International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 09 | Sep 2022 www.irjet.net p-ISSN: 2395-0072

FEM Analysis of the Aerial Ropeway Transport System

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Abstract - *The use of aerial ropeway transportation as an alternative to more traditional forms of public transportation on the ground is possible in urban and metropolitan areas. Construction of urban aerial ropeways transportation is an expensive endeavor that calls for significant sums of money due to the engineering and economic considerations involved in the process. The purpose of this thesis is to carry out qualitative and applied research in order to gain a better understanding of the capabilities and restrictions posed by the Areal Ropeway Transport systems. In order to provide answers to the questions raised by the thesis, it is necessary, as stated in the thesis, to draw conclusions and findings from the research conducted. These findings have the potential to benefit future research into the mechanical and physical behavior of Areal Ropeway Transport systems. This would broaden our understanding of the systems' applicability as well as the functionality they provide. In order to perform the simulation and parametric analysis of the Aerial ropeway while it was under load, the following programs were utilized: CATIA 5.1, ANSYS 2022 R1. As a direct consequence of this, we were able to carry out analysis using finite element analysis. It was determined that running a full aerial ropeway transport simulation would take too much time for routine engineering work. However, with simplified models, it is possible to successfully predict Total Deformation, Equivalent Stress, Equivalent Elastic Strain, Directional Deformation, Strain Energy, Frictional Stress, Force Reaction, Moment Reaction, Penetration, and Pressure.*

Key Words: Aerial Ropeway Transport; Simulation; Finite Element Method; CATIA; ANSYS.

1. INTRODUCTION

An aerial ropeway system is a mode of public transportation that, as the name suggests, transports passengers in cabins that are suspended in the air and are propelled by a cable that is positioned above the system. A single motor is located in one of the two main stations, and it is responsible for moving the cabins from one station to the next. These systems have traditionally been used in ski resorts to transport visitors and skiers across challenging terrain and surfaces. However, in recent years, they have found new applications throughout the urban environment, particularly in regions that have geographical characteristics that are unique to them. To put it another way, (Alshalalfah et al., 2012) the ART system can be grouped into five distinct parts. Included in this package are the terminals (stations), towers, cables, and evacuation and rescue systems, as well as the cabins.

In today's world, urban areas and the infrastructure that those areas support are under an increasing amount of strain. The human race is moving toward urbanization, despite the consistent increase in the population of the earth's inhabitants. The issue of climate change has emerged as a pressing and urgent one, joining the ranks of urbanization as a pressing and urgent concerns. There are a variety of contemporary modes of transportation that all contribute to the problem of the temperature of the Earth reaching new heights. The use of those specific kinds of transportation is not only detrimental to the natural world but also turns out to be ineffective. As a result, urban mobility and transportation become more difficult and less productive. On the other hand, in the cities of today, getting around is not a commodity. The ability to move around is directly related to employment opportunities, service provision, social interaction, and the pursuit of equality. (Statement of the United Nations, 2015) (Statement of the United Nations, 2014) (The Guardian, 2016; Carrington, Damian; Slezak, Michael) As stated by Dávila (2013), (Cox, 2009).

The usage of polluting and space-consuming modes of transportation, which in turn produces major congestion and impedes traffic flow, is currently the most important concern facing metropolitan infrastructures. This is because these modes of transportation cause significant congestion. As a consequence of this, the existing mode of automotive transportation is not a solution to the problem; rather, it is the problem itself.

This means of transportation trumps others in terms of privacy, flexibility in terms of time and schedule, and independence in terms of location. Because of its low passenger to area ratio1 and occupancy rates, as well as the fact that this mode of transportation is the mode of transportation that emits the most greenhouse gases, it posed a significant problem for cities all over the world. Moreover, it is the mode of transportation that contributes the most to global warming (C2ES, 2013). It didn't make a difference how wide or narrow the roads were; motor traffic filled them up just like "gas" (Newman and Kenworthy, 2011). This, in turn, results in a health hazard and adds to the growth in obesity by keeping drivers trapped in their automobiles for extended periods of time. According to findings published in the journal Public Health by a group of academics, driving a car is similarly detrimental to one's health as does smoking (Douglas, et al., 2011).

Over the course of the last ten years, there has been a discernible expansion in terms of the number of ropeway transportation systems located around the region. The transformation of their image and perception in the minds of government officials and urban planners from that of specialized transportation technology to that of a common and widespread one is a significant obstacle that must be overcome before they can achieve success. When it comes to this, there isn't much information available (and there are many publications with inaccurate, contradictory, or discouraging figures) (O'Connor and Dale, 2011) and there hasn't been much research or writing done on the topic (Alshalalfah et al., 2012) to point us in the right direction. Due to the absence of information made available to them from the grey literature, several government bodies and urban planners have misinterpreted and underqualified Areal Ropeway Transport systems (O'Connor & Dale, 2011).

From the late 1880s through the 1890s, cable-powered street railroads in Europe experienced a steady decrease. During this same time period, however, the use of funiculars in metropolitan areas across Europe remained mostly unaffected (Neumann, 2007). Up until the 1970s, ski resorts, in particular, put a significant amount of their faith in cable-propelled systems. As a result of the development of APMs (Automated People Movers) in the 1970s, urban planners reassessed the technology in order to determine its applicability in the built environment (Neumann, 2007).

During the modern era, art was utilized in urban settings only very infrequently. The city of Alger in Algeria was one of the few towns in the world at the time that utilized this innovation for its public transit system. The first aerial tramway line, known as El Madania, was constructed in 1956 in order to connect two communities that were situated 83 meters apart from one another and covered a distance of 215 meters. In 1982, during the renovation of the "El Madania," Algeria became the first country in the world to introduce Areal Ropeway Transport systems into its urban areas. Additionally, in Constantine, Algeria, a Mono-Cable Detachable Gondola system that is 2.4 kilometers (1.5 miles) in length was installed. To put it another way, the authors of this study, (Bergerhoff and Perschon 2012), said it this way: (Alshalalfah et al; 2012).

Areal Ropeway Transport was able to get off the ground after the city of Medellin in Colombia opened its first mono-cable detachable gondola system (Line K) in 2004. This was done in order to connect the hilly Santo Domingo Communes (also known as the Communities) to the Medellin metro transport system. When similar systems were put into place in Santo Domingo, citizens were able to traverse the distance that normally took them between two and two and a half hours in fewer than thirty minutes utilizing small private buses. These are the authors of the article that was published in 2012 (Bergerhoff and Perschon) (Alshalalfah, et al., 2012). After finding success in Medellin, the Areal Ropeway Transport system was exported to a number of other cities and countries, mainly in South America, where it was integrated into the public transit networks. The most interesting places I visited were Caracas (Venezuela) and Koblenz (Germany). In third place was La Paz (Bolivia) (Bolivia). The evolution of Areal Ropeway Transport systems and technology may also be traced back through time using the chronology provided by these systems.

2. ANALYSIS IN ANSYS

After the design of a Ropeway Cable for Aerial ropeway transport, it is important to know the characteristic response of the components to simulation conditions prior to the actual manufacturing of the bodies. A static finite element analysis can identify possible design flaws, such as stress concentrations, verify the component stiffness and give information that will help in the verification of calibration results.

By choosing the appropriate boundary conditions we can predict the performance and check if it is within the acceptable range of the available hardware. In this work, we present the dynamic finite element analyses using ANSYS 2020 R1. We study the mesh convergence to achieve the most accurate results and discuss the results.

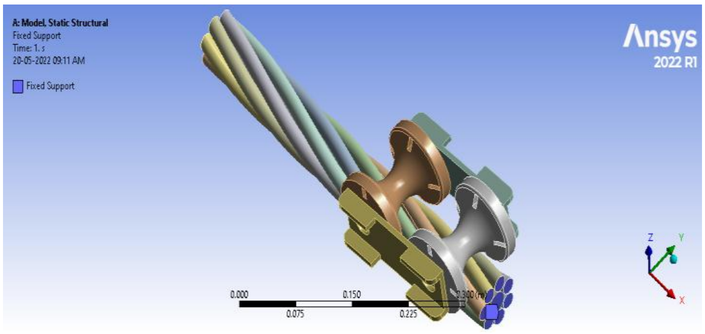


Fig. 1 Ropeway Cable after the modeling in CATIA software

2.1 MESH GENERATION

Finite element mesh is generated using parabolic tetrahedral elements. The von Mises stress is checked for convergence. An automatic method is used to generate the mesh in the present work.

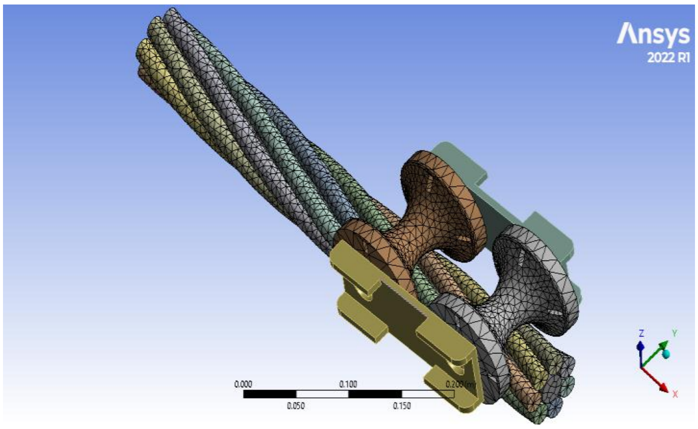


Fig.2 Triangular type of meshing is done in ANSYS software for Ropeway Cable Analysis

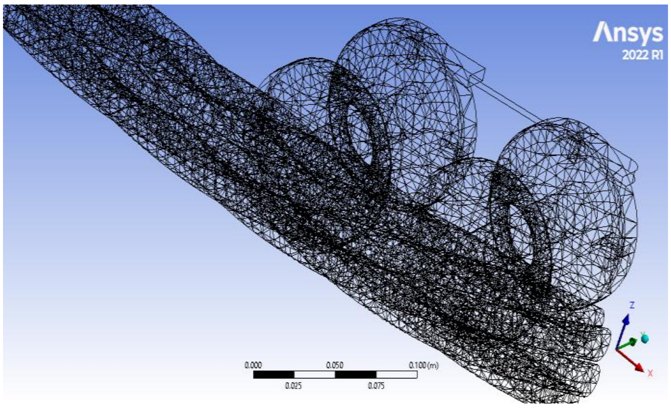


Fig. 3 Wireframe View of triangular type of meshing is done in ANSYS software for Ropeway Cable Analysis

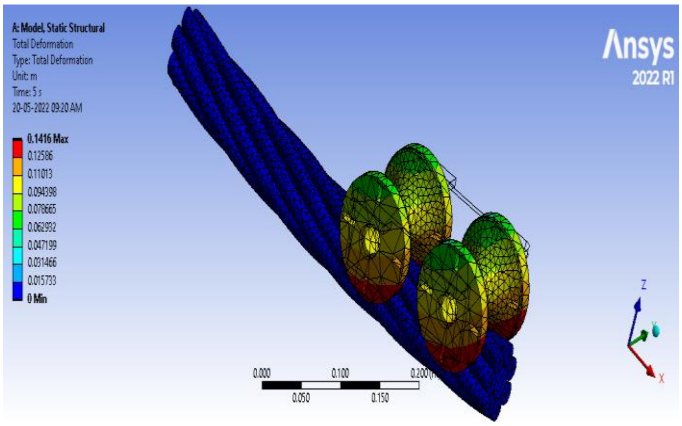
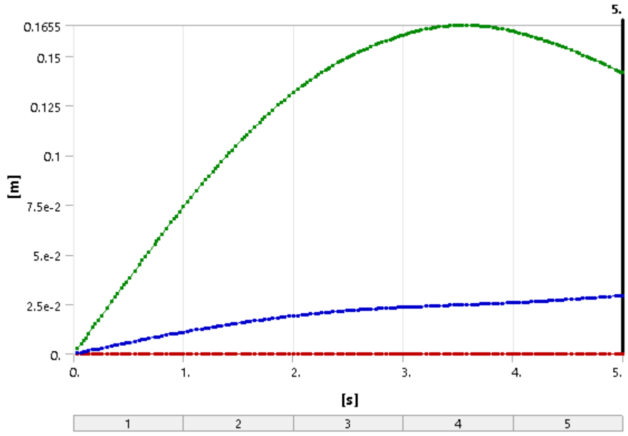


Fig. 4 Total Deformation generated in Ropeway Cable Analysis



Graph 1 Total Deformation maximum generated in Ropeway Cable of Aerial Ropeway Transport is 0.1655 m

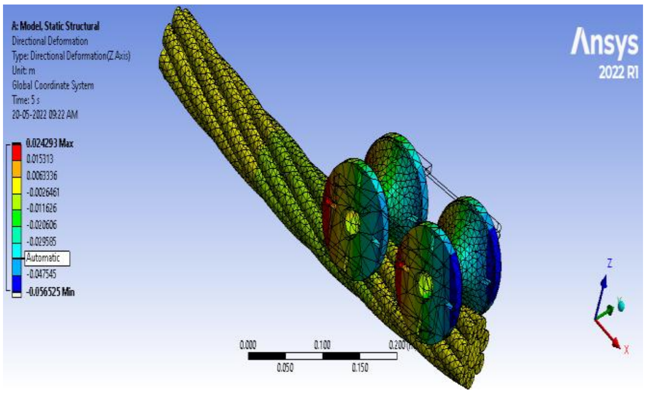
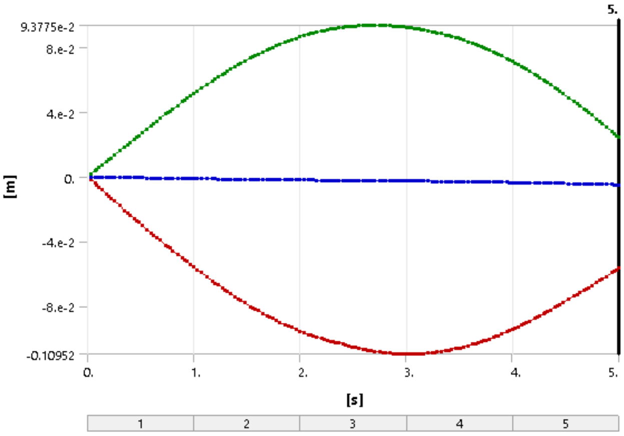


Fig. 5 Directional Deformation generated in Ropeway Cable Analysis



Graph 2 Directional Deformation maximum generated in Ropeway Cable of Aerial Ropeway Transport is 9.3775 ×10-2 m

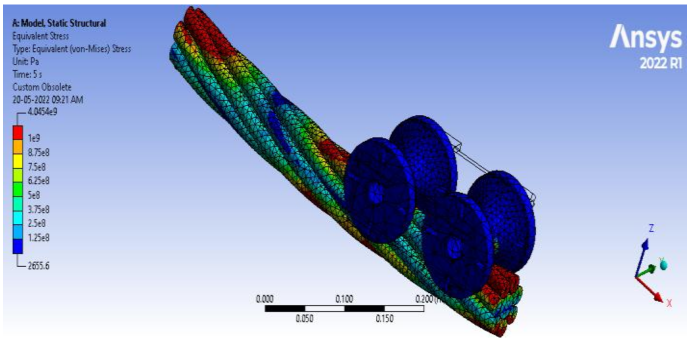
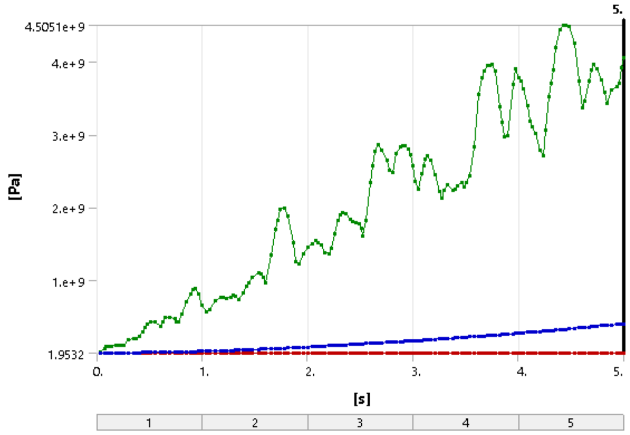


Fig.6 Equivalent Stress generated in Ropeway Cable Analysis



Graph 3 Equivalent Stress maximum generated in Ropeway Cable of Aerial Ropeway Transport is 4.5051 GPa

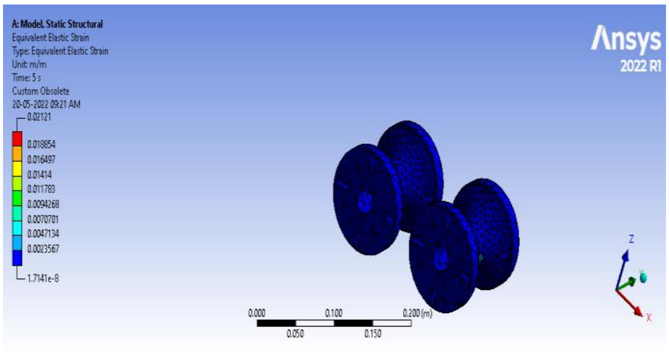
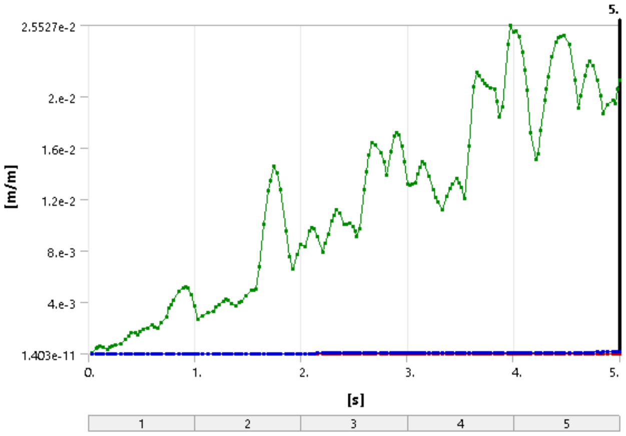


Fig. 5 Equivalent Elastic Strain generated in Ropeway Cable Analysis



Graph 4 Equivalent Elastic Strain maximum generated in Ropeway Cable of Aerial Ropeway Transport is of 2.5527 ×10-2 m/m

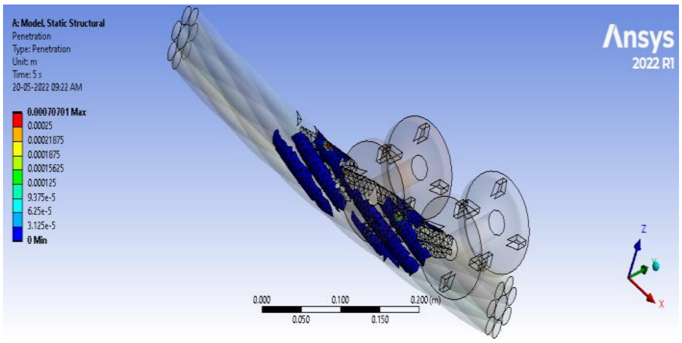
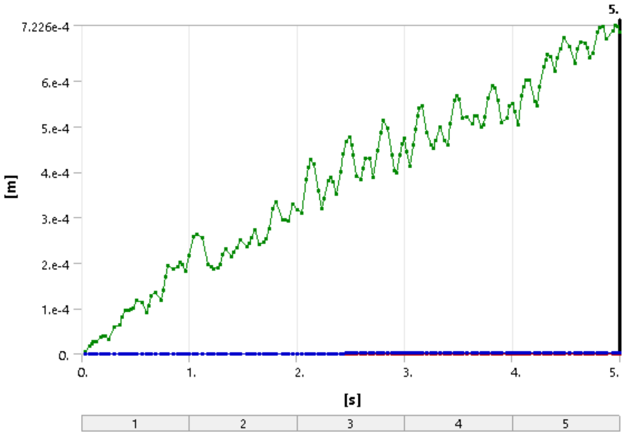


Fig. 6: Total Penetration generated in Ropeway Cable Analysis



Graph 5 Total Penetration maximum generated in Ropeway Cable of Aerial Ropeway Transport is 7.226 ×10-4 m

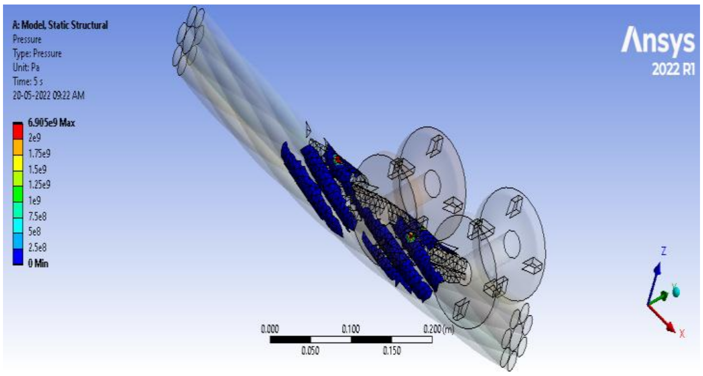
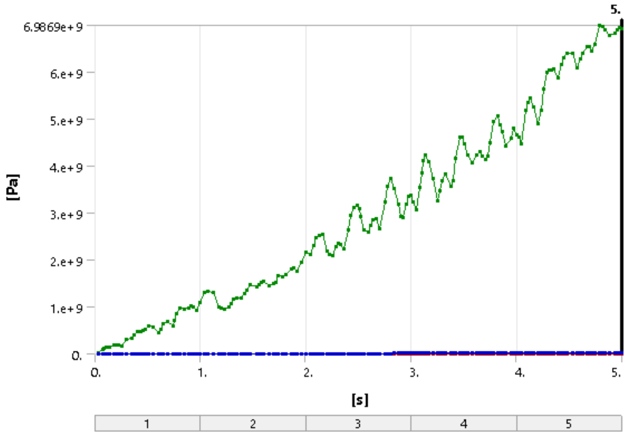


Fig. 7 Total Pressure generated in Ropeway Cable Analysis



Graph 6 Total Pressure maximum generated in Ropeway Cable of Aerial Ropeway Transport is 6.9869 GPa

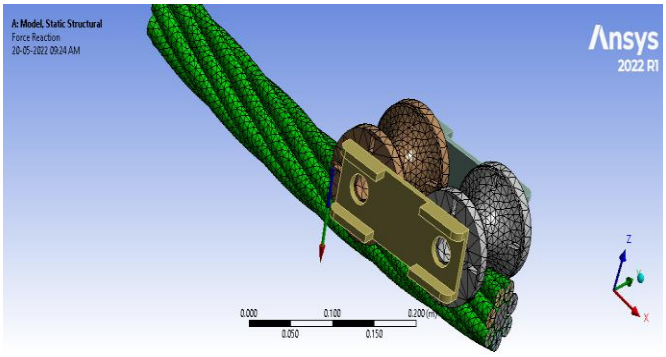
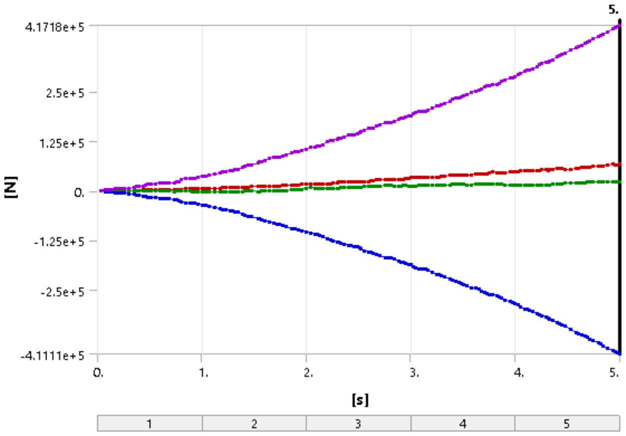


Fig. 8 Force Reaction generated in Ropeway Cable Analysis



Graph 7 Total Reaction Force maximum generated in Ropeway Cable of Aerial Ropeway Transport is 4.1718 x 105 N

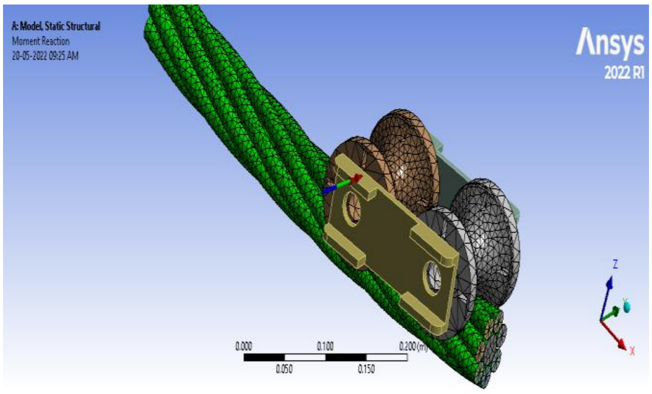
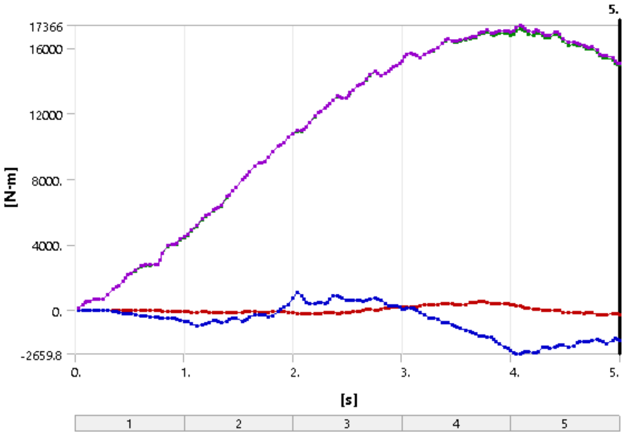


Fig. 9 Moment Reaction generated in Ropeway Cable Analysis



Graph 8 Total Moment Reaction maximum generated in Ropeway Cable of Aerial Ropeway Transport is 17366 N-m.

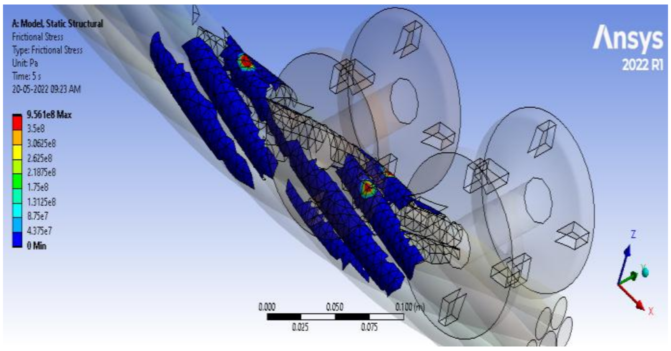
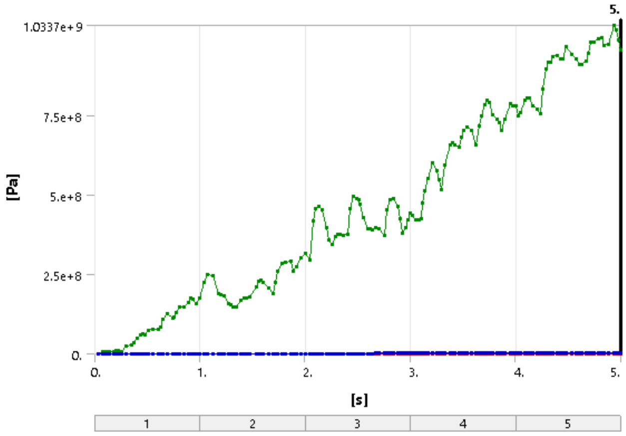


Fig. 10 Frictional Stress generated in Ropeway Cable Analysis



Graph 9 Frictional Stress maximum generated in Ropeway Cable of Aerial Ropeway Transport is 1.0337 GPa

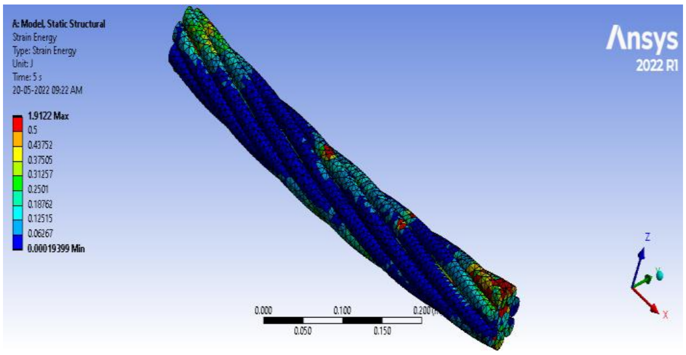
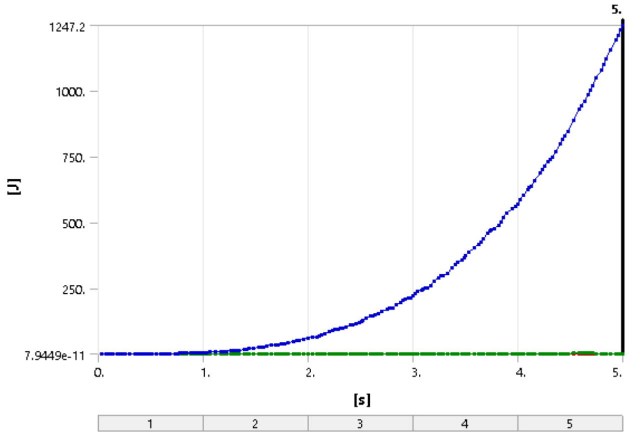


Fig. 11 Strain Energy generated in Ropeway Cable Analysis



Graph 10 Total Strain Energy maximum generated in Ropeway Cable of Aerial Ropeway Transport is 1247.2 J

7. CONCLUSION

In this investigation, the Finite Element Method was utilized to conduct an analysis of Aerial Ropeway Transport. The analyses have made use of a simplified finite element model achieved by making the assumption of symmetry as well as a non-simplified finite element model of the process.

An inspection was performed on the ropeway cable that would be used for the aerial ropeway transport system. The Equivalent Stress, Equivalent Elastic Strain, Total Deformation, Pressure, Reaction Force, and Directional Deformation exerted by the Ropeway Cable for Aerial Ropeway Transport System has been identified. The purpose of this study is to make an accurate prediction of the effects that different performance parameters have on the Ropeway Cable used in the Aerial Ropeway Transport System when the Cabinet Wheel is moving in a linear fashion.

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