Ultrarope

Issues with steel cable technology:

- Unable to perform in shafts spanning over 500 meters without serious energy consumption and mechanical integrity concerns.
- Experiences resonance in high winds, resulting in elevator shut down.

A Viable Solution:

- Patented by KONE, Ultrarope is the first iteration of carbon fiber elevator cables.
- Ultrarope shows the potential to raise the altitude limit of tall structures, and provides a means to create more energy sustainable cities.

Cost Analysis:

- Pricing is done on a case by case basis.
- On average, costs are approximated to be 20% more than traditional cable.
- This, however, must be weighed against the savings in energy costs, and maintenance costs that Ultrarope provides.

Energy Savings:

- Ultrarope shows a dramatic decrease in weight compared to steel for increasing shaft height, due to carbon fiber's lower density.
- KONE boasts a 45% reduction in energy consumption in shafts spanning 800 meters.

Cable Properties

Mechanical Properties:

<table>
<thead>
<tr>
<th></th>
<th>Steel Cable</th>
<th>Carbon Fiber Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Strength (MPa)</td>
<td>2000</td>
<td>4900</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>8000</td>
<td>1800</td>
</tr>
<tr>
<td>Specific Strength (N*m/kg)</td>
<td>2.5x10⁴</td>
<td>2.7x10⁶</td>
</tr>
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</table>

- Due to its lower density and greater ultimate strength, carbon fiber has a specific strength that is nearly 11 times as strong as steel's.
- Carbon fiber clearly has a mechanical advantage over steel in elevator cables.

Audio-Mechanical Properties:

- This equation implies that ropes having a lower linear density will have a longer natural resonant wavelength.
- Carbon fiber has a density of about 22% of the density of steel.
- Therefore carbon fiber will be able to be used over longer distances without resonating.

Cable Design

Load-Bearing Sections:

Ultrarope is comprised of four primary load-bearing sections, labeled "P". These sections are made of carbon fiber, reinforced in an epoxy resin matrix. It is possible to increase the number of these load-bearing sections, giving Ultrarope the capability of adjusting the cable strength according to the elevator Shaft height.

Flexibility Grooves:

Also seen are grooves, labeled G, that separate each load bearing sections. These grooves only measure 0.5mm in depth, but they act as an important component of the cable. The grooves provide a degree of flexibility, while improving the cable's mechanical properties. These fibers are saturated in polyurethane, heated, and molded into their desired shape.

Resin Coating:

The outer region, labeled "C", is coated in polyurethane due to its high coefficient of friction and resistance to wear. This helps eliminate slippage as the cable passes over the hoisting mechanism of the elevator.

Damage Sensing:

Each "P" section of the cable has a sensor fiber and reference fiber passing through its center. The reference bundle is used as a base comparison of the amount of strain felt on the sensor fibers. These sensor fibers are then connected to a condition monitoring device. This device is a small computer which is used to monitor the wear on the cable.