered to the skilled user who wants to adjust it. By utilising the power of parallel computing, you can automatically reduce the time it takes to create a mesh.

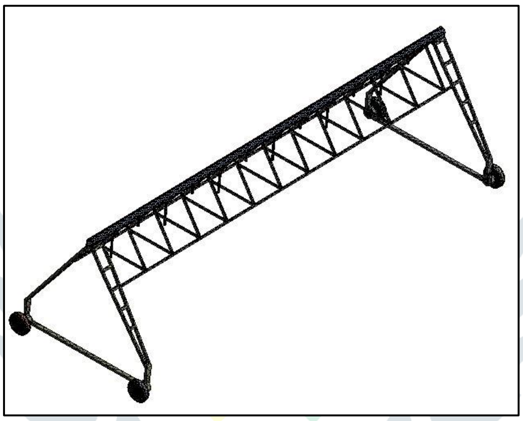


Fig.8 Meshing of Model

B. Boundary Condition

A model's boundary condition is the determination of a known value for a displacement or a related load. You can only set the load or displacement, not both, for a given node.

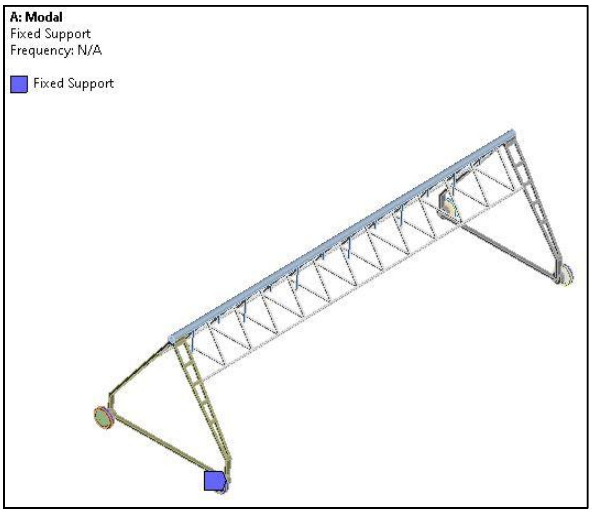


Fig.9 Boundary condition

V. RESULTS AND DISCUSSIONS

A. Modal Analysis (Mode Shape Result Of Structural Steel)

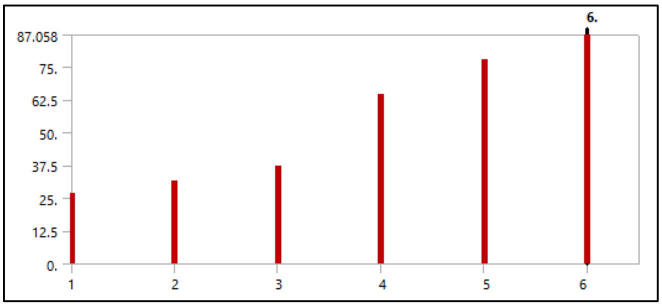


Fig.10 Graph displaying the structure's natural frequency

TABLE NO - I

Sr.no	Mode	Frequency(Hz)
1	1.	26.855
2	2.	31.383
3	3.	37.048
4	4.	64.619
5	5.	77.648
6	6.	87.058

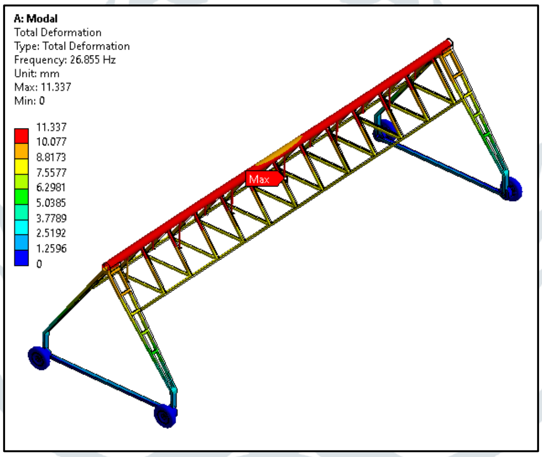


Fig.11 Fundamental Frequency of mode shape 1 is 26.855 Hz

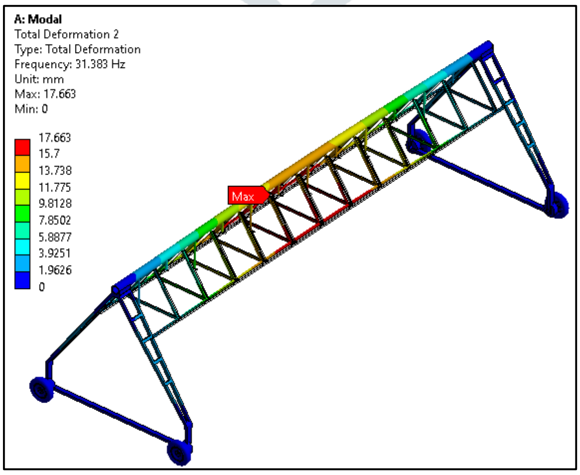


Fig.12 Fundamental Frequency of mode shape 2 is 31.383 Hz

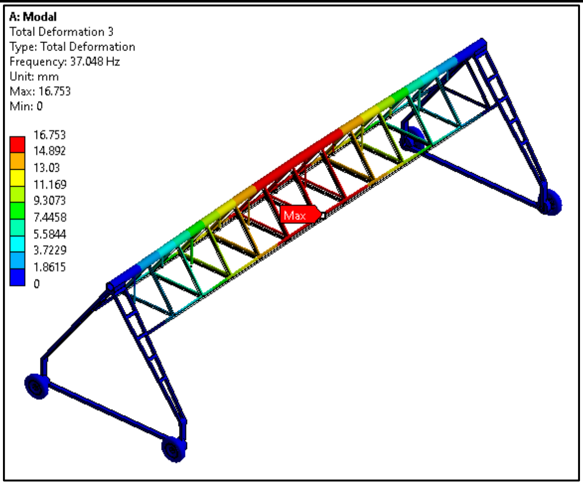


Fig.13 Fundamental Frequency of mode shape 3 is 37.048 Hz

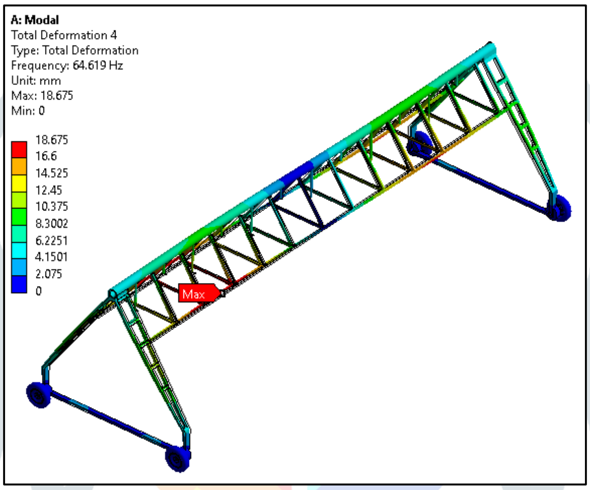


Fig.14 Fundamental Frequency of mode shape 4 is 64.619 Hz

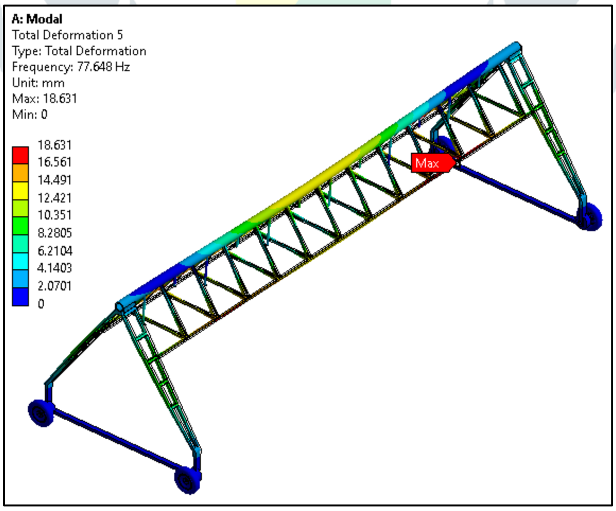


Fig.15 Fundamental Frequency of mode shape 5 is 77.648 Hz

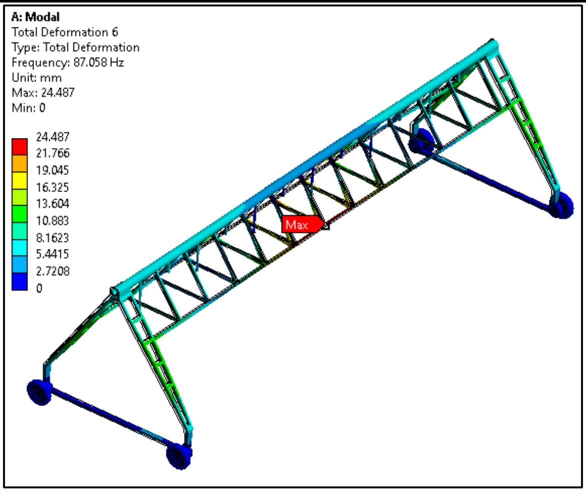


Fig.16 Fundamental Frequency of mode shape 6 is 87.058 Hz

B. *Modal Analysis On Bamboo Fibre*

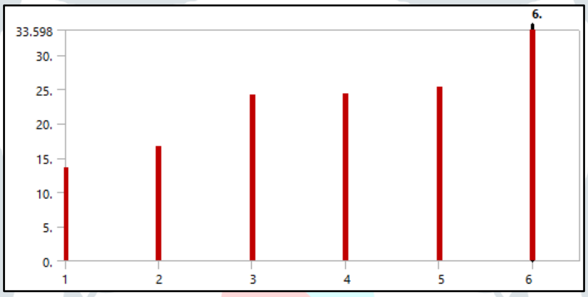


Fig.17 Natural frequency of the structure in graphical form

TABLE NO-II

Sr.no	Mode	Frequency(Hz)
1	1.	13.564
2	2.	16.712
3	3.	24.183
4	4.	24.362
5	5.	25.26
6	6.	33.598

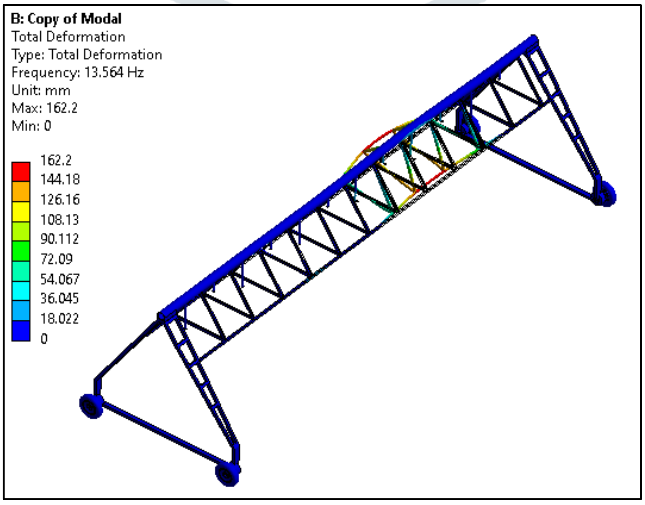


Fig.18 Fundamental Frequency of mode shape 1 is 13.564 Hz

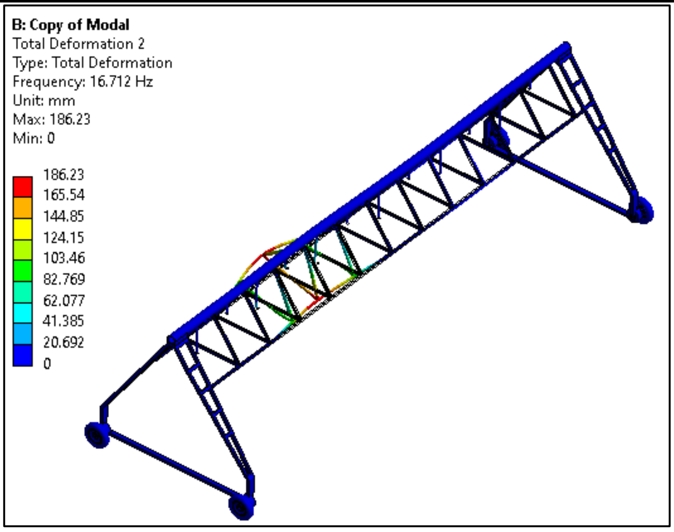


Fig.19 Fundamental Frequency of mode shape 2 is 16.712 Hz

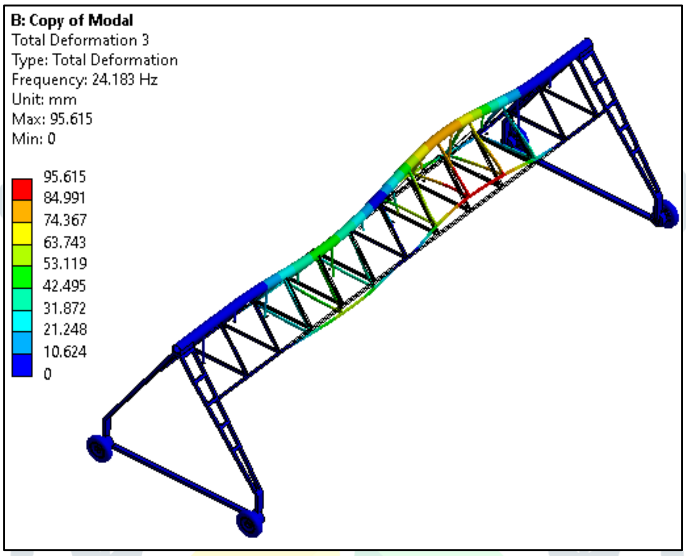


Fig.20 Fundamental frequency of mode shape 3 is 24.183 Hz

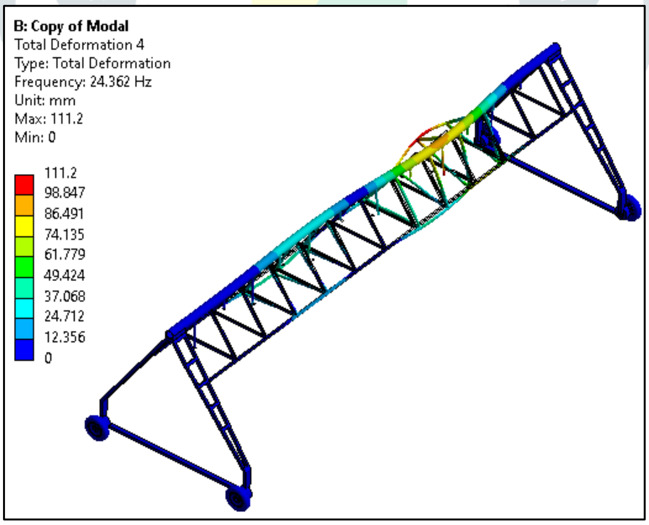


Fig.21 Fundamental frequency of mode shape 4 is 24.362 Hz

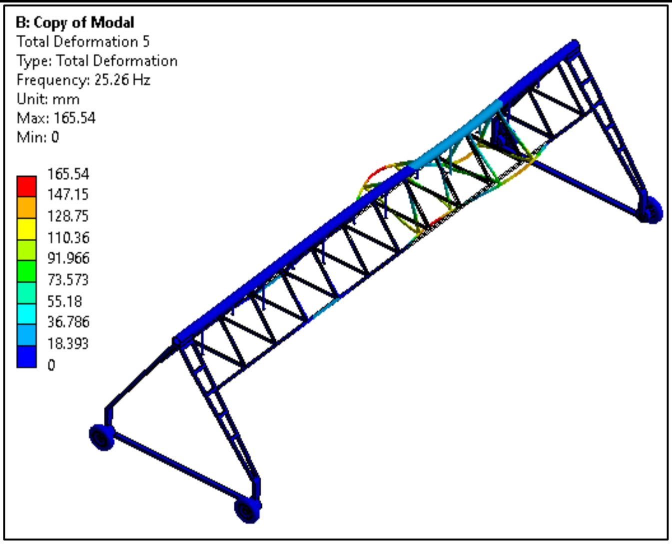


Fig.22 Fundamental frequency of mode shape 5 is 25.26 Hz

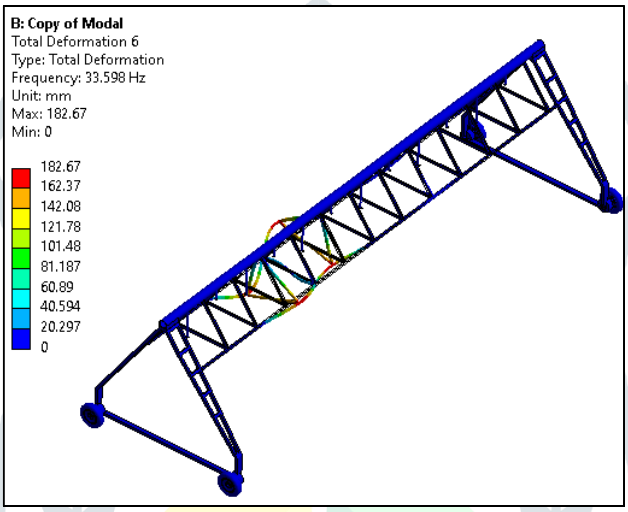


Fig.23 Fundamental frequency of mode shape 6 is 33.598 Hz

VI. CONCLUSION

- Designed the hanger irrigation system for the better water supply in agriculture and automation improvising in agriculture field.
- The 3D modelling of the hanger irrigation system is completed using SolidWorks software.
- Calculated torque required for the motor and power required for the pump to supply water to the whole system. CROMPTON 1HP SP MINI CHAMP electric motor was selected for the hanger irrigation system.
- A 12-inch pipe was selected for the irrigation system.
- The material selection for the structure is the mild steel and bamboo fiber.
- The analysis of the hanger irrigation system is performed to find out the fundamental frequency of the structure with material mild steel as well as bamboo fiber.
- The research has demonstrated that the hanger irrigation system is a promising technology for sustainable agriculture, with the potential to significantly reduce water usage and increase crop yields. The design process involved selecting appropriate materials and optimizing the spacing, height of the horizontal support structure. Our analysis using ANSYS 19 software helped identify potential structural weaknesses and assess the sustainability of the system, with bamboo being a more sustainable and cost-effective material choice than steel.
- There is not such a huge difference between the natural frequency of steel and bamboo fiber. Also bamboo fiber has high strength, high tensile strength and high stiffness due to this properties the structure will not deform early and will absorb the impact energy.
- Based on the modal analysis, it can be concluded that bamboo fiber can be used as an alternative to steel material, especially when cost and lower weight factors are taken into consideration.
- Overall, our findings contribute to the development of more sustainable irrigation systems, with potential applications in agriculture and beyond.

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