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Computational Analysis of Engineering Commercializing Natural Fibre KANS Rope by Comparing with Metal and Jute wire Rope Using ANSYS)

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Abstract- Fibre ropes are improved in strength throughout time to the point that they are beginning to replace wire ropes in certain applications. Fibre ropes are risen in durability and The Kans fibre ropes regains its strength after getting wet atmosphere and it can provide more mechanical strength. The development of high-tensile fibres and developments in fibre rope structures have been key contributions. It began with high-strength nylon and polyester fibre ropes, ropes made of both of those fibres, polyester and polypropylene ropes, as well as polypropylene and polyethylene ropes. As a consequence, stronger and stronger ropes can be manufactured, with a fibre strength component providing a "10-to-one strength-to-weight ratio" advantage over wire rope as the final outcome. Wire rope made from steel, jute fibre, and Kans fibre is subjected to FEM analysis in this work. Total 19 wire is used to make wire rope with having 0.335 mm diameter each and outer pitch as 87.983 mm and overall length of 44 mm. When using the "ANSYS structural model simulation software", findings are assessed in terms of equivalent stresses, maximum principal stresses (MPS), bending stresses (ETS), and equivalence strains (EQT) & total deformation. The study's main goal is to determine how efficient natural fibres may be in substitute of steel as a wire rope. Kans fibre wire rope will be introduced in commercial work in place of steel wire such as Ropes for hand lifts on construction sites, Helicopter ropes.
Keywords- Wire rope, Natural fibres, Kans fibre, Jute fibre, ANSYS

I. INTRODUCTION

In earth at various geographic locations, climate changes are different at diurnal time. Which is suitable for crop growth an ecosystem as per geographic condition. Indian climate is that where is the possibility of occurrence off on all these seasons and also in India variety of corps and seeds area versatile. In Indian agriculture, various useful crops are grown. In today technological scenario, using tree &crops fibre various human utility these are producing. In Indian climate A crop also grow in which is called as KANS, a waste/crop. Long length approx. 1 m to 1.5 m. green in colour at starting and finally changes colour golden in after dry conditions dry KANS has property to regain, it's strength double in case when it's wet again. Keep it to is soaking of water for 1 to 2 hours.
Since its strength can be raised upto to certain limit it is found it's major application in agriculture field to tie crops due to easy availability without any cost and also it is possible to store longer time and for later uses. Due to it's light. it's also using is as a ROPE which is made by, skilled full person with additional method of handicraft by rotating wheel. Somehow it is commercial using at a small scale in town and using at small constructions site to create by structure by with KANS rope.

wire rope is often compared to a machine, with a series of components all working together to achieve a desired outcome. In its simplest form a rope consists of as little as three wires, but most applications require ropes with constructions which are significantly more complex. The figure below illustrates a crosssection of a steel wire rope; the components of a wire rope are identified (Banfield and Casey 1998) .

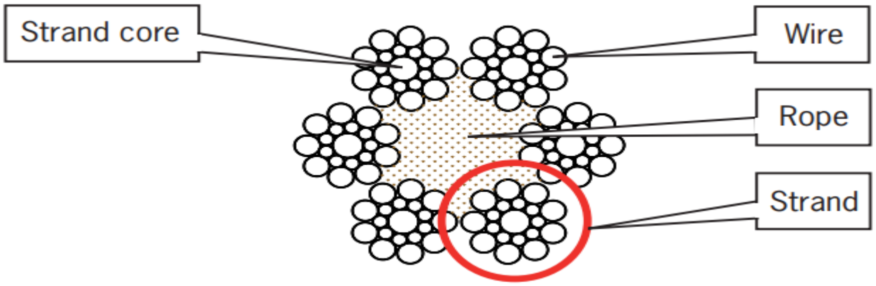

Figure 1 Cross section of a steel wire rope with the components of the rope identified
It can be seen that this rope is a fairly complicated piece of equipment. In this case six strands are helically formed around a core of fibre. Each strand is made up of several wires which are themselves formed around a strand core (Torkar and Arzenšek 2002).

- Wire: A wire is the most basic unit used to make a rope.

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- Strand Core: Most strands have a single steel wire as a strand core. To achieve more flexibility non-metallic cores are used. Cores of shaped strands have the additional function of providing the basis for the shaped core. Examples of shaped strand cores are shown in below figure.
- Strand: A series of wires twisted together over a strand core (often a strand core is a single wire). Strands can either be of equal lay or unequal lay. These are described later in this document.
- Rope Core: All ropes with more than three strands require a rope core. Rope cores are required to ensure constructional stability and provide sufficient support to avoid severe interstrand contact.

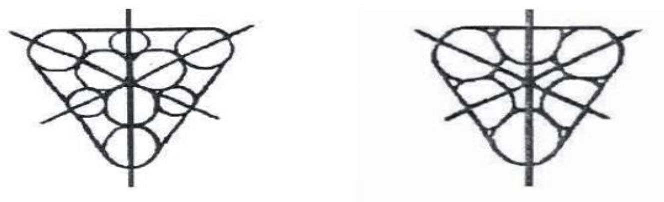

Figure 2 A plated triangular strand(left) core alongside a Brangle strand core(right)

A. Natural Fibre

A composite material is a combination of two materials with different physical and chemical properties. When they are combined they create a material which is specialised to do a certain job, for instance to become stronger, lighter or resistant to electricity. They can also improve strength and stiffness. The reason for their use over traditional materials is because they improve the properties of their base materials and are applicable in many situations.

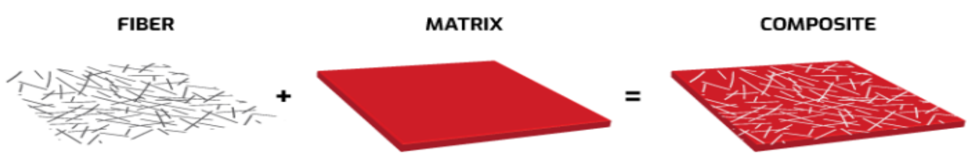

Figure 3 Composite material

II. LITERATURE REVIEW

(Zhang et al. 2020) Problems arise in the detection of defects in wire rope by magnetic flux leakage testing. The most obvious problems are that the excitation devices are cumbersome and inconvenient and the signal-to-noise ratio of damage signals is often low. This paper proposes a small detector. Compared with traditional detection devices, the proposed device has the advantages of a simple structure, easy installation, low weight and good portability. The weight of the device is only 508 g. The surface of the wire rope is characterized by wires and strands. The amplitude of the strand-waveform magnetic signal generated by the special helical structure of wire rope is larger than that of the defect signal. The magnetic image is processed using an adaptive spatial notch filter and the gradient method, and the detection results are analyzed. The strand-waveform magnetic signal cannot be completely eliminated, and not all defects can be detected. A new method is proposed to eliminate strand-waveform noise using the instantaneous phase solution in Hilbert transform and wavelet analysis. Experiments show that the proposed method suppresses noise well and detects and accurately locates all defects.
(Guerra-Fuentes et al. 2020)After 53 days of service of a steel wire rope in a 12-ton overhead crane system a catastrophic failure has occurred during operation. The wire rope was inspected and sectioned in both sides of the failure. To determine the reason of the failure, samples from the damaged rope were analysed using visual inspection, stereoscopic analysis, scanning electron microscopy and micro hardness tests. Information was collected from worksheets to correlate operation conditions and possible failure causes. After first inspections of the failure zones in the steel wire rope, damage was apparently not caused by fatigue. After stereoscopic and microscopic observations, a mechanism of failure was determinate and proposed. In the initial stage, there was a localized plastic deformation and wear of individual wires accelerating stress concentration and finally fatigue. All these events were correlated with the hoist system operation and installation conditions.
(Ivanov et al. 2020)Behaviour of steel wire rope slings when they are bent over small diameter rigid bodies, e.g. pins, has been studied to determine the reduction of the slings' static strength due to bending. For this purpose, the Papailiou model

was extended by adding plasticity in the material behaviour and expanding the friction model from a single layer strand to multiple layers and multiple strands. It was shown that in addition to the diameter ratio, the sling bending strength reduction factor depends on the friction between the wires in the rope and the geometry of the rope, namely the lay angle and the number of wires in the rope. The actual breaking load was obtained from experiments on small and full-scale rope slings at rather low ratios of the pin to rope diameter and compared with modelling results and the sling capacity reduction factor associated with bending prescribed by guidelines for lifting operations.

(Liu et al. 2020)The effect of lay direction of individual wires on the mechanical behavior of multi-strand wire ropes under axial loading is investigated based upon Love's thin rod theory. A typical 7 × 7 wire rope with an independent rope core is treated. Eight different lay directions of the wire rope are considered, in which the lay direction of the double helix wires is emphasized. Two theoretical models, namely the hierarchical calculation method and the direct calculation method, are used to calculate the internal forces of the rope. The numerical results based on the two models are assessed within the context of the finite element analysis of the multi-strand rope. It is highlighted that the result given by the hierarchical calculation method is closer to the FEM result. The mechanical responses on simple strand and multi-strand rope predicted by the two theoretical models are in good agreement with experimental data. The lay effect of wire rope and the effect of initial helix angle of individual wires on the internal forces of rope are analysed in detail. It is demonstrated that the lay direction mainly affects the torque of the rope, but not the tensile force; while both the torque and the tensile force strongly depend on the initial helix angle of individual wires. It is implied that the global mechanical properties of wire rope can be adjusted with the lay direction and the helix angle of wires within the rope.

(Chang et al. 2019)Surface wear is the main reason for the breaking failure of the wire rope in service, particularly in the multi-layer winding hoist system of a coal mine. Understanding the effect of wear scars on the failure and mechanical properties of the rope is the effective way to ensure the safety of multi- layer winding hoist. In this paper, the breaking failure characteristics of hoist ropes with different wear scars were investigated by the breaking tensile test. The temperature rise in the wear scar regions was obtained and analyzed. Additionally, the finite element method was used to simulate the mechanical properties of the wear-out strands subjected to tensile load. Results show that the severe plastic deformation and obvious temperature rise occur in the wear scar region. The temperature rise curves during the breaking tensile test can reflect the number and the order of the fractured strands. The wear-out outer wires fracture earlier than the internal wires, and the wires with irregular wear scar always fracture along the sliding wear direction at the location with the maximum wear depth. Additionally, the wear scar caused by left cross contact will cause stress concentration and uneven distribution, and the wear depth makes it more obvious.

(Chen et al. 2017)A wire rope is often subjected to a varying axial tensile force or torsional moment, resulting in its unstable performances. However, this problem has not been studied to date due to the lack of a scheme effectively determining the inter wire contact status. For this, an inter wire full contact model considering different contact statuses is established based on contact mechanics and thin rods theory. Then the model is solved with the semi-analytical method (SAM), into which the conjugate gradient method (CGM) and fast Fourier transform (FFT) are employed for analysing the contact behaviour. With the above contact dealing, the full contact performances are achieved for the core-wire contact, the wire-wire contact and the coupled contact statuses of the strand subjected to varying axial loads. And it is found that the inter wire contact status of the strand may change with the varying loads, resulting in the unstable distributions of the inter wire contact pressure and deformation. Meanwhile, the validity of the proposed full contact model is verified.

III. METHODOLOGY

For analyzing stress and strain in wire rope, ANSYS software is used and in ANSYS workbench, static structural model is selected which defines and calculate physical properties and stress, strain and deformation. For design of wire rope or jute rope, CATIA software is used because of its easy interface and easy process. The by importing the design into ANSYS model, process is followed by giving the materials which will be used in analysis. Then by applying boundary condition according to defined parameters and according to base paper, results are evaluated in form of equivalent stress, strain and total deformation.

A. Natural Fibre

- Total length of wire rope = 44 mm
- Single wire diameter = 0.335 mm
- No. of wire included in rope = 1×19
- Outer pitch = 87.983 mm

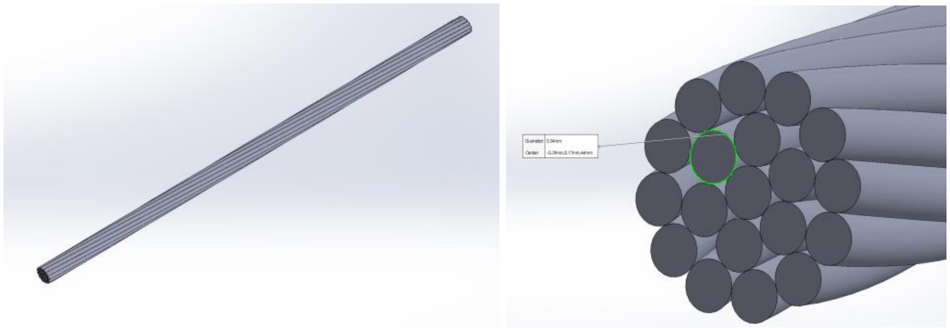

Figure 4 Wire rope design and diameter of single wire

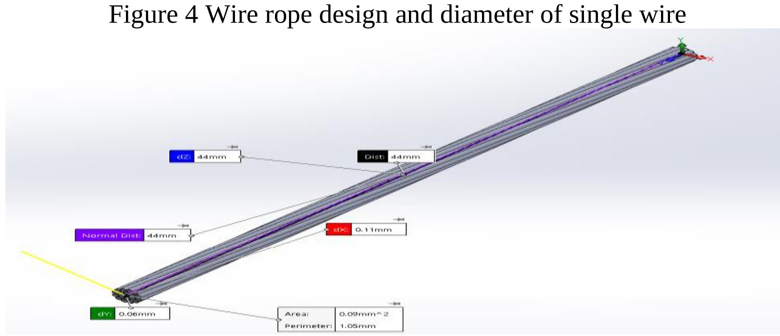

Figure 5 dimensional view of wire rope

A. Material property

The property of Stainless steel, Jute fibre, Kans fibre is determined with respect to their Young's modulus, density and Poisson's ratio and their separate values are listed in table below:

Table 1 Material property

Properties	**stainless steel**	**Jute fibre**	**Kans fibre**
Young's modulus(GPa)	180	20	9.5
Density (Kg/m^3)	7850	1450	441
Poisson's ratio	0.3	0.38	0.33

A. Meshing

Meshing is an important part of Computer Aided Engineering for the process of simulations. The accuracy as well as the fusion and the swiftness of solutions are affected by the mesh. Moreover the time taken by creating the wired of the model is very frequent to get the outcomes of CAE solutions. Thus if the automation of mashing tools are good then it is better for the solution.

Once the design is created in Catia then convert it in to the stp file and then transfer this file to ANSYS then it goes for the simulations, then in meshing and finally goes for the selection of name.

Nodes	194770
Elements	28819

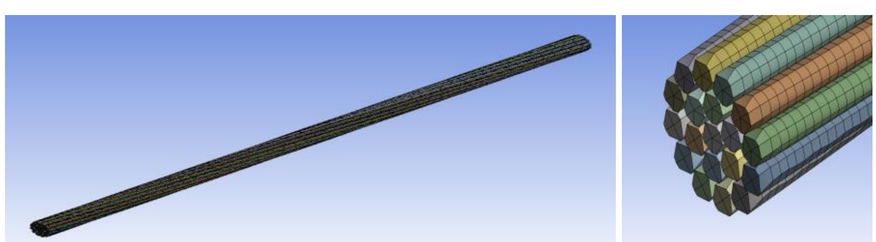

Figure 6 Meshing of wire rope

A. Boundary condition

Three different materials are selected for static structural analysis and we examined stress, strain and total deformation for all three materials separately.

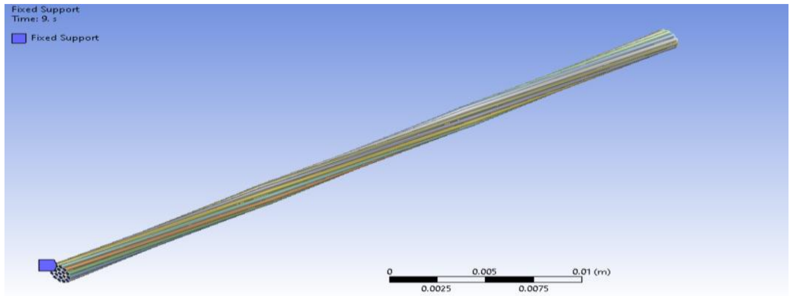

Figure 7 Fixed side of wire rope

Table 2 Case design

Case	Material	Load
Case-1	Stainless steel	2000, 4000 and 6000N
Case-2	Jute fibre	2000, 4000 and 6000N
Case-3	Kans fibre	2000, 4000 and 6000N

IV. Results

The improvement in adhesion technology for joining different types of materials has led to expectations of weight reduction in cars and commercial vehicles. Various levels of stress and stress ratios are loaded onto the joints of such transport vehicles. These review papers focus in design methods for design of the seal ring, flange and bolts in addition to assembly guidelines.

In below mentioned table, Maximum stress, stain and total deformation is defined and compared for all the cases. Which shows value of maximum stress is maximum in Jute fibre because of its mechanical properties and value of strain is maximum in Kans fibre. And in the total deformation case as well Kans fibre got the maximum deformation. And jute fibre got the maximum principal stress in comparison to other materials.

Table 3 Maximum value obtained of each parameter with each material with 2000 N

parameter	Stainless Steel	Jute fibre	Kans fibre
Stress(MPa)	2375.8	2568.7	2448.4
Strain	0.012637	0.12844	0.25772
Total Deformation(mm)	0.31073	2.9235	6.1514
Maximum principal stress(MPa)	3002.9	3582.6	3194.4
Shear stress(MPa)	297.81	389.76	331
Strain energy(mJ)	0.021481	0.20079	0.4253
$\boldsymbol{\sigma_T = \sigma(1+\varepsilon)}$	2405.822	2898.623	3078.12848
$\boldsymbol{\varepsilon_T = ln(1+\varepsilon)}$	0.0125578	0.120836	0.22887

Table 5.2 shows equivalent stress, maximum principal stress, shear stress, total deformation, strain energy and elastic strain in case of applying 4000 N axial load on one side of rope and results of all cases having material as steel, jute fibre and Kans fibre are compared.

Table 4 Maximum value obtained of each parameter with each material with 4000 N

Parameters	Stainless Steel	Jute fibre	Kans fibre

Stress(MPa)	4751.5	5137.5	4897.7
Strain	0.025274	0.25687	0.51545
Total Deformation(mm)	0.62146	5.847	12.303
Maximum principal stress(MPa)	6005.8	7165.1	6388.7
Shear stress(MPa)	595.61	779.52	661.99
Strain energy(mJ)	0.085926	0.80317	1.7012
$\sigma_T = \sigma(1+\varepsilon)$	4871.5894	6457.169	7421.97
$\varepsilon_T = ln(1+\varepsilon)$	0.02495	0.22862	0.4157

Table 5.3 shows equivalent stress, maximum principal stress, shear stress, total deformation, strain energy and elastic strain in case of applying 6000 N axial load on one side of rope and results of all cases having material as steel, jute fibre and Kans fibre are compared. And the comparative values are in the same pattern as the above to cases.

Table 5 Maximum value obtained of each parameter with each material with 6000 N

Parameters	**Stainless Steel**	**Jute fibre**	**Kans fibre**
Stress(MPa)	7127.3	7706.2	7345.1
Strain	0.037911	0.38531	0.77317
Total Deformation(mm)	0.9322	8.7704	18.454
Maximum principal stress(MPa)	9008.6	10748	9583.1
Shear stress(MPa)	893.42	1169.3	992.99
Strain energy(mJ)	0.19333	1.8071	3.8277
$\sigma_T = \sigma(1+\varepsilon)$	7397.503	10675.47	13024.11
$\varepsilon_T = ln(1+\varepsilon)$	0.03721	0.325923	0.572768

Comparison of stress

Equivalent stress comparison in all materials

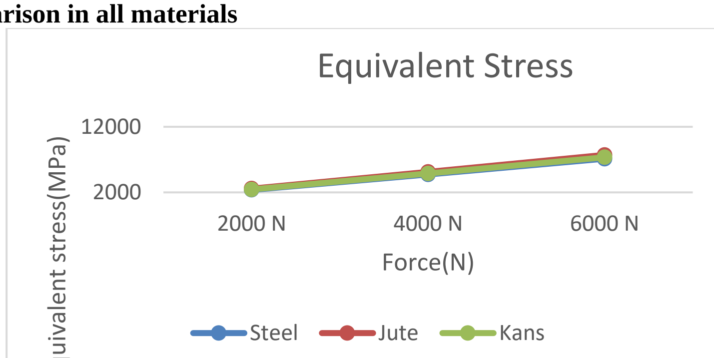

Figure 8 Equivalent stress with respect to force (N)

Above mentioned graph is a comparison of equivalent stress obtained in all cases by applying different load conditions. Here in this graph X-axis is representing load applied and Y-axis is representing stress in MPa. As the graph shows, value of stress is increasing as the load increasing which is followed by each material in a same way. And if material of rope is compared then maximum stress is obtained in jute fibre with having 6000 N load which is 7706.2 MPa and minimum equivalent stress is obtained in steel with having 2000 N load which is 2375.8 N. and Kans fibre provides moderate results as compare to both the cases which can be a good replacement of steel as compare to jute fibre.

Maximum principal stress comparison in all materials

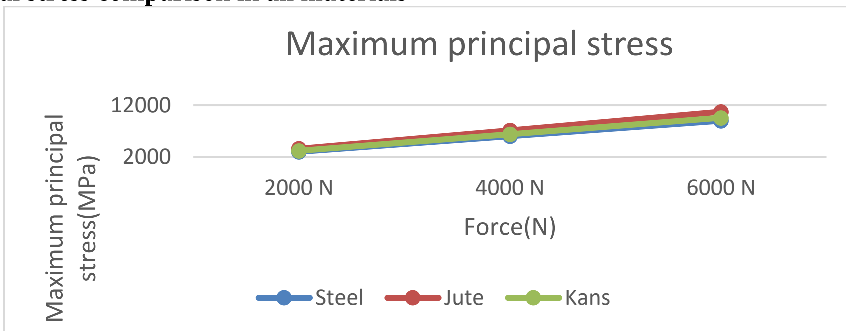

Figure 9 Maximum principal stress with respect to force (N)

Above mentioned graph is a comparison of Maximum principal stress obtained in all cases by applying different load conditions. Here in this graph X-axis is representing load applied and Y-axis is representing maximum principal stress in MPa. As the graph shows, value of stress is increasing as the load increasing which is followed by each material in a same way. And if material of rope is compared then maximum principal stress is obtained in jute fibre with having 6000 N load which is 10748 MPa and minimum equivalent stress is obtained in steel with having 2000 N load which is 3002.9 N.

Shear stress comparison in all materials

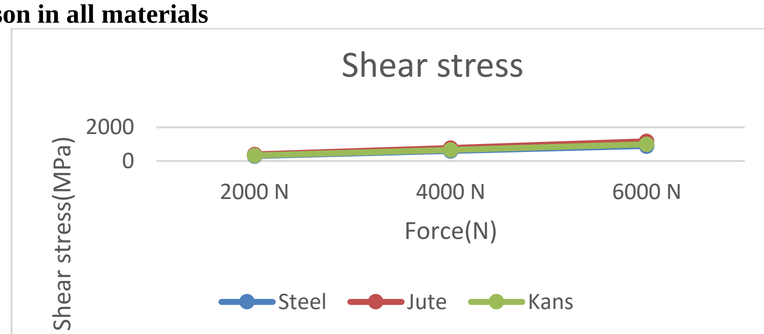

Figure 10 Shear stress with respect to force (N)

Above mentioned graph is a comparison of shear stress obtained in all cases by applying different load conditions. Here in this graph X-axis is representing load applied and Y-axis is representing shear stress in MPa. As the graph shows, value of shear stress is increasing as the load increasing which is followed by each material in a same way. And if material of rope is compared then maximum shear stress is obtained in jute fibre with having 6000 N load which is 1169.3 MPa and minimum equivalent stress is obtained in steel with having 2000 N load which is 297.81 N

Comparison of Strain

Equivalent elastic strain comparison in all materials

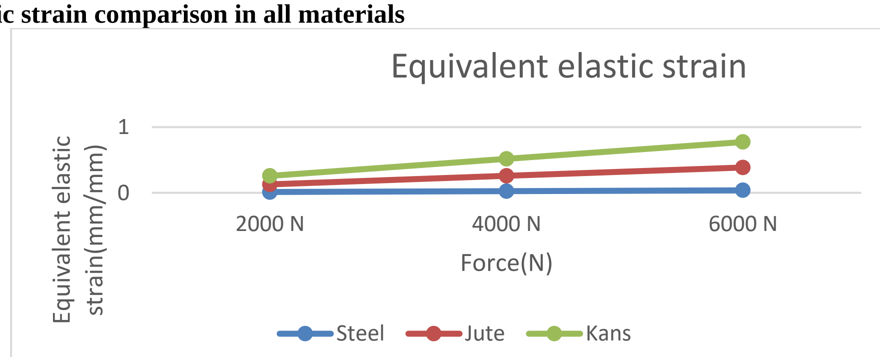

Figure 11 Equivalent elastic strain with respect to force (N)

Above mentioned graph is a comparison of equivalent elastic strain obtained in all cases by applying different load conditions. Here in this graph X-axis is representing load applied and Y-axis is representing stain obtained in mm. As the graph shows, value of strain is increasing as the load increasing which is followed by each material in a same way as it was in the stress formation. And if material of rope is compared then maximum strain is obtained in Kans fibre with having 6000 N load which is 0.77317 mm/mm and minimum equivalent strain is obtained in steel with having 2000 N load which is 0.01263 mm/mm. and jute fibre provides moderate results as compare to both the cases.

Strain energy comparison in all materials

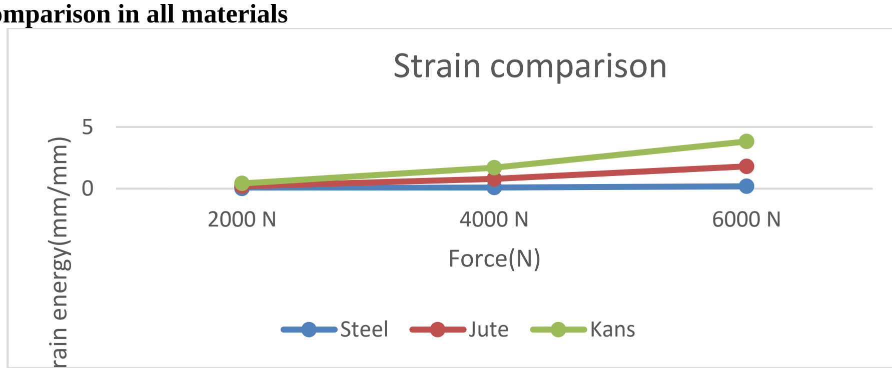

Figure 12 Strain energy with respect to force (N)

Above mentioned graph is a comparison of strain energy obtained in all cases by applying different load conditions. Here in this graph X-axis is representing load applied and Y-axis is representing strain energy obtained in mJ. As the graph shows, value of strain energy is increasing as the load increasing which is followed by each material in a same way as it was in the equivalent strain formation. And if material of rope is compared then maximum strain energy is obtained in Kans fibre with having 6000 N load which is 3.8277 mJ and minimum strain energy is obtained in steel with having 2000 N load which is 0.021481 mJ. Kans fibre shows rapid increase in strain energy as force increases from 4000 N to 6000 N.

Comparison of total deformation

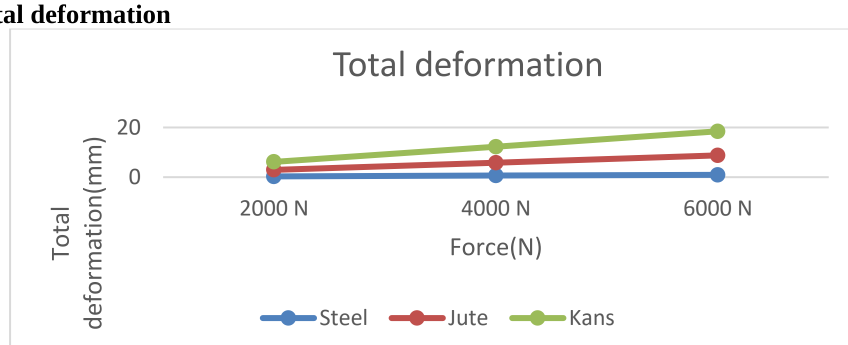

Figure 13 Total deformation with respect to force (N)

Above mentioned graph is a comparison of total deformation obtained in all cases by applying different load conditions. Here in this graph X-axis is representing load applied and Y-axis is representing stain obtained in mm. As the graph shows, value of strain is increasing as the load increasing which is followed by each material in a same way as it was in the stress formation. And if material of rope is compared then maximum strain is obtained in Kans fibre with having 6000 N load which is 0.77317 mm/mm and minimum equivalent strain is obtained in steel with having 2000 N load which is 0.01263 mm/mm. and jute fibre provides moderate results as compare to both the cases.

V. CONCLUSION

In this study, stress and stain analysis is performed to find out the better material for wire rope material which can bare same strength with more easy way. And for that steel is replaced with naturally available fibre which is jute fibre and Kans fibre. And they are analysed with same boundary condition and with same load applied which were applied on steel wire rope. Values of stress is found maximum by using jute fibre whereas value of total deformation is found maximum by using Kans fibre. As per the results it can be calculated that natural fibres like jute fibre, Kans fibre can be a good replacement for steel ropes because natural fibre also fulfilling the required strength of the wire rope. And according to the comparison of results it can be concluded that kans fibre is a better replacement of steel as it provides better results as compare to jute fibre.

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