# O.I.T.A.F. Seminar Work Committee No. II

## Get the best out of your ropes!

# Operational aspects influencing the life of strand ropes

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# Operational aspects influencing the life of strand ropes

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2. Operational aspects over time
3. Rope installation
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# 1. Introduction

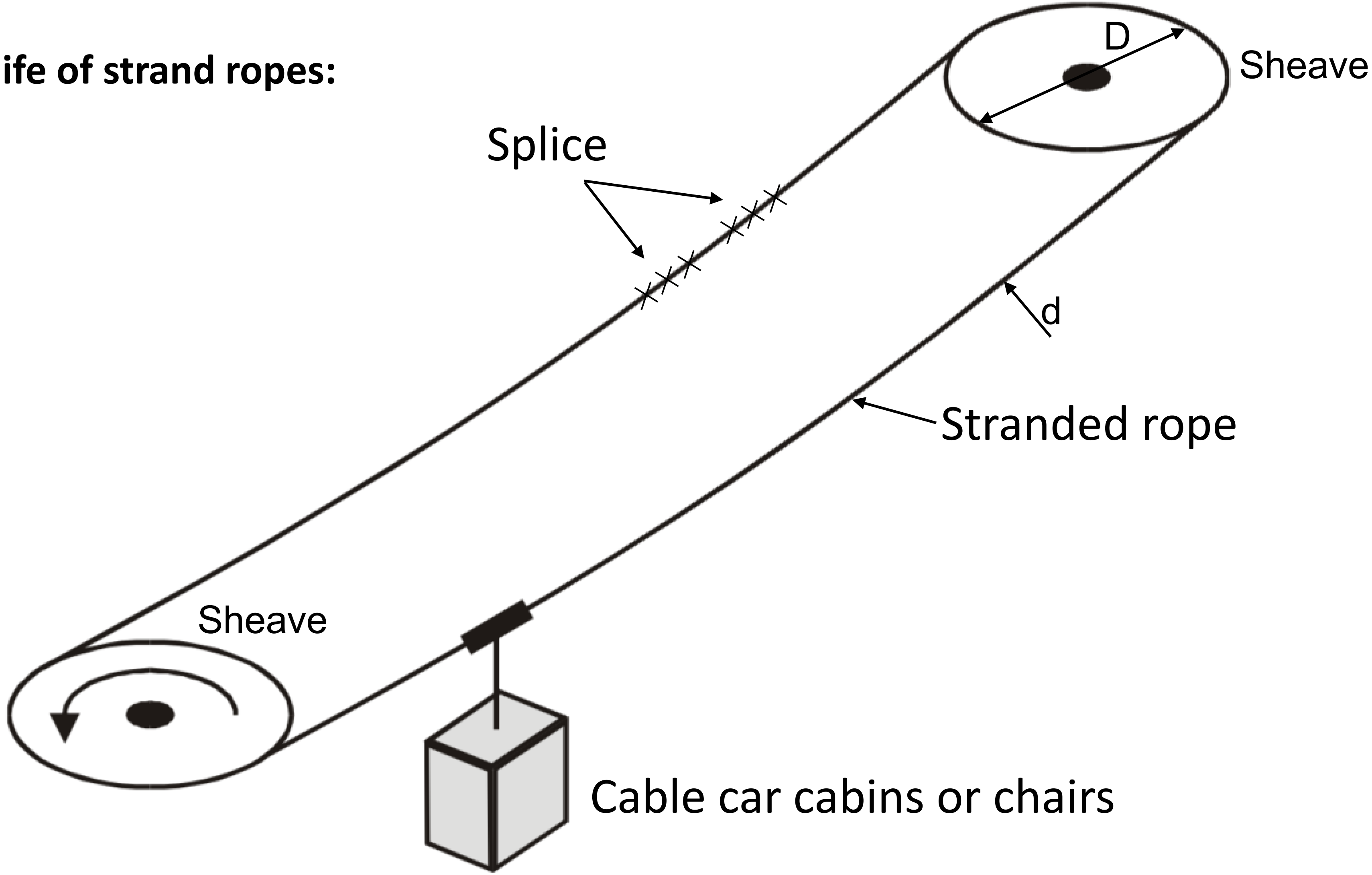
**Aspects influencing the life of strand ropes:**
Technical aspects

Operational aspects

Maintenance

Design and maintenance of the splice

**Influences that cannot be planned**




Typical ropeway system

# 2. Operational aspects over time

- Within the last 20 years, ropes and their field application have developed rapidly
- Most important advantage of a rope is the fact that it reveals an upcoming damage early in time
- If operators recognize the signs of damage, disasters are hardly possible
- Economic development was possible in terms of "bigger, faster, lighter, longer, more efficient, cheaper, etc.“
- Number of bending cycles is the main influence on the service lifetime of a rope

Development of number of bendings over the last decades and influence of parameters

| Year | Installation Length [m] | Number of Sheaves | Max Speed [m/s] | Operation hours per day | Operation days per year | Max bendings per year | Increase Factor |
|---|---|---|---|---|---|---|---|
| 1953 | 2390 | 2 | 2.5 | 7 | 120 | 3163 | 1 |
| 1999 | 932 | 2 | 5.5 | 8 | 270 | 45888 | 15 |
| 2010 | **805** | **2** | 6 | 18 | 365 | 176288 | 56 |
| 2022 | **2800** | **4** | 7.5 | 19.25 | 365 | 135506 | 43 |

# 3. Rope installation

**Abrasion** - critical situation, rope too close to the soil

**Contact with obstacles** - disastrous situation

# During rope installation or during operation

**Abrasion or crush** of the outer wires of several strands

# Rope installation and maintenance

**Improvised clamp**
missing groove
unsmooth surface
unknown sliding force

# Forced bending cycles

**Deflection sheave**
kinging on a diverting sheave caused by insufficient orientation of the sheave

# 4. Influences during operation

**Differences in rope tension forces** lead to changes in the lay length, in torque and twist, but also to different transverse forces. Fatigue and abrasion may occur.

**Expected different rope tension results from:**

- Height difference bottom station - mountain station (haulage rope)
- Difference of rope tension before drive wheel - after drive wheel
- Load condition
- Dynamic forces from acceleration / deceleration
- Meteorological influences (temperature, wind, ice, etc.)

**Unexpectedly fast changes** may occur from heavy storm with gusts, ice shedding, trees fall on ropes, etc.

It is important to remember not to constantly change the driving speed. A constant driving speed protects the system (oscillations / vibrations) and the rope.

and

The energy in the system (in the rope) dependents quadratically from the driving speed.

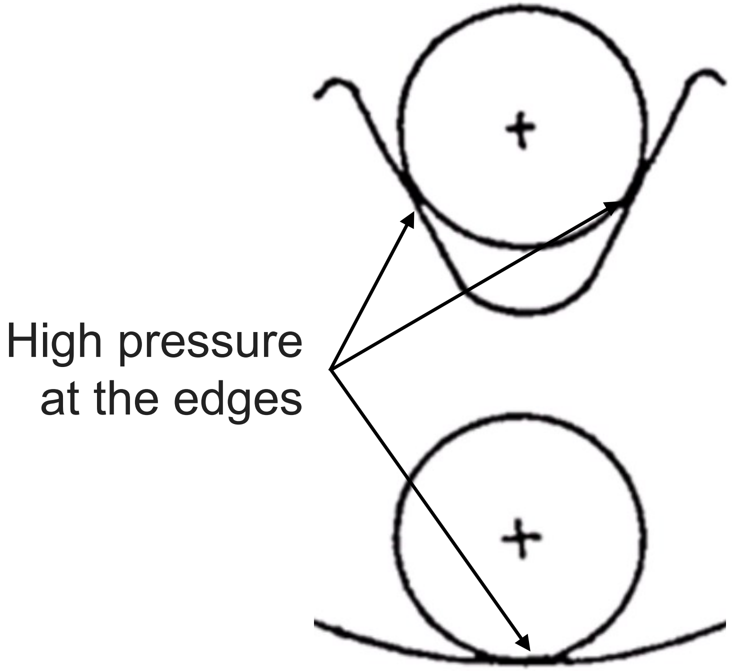
# During operation, grips

**Damage**
caused by fixed grips after
a too late relocation

**Negative imprint**
of the rope in a fixed grip

# Running on rollers and sheaves

Small lining grooves lead to wear at the edges and to twisting

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Ropeway drives using a double grooved traction sheave and a counter sheave with different diameters lead to wrapping tension, further unequal abrasion and high stresses in the rope

# Running on rollers and sheaves

Roller Damages seriously damage the rope

Running ropes should only touch the soft inserts of rollers, wheels, supports and the clamps

Other contact, with any hard construction elements or flanges of rollers can damage the rope massive

# Environmental influences, lightning strikes

**Lightning strikes**
Not predictable

Not reliably detectable by MRT

Recognisable by visual inspection

# Environmental influences, heat on rope

Heat impact on a carrying-hauling rope

**Heat of fire**
damages the outer wires starting at about 200°C

Failure of the core means that the rope compound loses its support leading to touching strands, wear, corrosion and wire breaks

Lubricants can melt from about 60°C or even lose their properties at about 100°C

Ropes should be kept in motion to prevent local rope sections from heat damages

After exposure to heat on ropes, it is essential that they are assessed by competent persons

# Environmental influences, heat on structures

**Heat from sunlight**
towers are prevented from heating up by installing sheet-metal panels covering the shafts

**Melting of permafrost**
leads to deformations, settlements and thus to dis-alignments of the track, to twisting and different lay length, up to rope derailment

**Melting of permafrost under drive stations**
To protect the permafrost from warming up, foundations are specially insulated against the subsoil to prevent dis-alignments of the track

# Environmental influences, electrical fields

**Moving rope in electromagnetic field** generates electrostatic charges of the rope. At electrically earthed points of contact with the rope, the wires may locally overheat.
Increased wire fracture and reduced lifetime of the rope are the results.

**Conclusion**
No ropeways near high-voltage powerlines and transmitter-masts.

As a rule, the ropeway control reacts more sensitively than the rope…

# Environmental influences, volcanic ashes

**After volcano eruption**
Ropeways in the vicinity of volcanoes are very exposed to atmospheric influences such as carbon, sulfur, salt water, etc.

**Bright ropes** instead of galvanized ropes
In this specific environmental condition, the bright ropes shall be advised in respect to the galvanized ropes. In fact, the released sulfur vapors are able to connect with the zinc and create a brittle structure that result in a premature and fast rope failure.

**Rope after volcano eruption**
Without cleaning, the lifetime of the rope is greatly reduced

# Derailment and rollovers


Rollover of a hauling rope

**Rollover of hauling rope**
Rollovers can be caused by vibrations due to emergency braking or wind.

Both track rope and hauling rope should at least be visually inspected after such an incident.

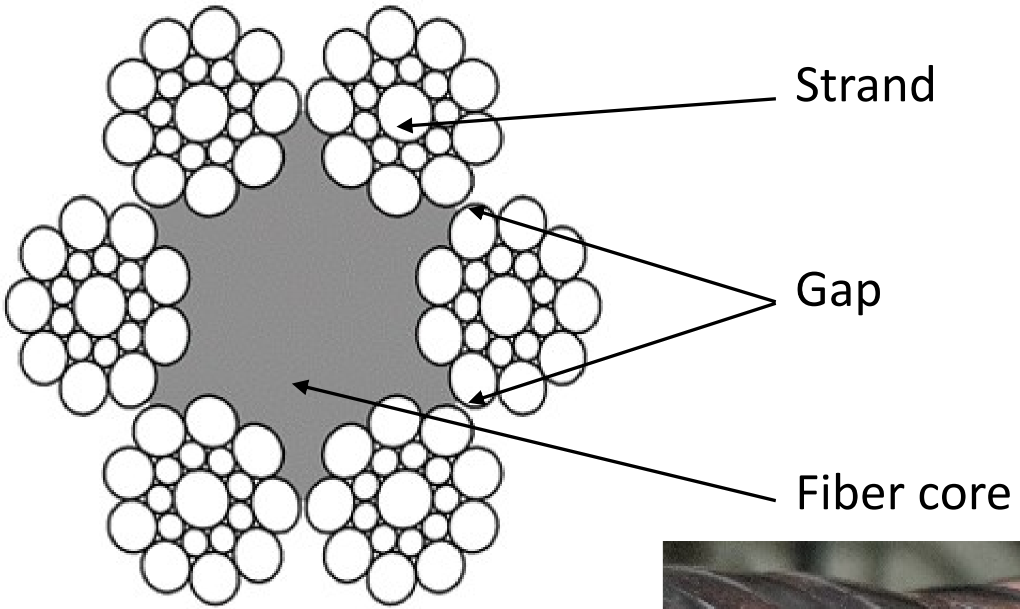
**Derailments** of funicular ropes can happen, too.

Especially for concave slope designs, in combination with transverse wind, the rope can fail to lay back into the track rollers.

If derailments happen in the passing loop, the rollers may be insufficiently adjusted or worn. In this case, the rope can be damaged over a long distance.

**In any case of derailment, a competent person should be consulted.**

# 5. Corrosion




Stranded rope

**Cleaning and lubrication**

a very important topic
will be covered in a later lecture

Corrosion induced by friction between touching strands

# Corrosion

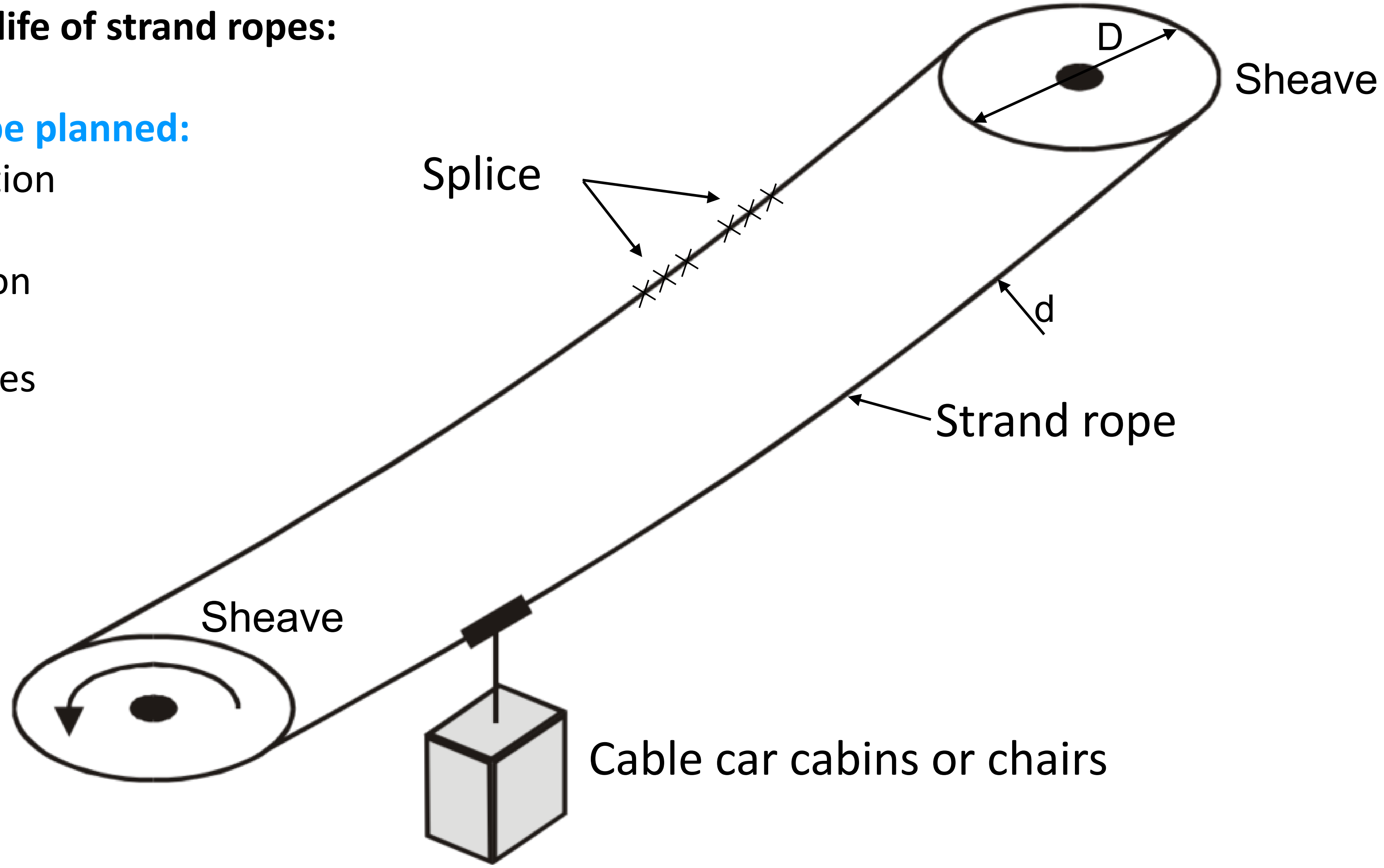
Wire breaks due to corrosion

# 6. Summary

**Aspects influencing the life of strand ropes:**

**Influences that cannot be planned:**

- Failures during installation
- Failures during operation
- Environmental influences
- Corrosion
- Etc.

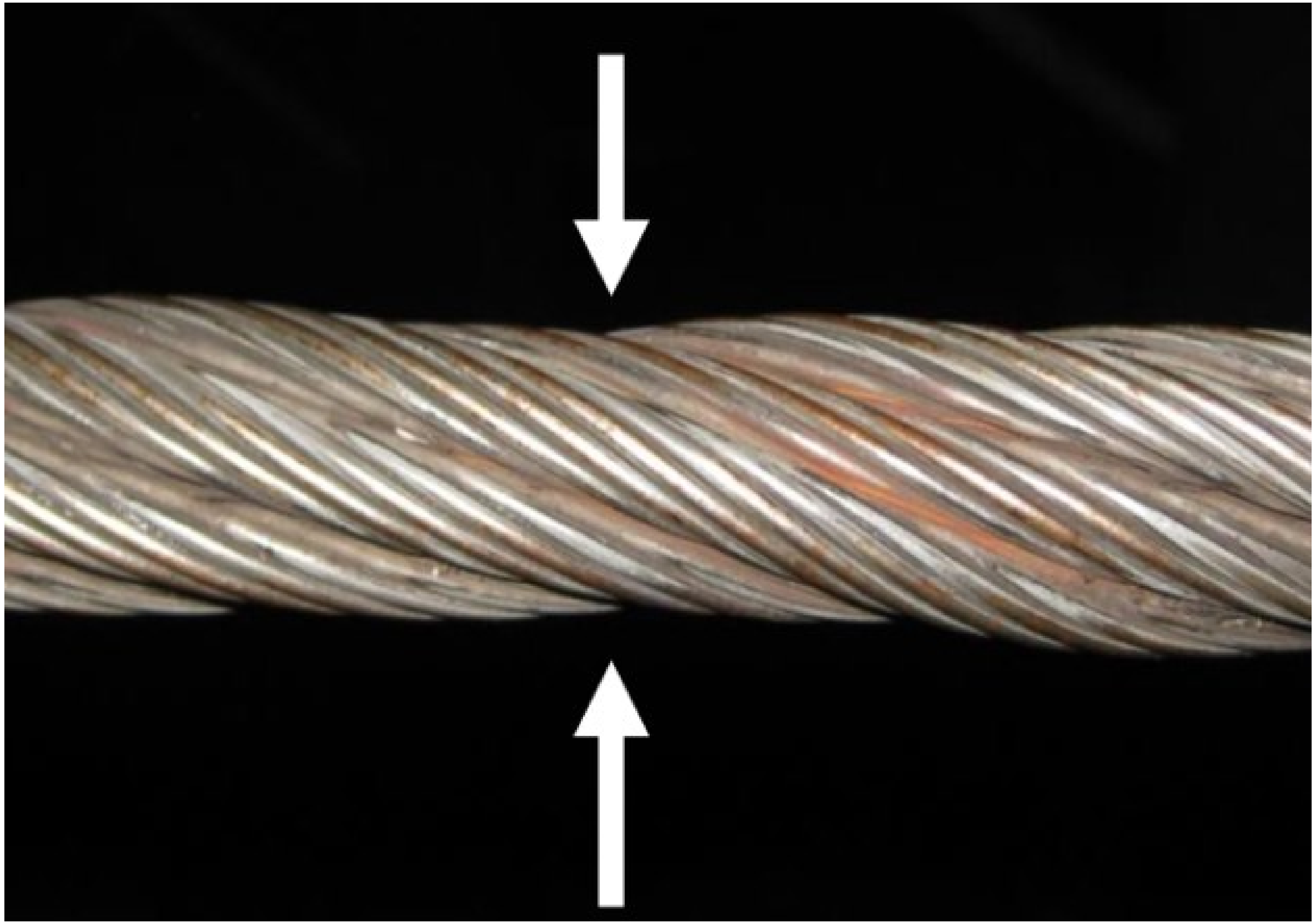



Typical ropeway system

# Summary

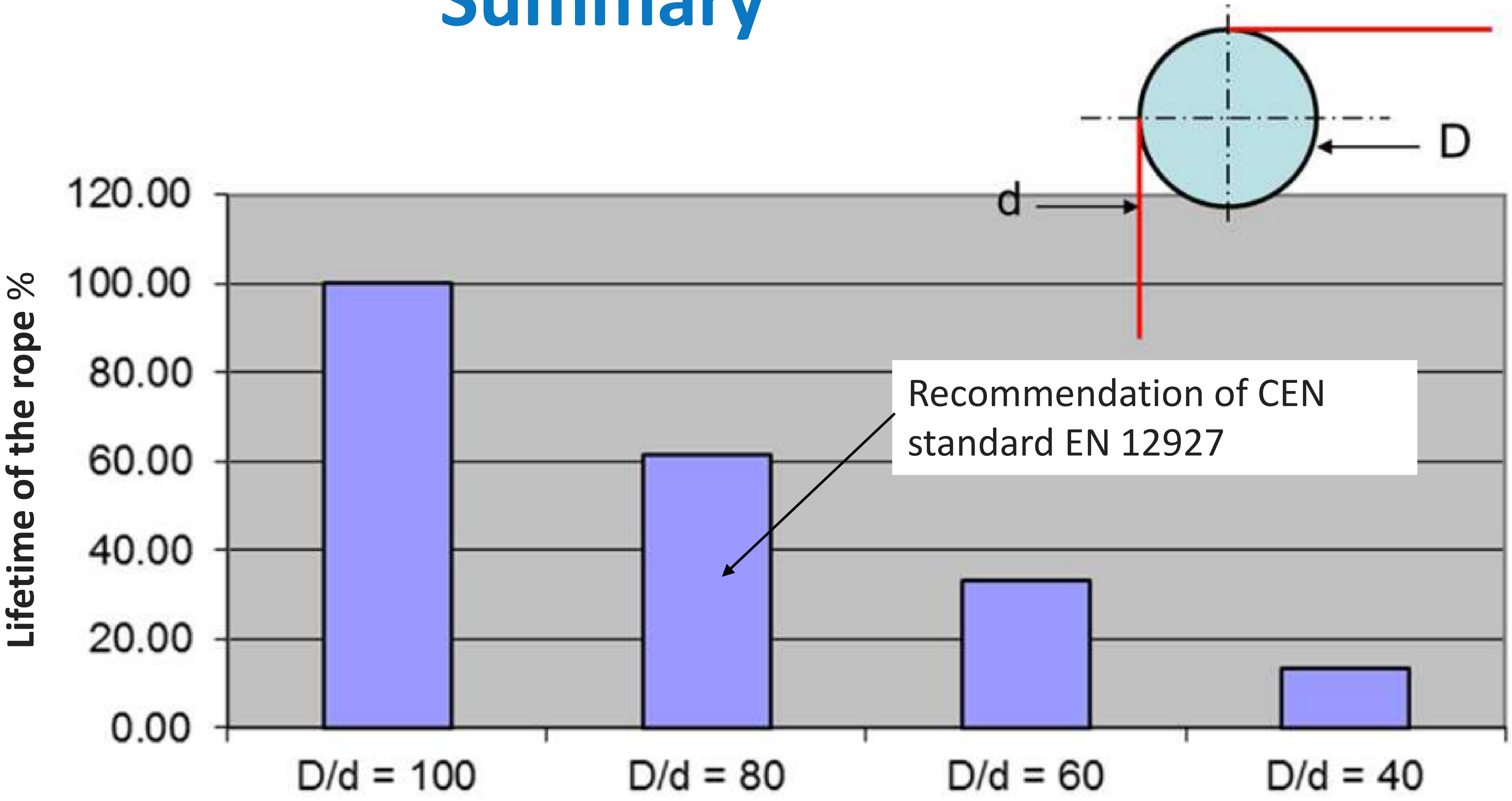
Aspects influencing the life of strand ropes:

**Splice**



Tuck tail end that needs to be repaired

# Summary




**Comparison of lifetime as function of diameter ratio**

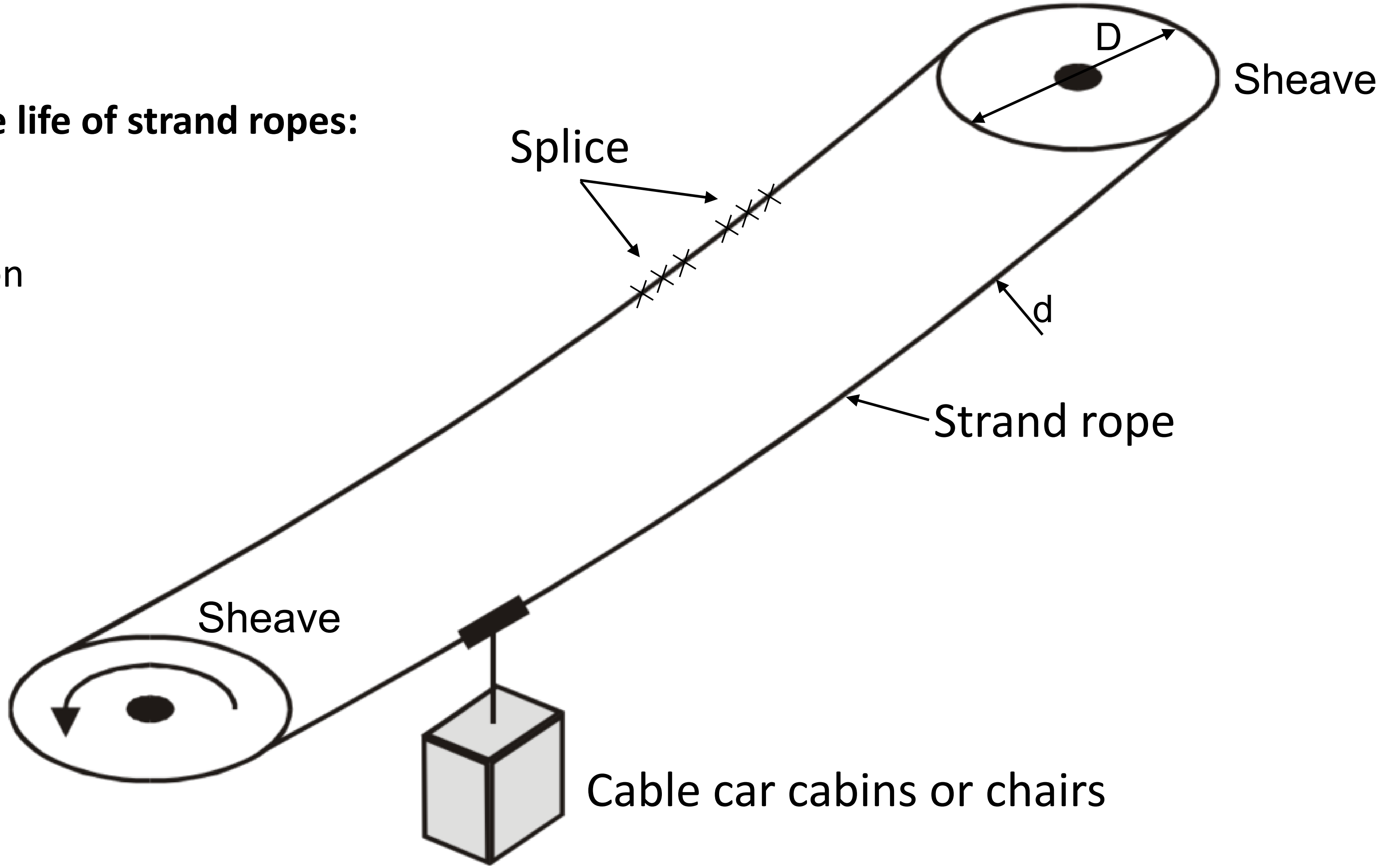
# 7. Basics for a lifetime estimation (calculation)

**Aspects influencing the life of strand ropes:**

Maintenance:
- Cleaning / Lubrication

Technical aspects:
- Number of sheaves
- Diameter ration D/d

Operational aspects:
- Bendings per time




Typical ropeway system

# Lifetime estimation of strand ropes

Common wire break due to bending cycles

**Thank you for your attention !**

**Vielen Dank für eure Aufmerksamkeit !**

**Merci beaucoup pour votre attention !**

**Grazie per la vostra attenzione !**