Cables in dynamic applications

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Mechanical stress for cables

Flexible cables are exposed to the following kinds of mechanical stress:

- **Push and pull load**
- **Bending / flexing load**
- **Torsion load**

To withstand these load types on a permanent basis, specific requirements are needed for appropriate design and testing capabilities.

Pull and Push

Forces act lengthwise to the cables:

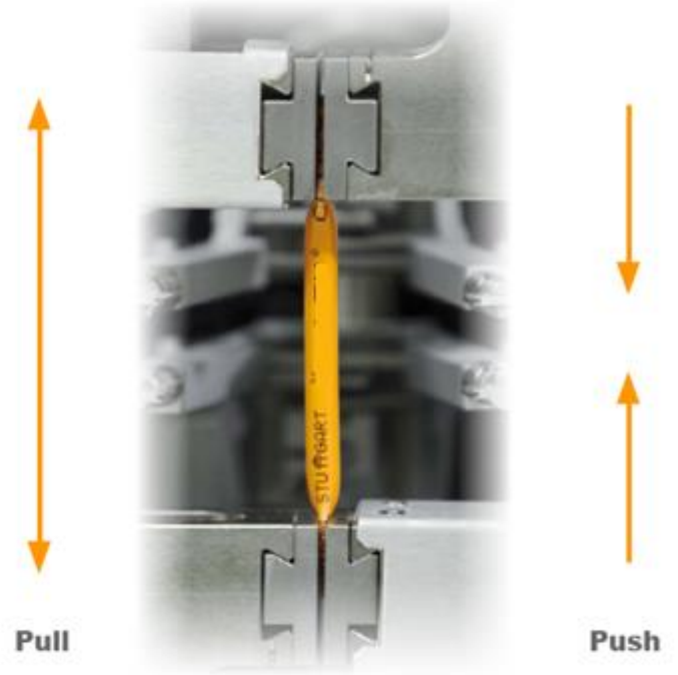
Static: Influence on the cable through gravitation, for example fountain-submersible pumps (vertical hanging cable)

Dynamic: Horizontal lines in a moving chain management system are subjected to acceleration forces
→ Forces (horizontal motion).

Static and dynamic: Elevator cables are subjected to both gravity and acceleration (vertical movement)

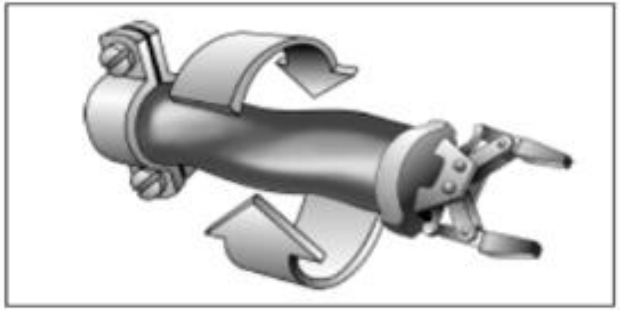
The elasticity differs considerably depending on the material:

- PUR → 600%
- PVC → 200%
- Cu → 20% until it cracks



Torsion

Torsion is the **twisting**, that occurs when a torque acts on a subject.



For example, torsion occurs on a cable when a rotational **force is applied to one end**, while the **other end is held firm.**

Bending & Torsion:

Multi-axis articulated robot arm

Typical 6 Axis

Torsion:

Swivel arm-robot
SCARA Robot

SCARA = Selective Compliance Assembly Robot Arm

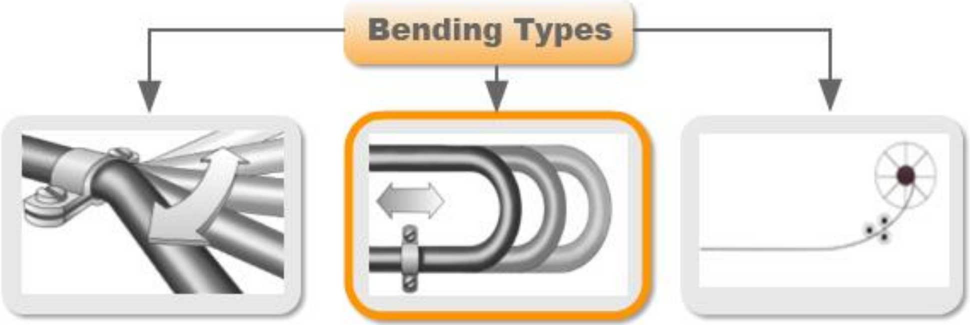
Typical 3 Axis

Bending / flexing

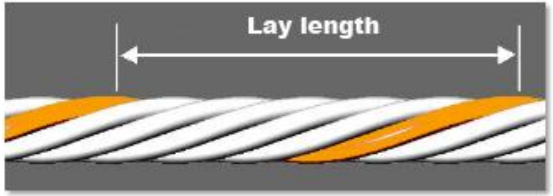
Three different forms of bending are distinguished:

- **Simple flexing (tick/tock)**
- **Continuous flexing**
- **Continuous flexing with guided conditions**

Power chain cables are mostly exposed by a flex zone along the cable's entire length.



Design of highly flexible cables



What is lay length and why are the cables twisted?

The term **lay length** describes the **length of the route** required for a single wire to complete a **360° rotation**

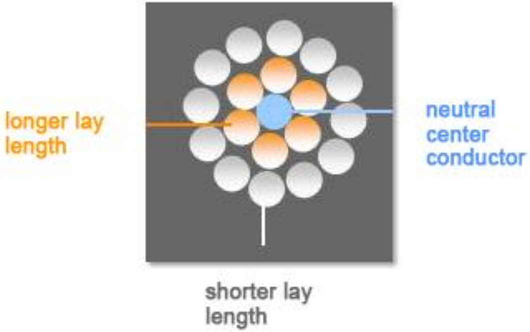
With shorter lay lengths, a balance between expansion and compression frequently takes place.

From this we can conclude:

The shorter the lay length, the better the flexibility and mobility of the cable.

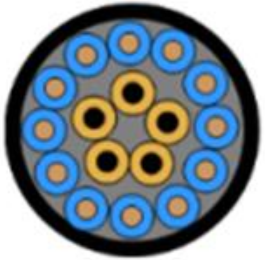
The individual layers influence the overall flexibility, the further away they are from the neutral center conductor.

Therefore **inner layers** are made with **longer lay length**, and **outer layers** use relatively **short lay lengths.**



Design of flexible cables

What types of constructions are available?



Twisted in layers

- **Advantages:**
  - Reduced outer diameter
  - Dismantling/strippability
- **Disadvantages:**
  - Long travel distances

Twisted in bunches

- **Advantages:**
  - Long travel distances
  - Torsional stress
- **Disadvantages:**
  - Larger outer diameter
  - Dismantling/strippability

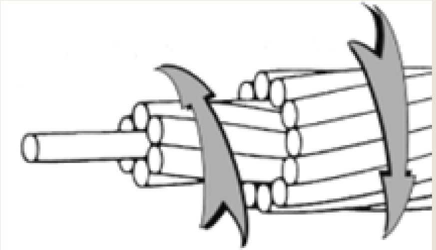
Twisted in pairs

- **Application:**
  - Data cables

Design of highly flexible cables

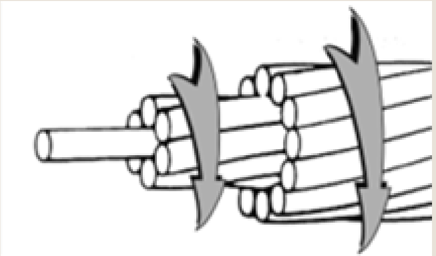
What are typical cable compositions (twisted in layers)?

Contra-Helical (reversed lay) stranding



Each layer is twisted in a **different direction**

Unilay stranding



The overlying layers are twisted together in the **same direction**

Design of highly flexible cables

Which design is necessary, in order to withstand the respective kinds of stress?

Bending / flexing:

- Stranded conductor class 6, possibly even class 5 is possible
- Short lay lengths
- Reversed lay stranded
- Special insulation material
- If Shielded, a copper braid is typically used

Torsion:

- Stranded conductor class 6, possibly even class 5 is possible
- Long lay lengths
- Unilay stranded
- Special insulation material
- If Shielded, a copper layer is typically used

Taking a look at the **structural design of the FD/CHAIN cable**, you can see that is fundamentally differs from the **“ROBOT” cable.**

While **guiding chain lines are twisted short** to allow the bending occurrence during the relative movement of individual wire against one other, the trend in **ROBOT cable** is toward significantly **longer twisted cores.**