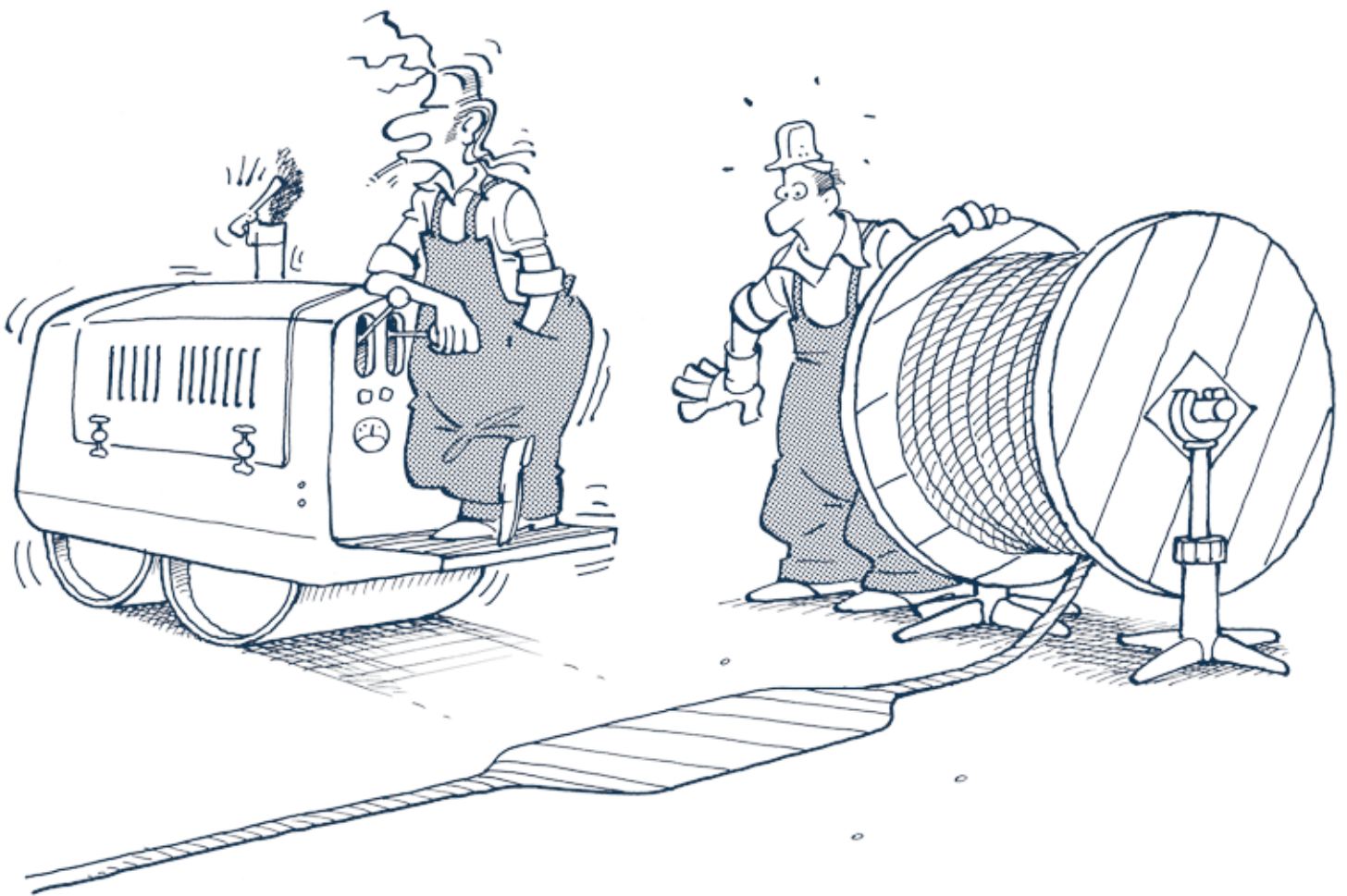


CASAR[®]

SPECIAL WIRE ROPES



Steel Wire Ropes for Cranes

Problems and Solutions

Steel Wire Ropes for Cranes

Problems and Solutions

by **Dipl.-Ing. Roland Verreet**

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1 The steel wire rope – a multiple-redundant machine element

Imagine the following situation: An inspector has examined the hoist rope of an offshore crane and he has found 10,000 wire breaks. He insists that the rope is still in good working condition. Could this be true?

Before wire ropes were invented in 1834, chains were the most common lifting means. They have, however, one essential disadvantage: Chains are *linear* arrangements of load bearing elements. If only one chain link fails, the whole system will fail (Fig.□1).

Steel wire ropes, on the other hand, are *parallel* arrangements of load bearing elements. If one rope element fails, the breaking strength of the wire rope is reduced only locally, and usually by less than 1% (Fig.□2).

Wire ropes are multiple redundant systems of load bearing elements. In a redundant system every element which is necessary for the proper functioning of the system exists at least twice. For example, some of the parts of our human body are redundant: If we lose the eyesight on one eye, we can still see. And if we lose the hearing on one ear, we can still hear. If in a wire rope one wire fails, there are still about 250 other wires to carry the load.



Fig. 1: *The chain. The break of one element leads to the failure of the whole system.*



Fig. 2: *The steel wire rope. The break of one element has hardly any effect.*

But what will happen if during the service life of the rope more and more of these wires fail? If we have lost the eyesight on both eyes, we can no longer see. And if we have lost the hearing on both ears, we can no longer hear. Therefore, should not also the wire rope fail if *every single one* of its 250 wires is broken?

No. It sounds incredible, but a wire rope can still be in good condition even if every single one of its wires is broken *200 times*!

Figure 3 shows a schematic arrangement of the 250 wires making up a wire rope (for space reasons, only 30 wires are displayed). Along the rope length, every single one of the 250 wires is broken once. Each wire break, however, merely represents a *local* reduction of the rope's breaking strength. A few millimeters away from the location of the break the broken wire will again bear its full share of the load.

If we have a very uniform distribution of the wire breaks along the rope length so that in every short piece of rope only one wire break can be found, the breaking strength of every single one of these sections is weakened by less than one percent only. In a pull test this wire rope might achieve its full catalogue breaking strength even though every single one of its elements is broken!

Still, there must be rules about how many broken wires per rope length unit can be tolerated. The discard number of wire breaks is defined in the applicable national or

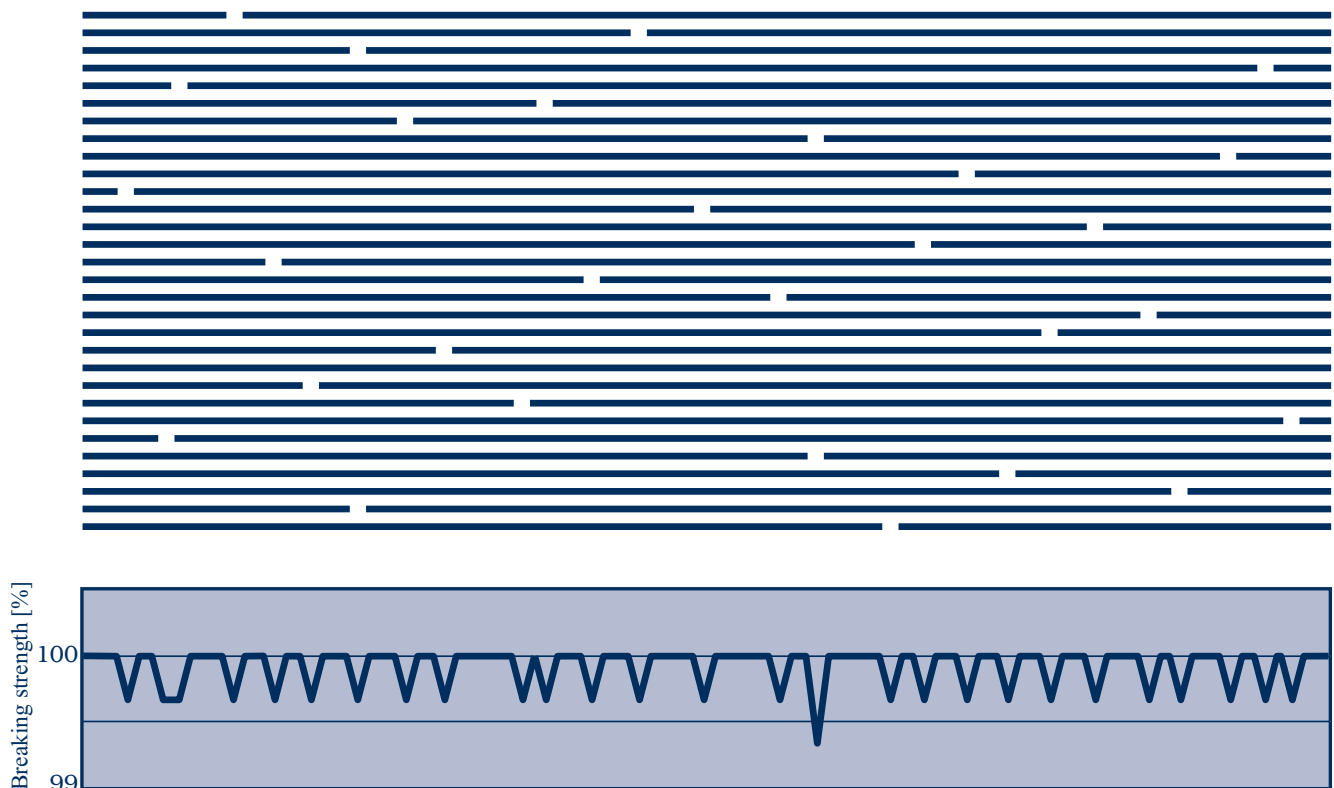


Fig. 3: *Each wire break only leads to a local reduction of the rope's breaking strength.*

international standards and in the rules of the classification societies as a permissible number of wire breaks per multiple of the wire rope diameter, e. g. per 6 x rope diameter (one rope lay length) or per 30 x rope diameter (5 rope lay lengths).

Our inspector has found 10,000 wire breaks, but the discard number was not reached in any single rope section of a length of 6 x d or 30 x d. So he was perfectly right in his decision to keep the rope in service.

This example shows that under normal conditions a wire rope is a very safe and reliable machine element.

2 Problem: Local concentrations of wire breaks

A few days later our inspector comes back from examining the hoist rope of a sister crane. He has found only 15 wire breaks, but he insists on discarding the wire rope. After allowing 10,000 wire breaks on the first crane, this sounds a bit strange. Could the inspector be wrong this time?

If the wire breaks are concentrated in a very short section of the rope (Fig.□4), e. g. as a consequence of a misuse or because of a local mechanical damage, the reductions in breaking strength will add up to a critical value, and the rope must be discarded. Although 500m of the rope are as good as new, it must be discarded because 5cm are in a bad state.

Wire ropes with a local concentration of wire breaks are unsafe. Our inspector's decision to discard the rope is correct.

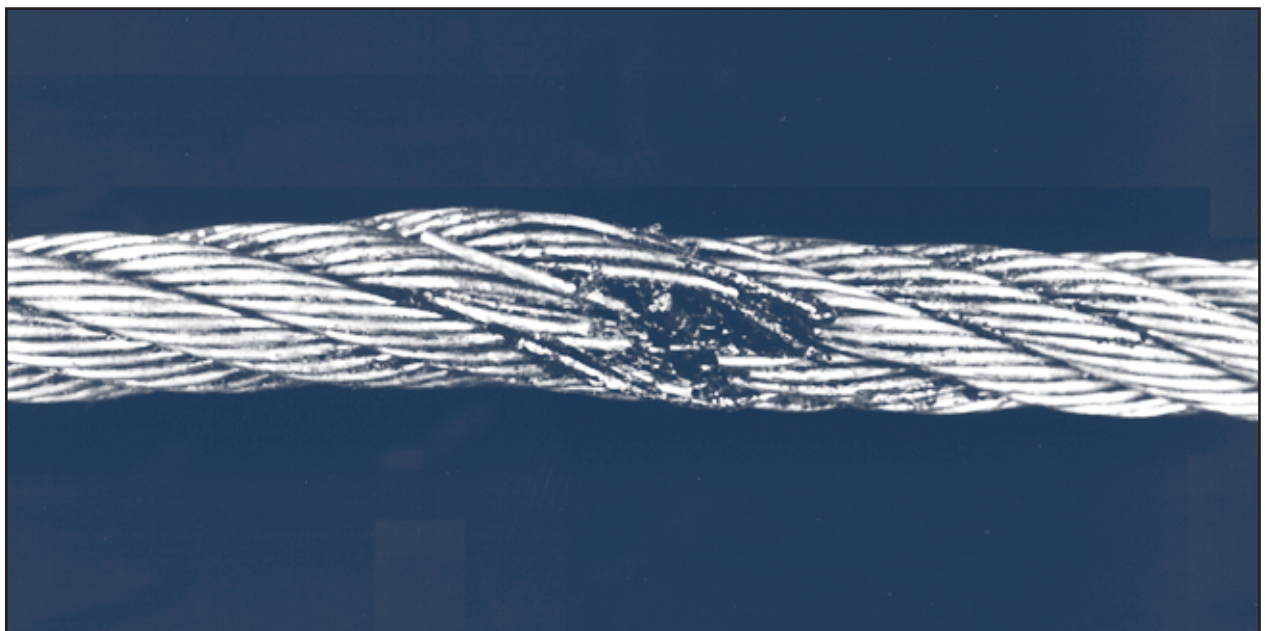


Fig. 4: *A local concentration of wire breaks*

3 Problem: Internal wire breaks

The hoist rope of a third crane of the same design does not show a single wire break. After examining the rope, our inspector insists that it must be discarded. Why?

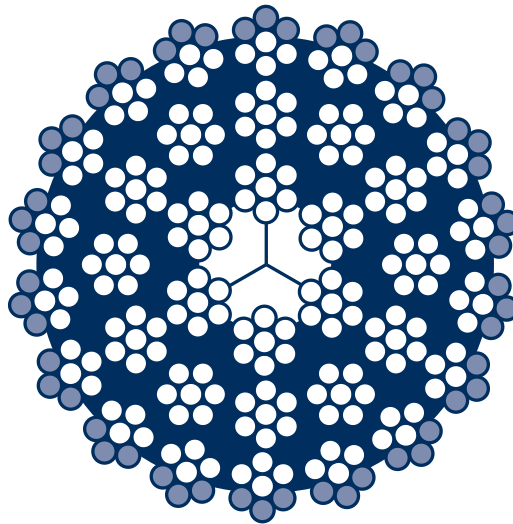


Fig. 5: *Only about 20% of the metallic cross-section of the wire rope can be inspected visually.*

During a visual rope examination, only the condition of the *visible* parts of *outer* wires can be evaluated. The metallic cross-section of the outer wires, however, only represents about 40% of the metallic cross-section of a rope, and only about half of the length of these outer wires is visible (Fig. □5) This means that during a visual rope inspection we can only examine the condition of 20% of the metallic cross-section of the rope and we can only *hope* that the other 80% are in as good a condition.

**Visual Rope Inspection:
20% Evidence – 80% Hope**

Quite often, however, the visible 20% of the cross-section look good, while a great number of wire breaks are concealed in the invisible part of the rope. Wire ropes with internal wire breaks and no external sign of damage are extremely dangerous.

3.1 Problem: Internal wire breaks in a 6-strand rope with steel core

During the examination of a wire rope 6x36 Warrington-Seale with a steel core (Fig. 6) no outer wire breaks could be found. After bending the rope by hand, however, it was obvious that every single outer wire was broken inside the rope (Fig.□7).

The contact conditions between the steel core and the outer strands are characterized by very high local contact stresses (Fig. 8). Therefore the outer wires of the rope can break at their points of contact with the steel core. The free length of the broken wires in Fig.□7 clearly shows that this is the case here.

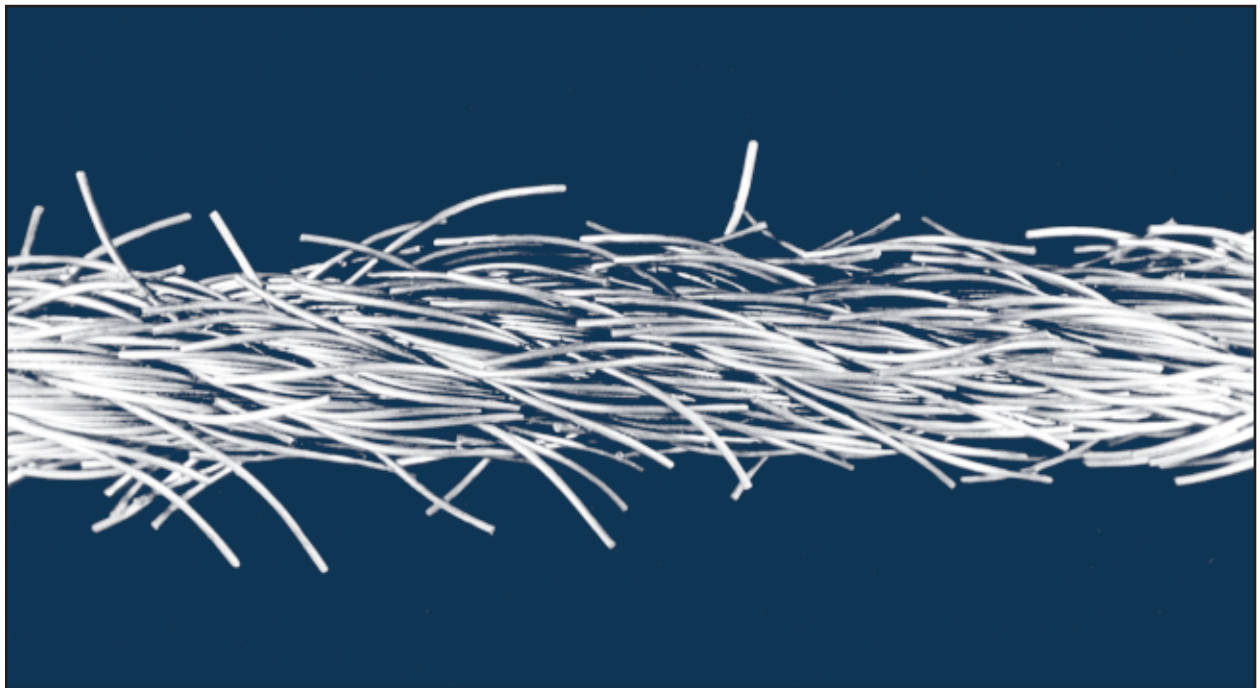


Fig. 7: *Numerous wire breaks at the points of contact between the steel core and the outer strands*

3.2 Solution: 8-strand ropes with an internal plastic layer

Figure 9 shows the cross-section of an 8-strand rope with a plastic layer between the steel core and the outer strands (Casar Turboplast). The plastic layer does not only seal in the rope lubricant and protect the core against the corrosive environment, it also prevents metal-to-metal contact between the two strand layers and so reduces the contact pressures between the steel core and the outer strands (Fig.□10). The plastic layer therefore successfully helps prevent internal wire breaks.

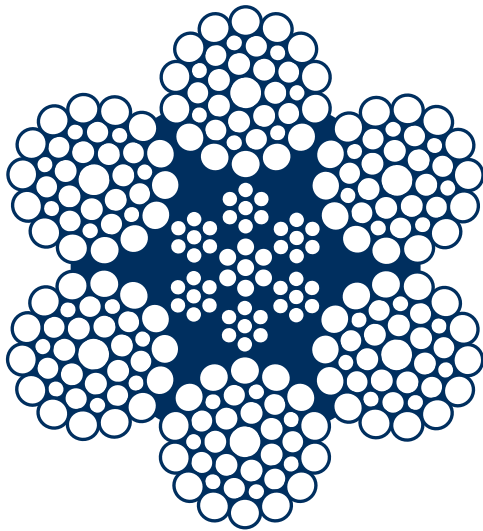


Fig. 6: Wire rope with steel core (6x36 Warrington-Seale IWRC)

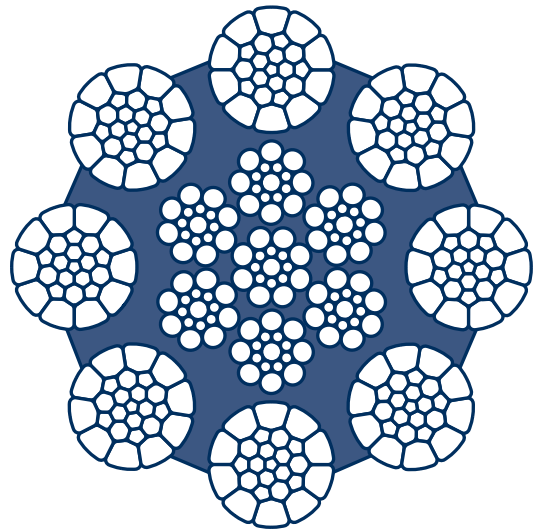


Fig. 9: 8-strand rope with a plastic layer between the steel core and the outer strands (Casar Turboplast)

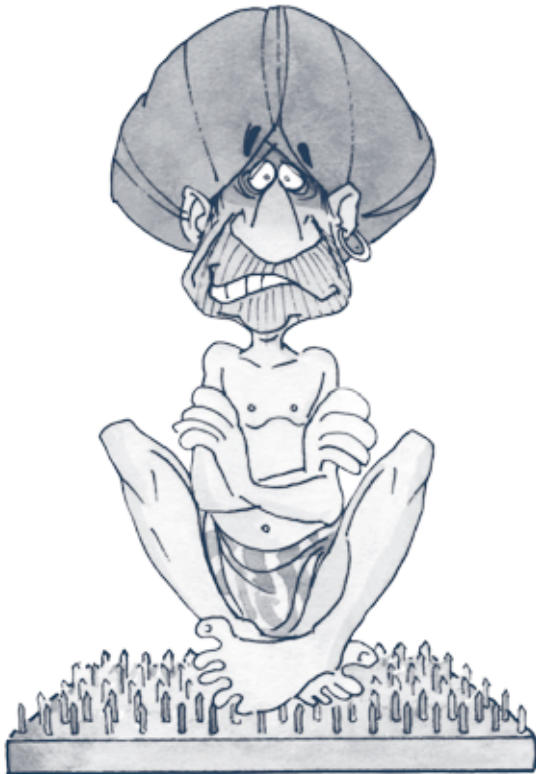


Fig. 8: Very high local contact stresses between the steel core and the outer strands (6x36 Warrington-Seale IWRC)



Fig. 10: The plastic layer acts like a cushion. It reduces the contact stresses between the steel core and the outer strands and helps prevent internal wire breaks (Casar Turboplast).

4 Problem: Internal wire breaks in conventional rotation-resistant ropes

In rotation-resistant ropes, the core is closed in the opposite direction to the outer strands. Therefore rotation-resistant ropes are even more prone to internal wire breaks than 6- and 8-strand ropes.

Fig. 11 shows the cross-section of a rotation-resistant hoist rope 36x7. Fig. 12 shows the external surface of such a rope after a few months of service. Externally, the wire rope does not show a single wire break.

After removing the layer of outer strands, many wire breaks appear on the rope core at the cross-over points between the two strand layers (Fig. □13) After removing the second strand layer, the innermost layer also shows a high concentration of wire breaks (Fig. □14).

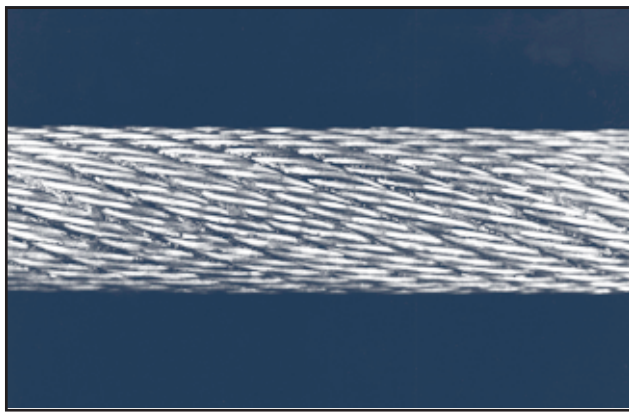


Fig. 12:

Wire rope 36x7 after a few months of service. Externally, the wire rope does not show a single wire break.

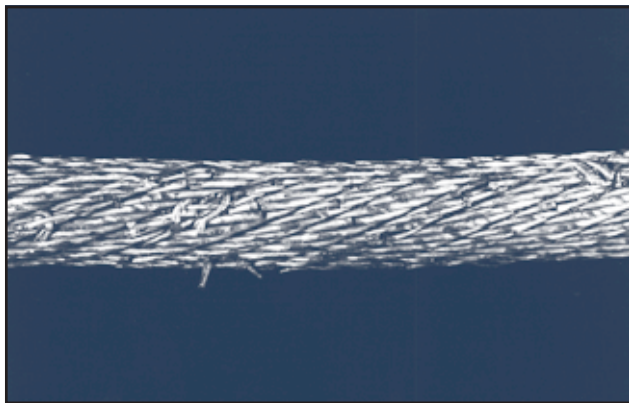


Fig. 13:

After removing the layer of outer strands, many wire breaks are visible on the rope core at the cross-over points between the two strand layers.

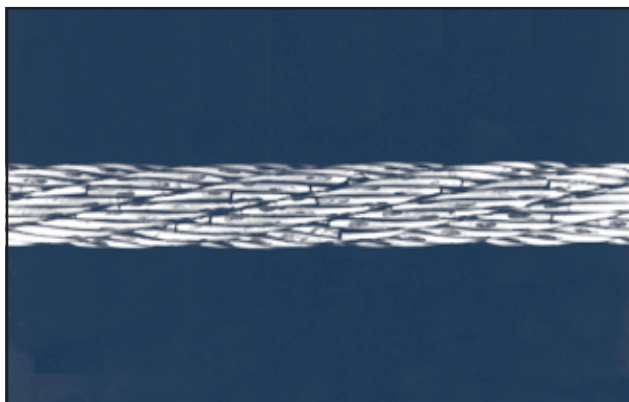


Fig. 14:

The innermost layer also shows a high concentration of wire breaks.

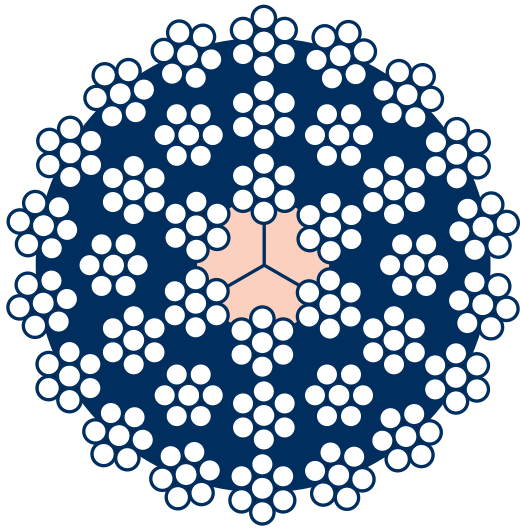


Fig. 11: *Rotation-resistant hoist rope (36x7)*

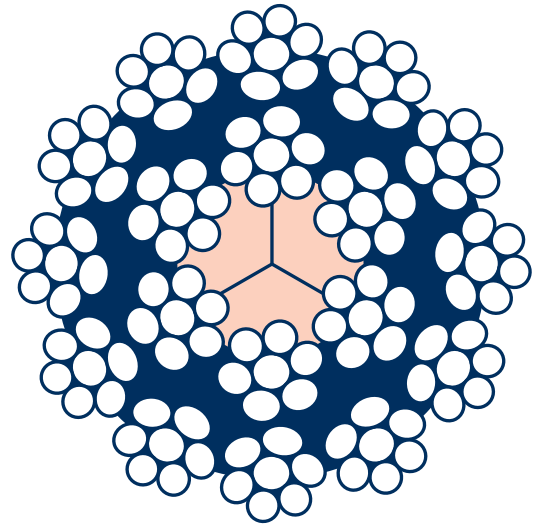


Fig. 15: *Semi- rotation-resistant hoist rope (18x7)*

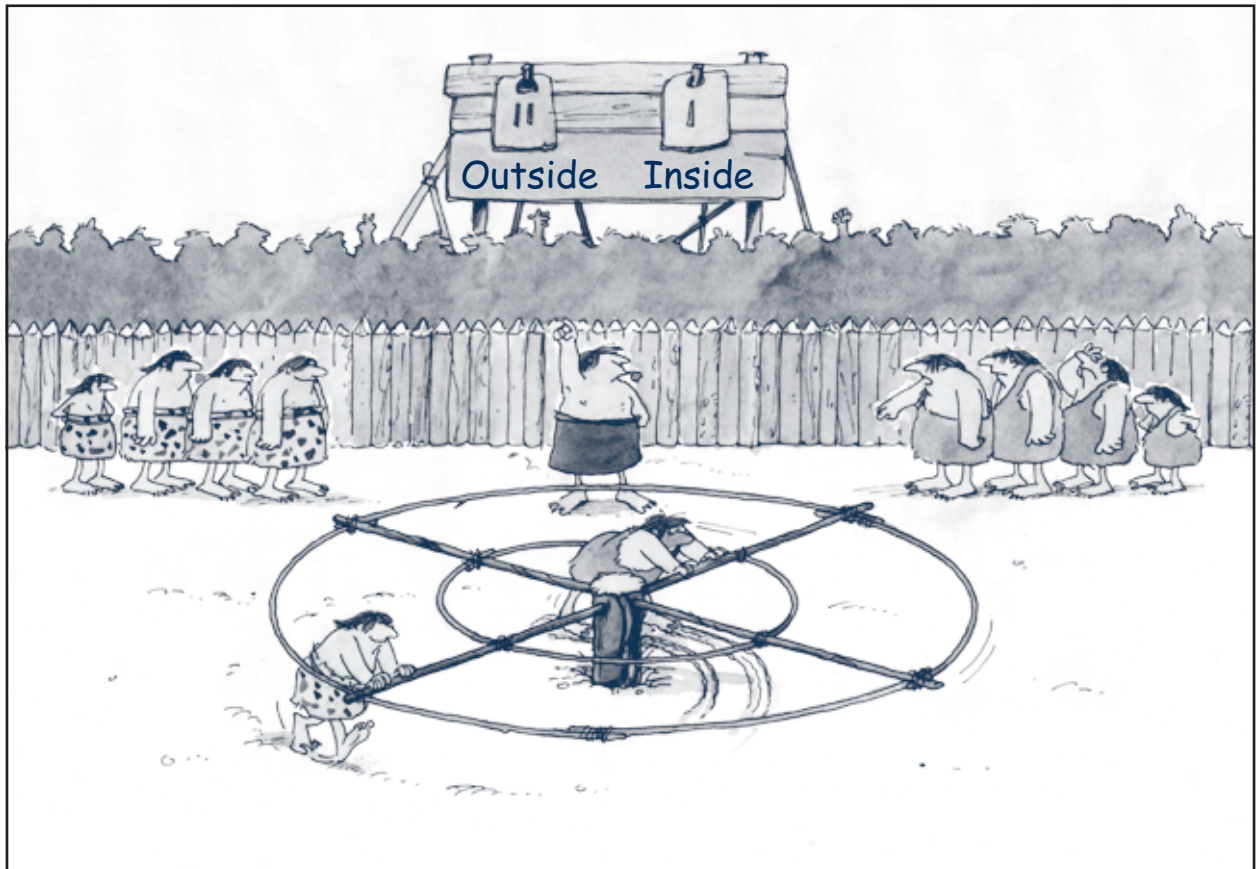


Fig. 16: *Due to their longer lever arms the outer strands have an advantage.*

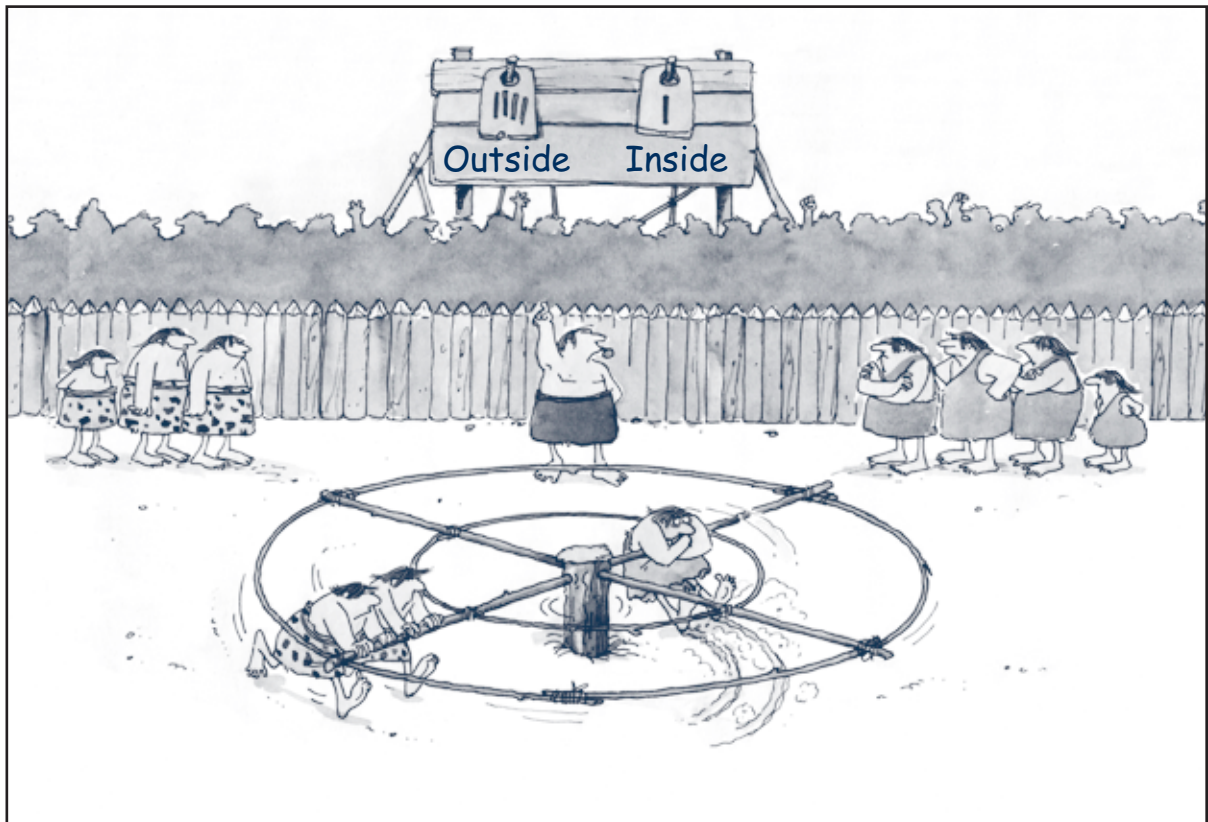


Fig. 17: In an 18x7 rope the metallic cross-section of the outer strands is twice that of the rope core.

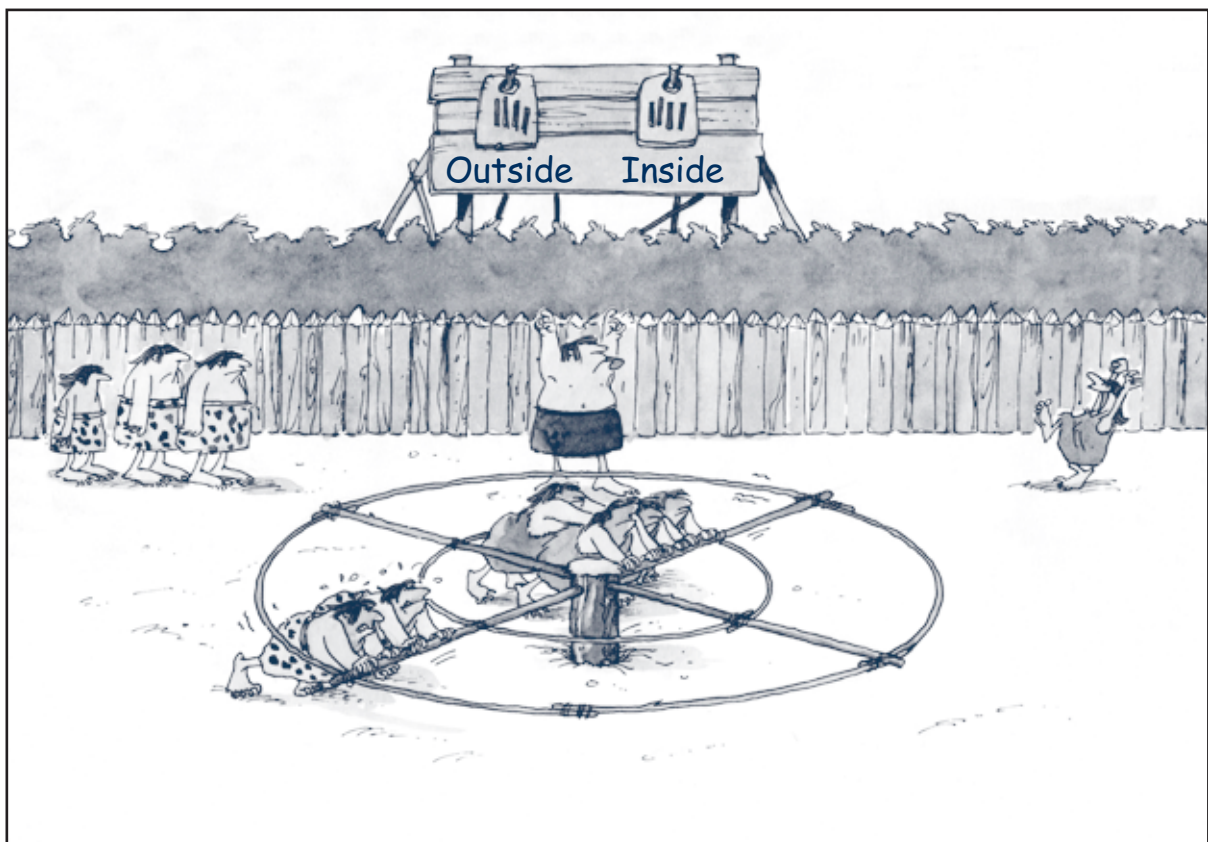


Fig. 18: An equilibrium is achieved because the athletes on the inside with the short lever arm outnumber those on the outside with the long lever arm.

4.1 Intermezzo: Rotation resistant wire ropes

If you use 18x7 ropes (Fig. 15), 18x19 ropes or one of their compacted variations as hoist ropes on your cranes, don't tell your insurance company!

Ropes of these designs have a built-in defect, as is shown by the following example: Two teams are trying to push a turnstile in opposite directions. The competition is not exactly fair because the one team pushes the turnstile at the end of its bars and thus benefits from the considerably longer lever arm, whilst their opponents are pushing it near the centre (Fig. 16).

If those pushing the turnstile near the centre do not stand a chance when the number of their competitors is equal, how much harder must it be for them when they are outnumbered by twice as many pushers at the outer end of the bars (Fig. 17)?

This is exactly what happens in 18x7 or 18x19 ropes and their numerous variations. These constructions contain six inner strands which must compete with twelve outer strands of the same diameter, and with lever arms twice as long. Ropes of that design can only be reasonably rotation-resistant if the inner strands are hopelessly overloaded!

In other words: In these rope constructions, the core will always be overloaded. It will, therefore, deteriorate at a much faster rate than the outer strands. The internal wire breaks are built-in by design.

Fig. 18 shows how stability should be achieved: The athletes on the inside with the short lever arm should outnumber those on the outside with the long lever arm!

And this is exactly how good rotation-resistant ropes achieve stability without overloading the rope core: The metallic cross-section of their core is considerably greater than the metallic cross-section of the outer strands.

Rotation-resistant ropes must have more metal in the core than in the outer strands!

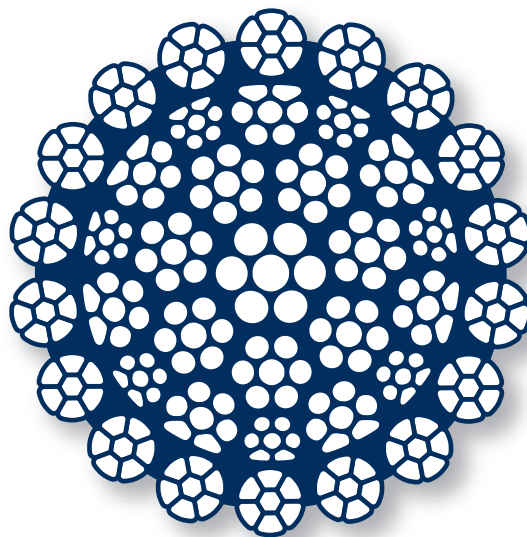


Fig. 19: 40-strand rotation-resistant hoist rope with compacted outer strands and a compacted wire rope core (Casar Eurolift)

4.2 Solution: Rotation-resistant special wire ropes with compacted rope core and compacted outer strands

Fig. 19 shows the cross-section of a 40-strand rotation-resistant hoist rope with a compacted wire rope core and compacted outer strands (Casar Eurolift). Compacting the core as a whole leads to higher breaking strength and to higher rotation resistance of the rope. In addition, the enlarged bearing surface of the smoothened core leads to a considerable reduction of contact pressures between the steel core and the compacted and smoothened outer strands (Fig. □20) and thus reduces the danger of internal wire breaks.

Rotation-resistant wire ropes such as Casar Eurolift should preferably be operated with an open swivel.

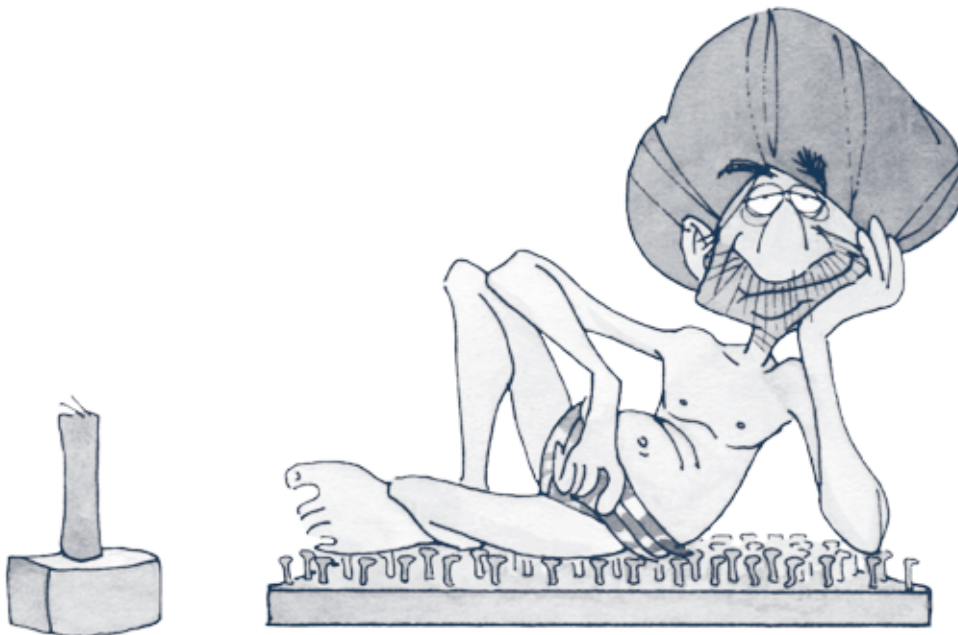


Fig. 20: *The enlarged bearing surfaces of the smoothened steel core lead to a considerable reduction of contact pressures between the steel core and the compacted and smoothened outer strands and so reduce the danger of internal wire breaks.*

5 Electro-magnetic wire rope testing

It should also be noted here that internal wire breaks can be detected by electro-magnetic wire rope testing instruments. The tests can either be carried out by qualified personnel of the company operating the crane (Fig. 21) or by independent companies providing this service.

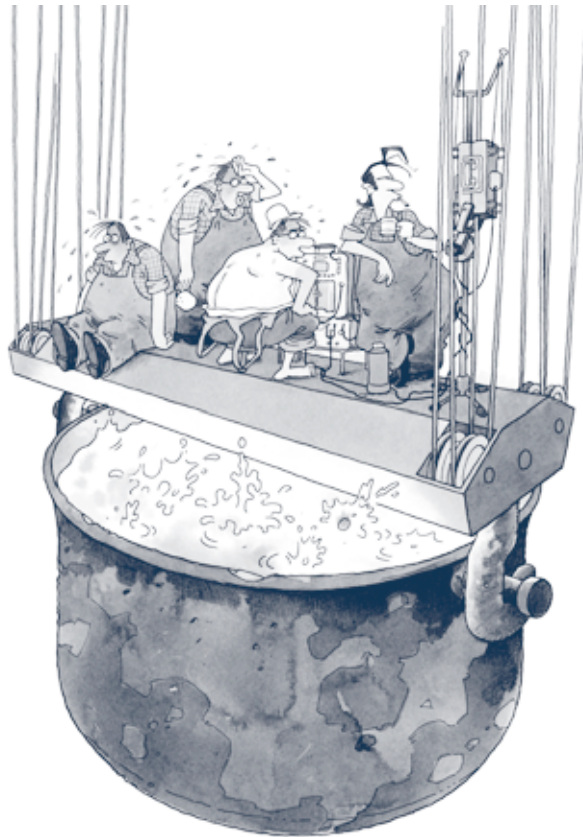


Fig. 21: *Electro-magnetic rope testing under load*

6 Problem: Corrosion of steel wire ropes

The total surface of all the wires making up a wire rope is about 16 times as big as the surface of a single steel bar of a comparable metallic cross-section (Fig. 22). This means that if no precautions are taken, in a corrosive environment a steel wire rope will corrode about 16 times as fast as a steel bar.

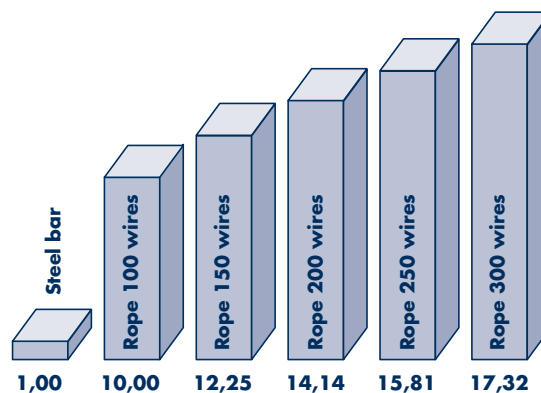


Fig. 22: *The total surface of all wires making up a wire rope is about 16 times as big as the surface of a single steel bar with a comparable metallic cross-section.*

6.1 Solution 1: Galvanized wires and plastic-coated rope cores

Steel wire ropes for use in corrosive environment should be made of galvanized wires. Even if the zinc coating is locally abraded, the uncovered wire zones will be protected by the zinc on the neighbouring wires (cathodic protection).

The rope core should, in addition, be plastic-coated. The plastic coating will hold the lubricant inside the core and keep out corrosive elements.

6.2 Solution 2: Relubrication at regular intervals

The rope wires will lose more and more of their zinc coating during service. In addition, more and more of the lubricant will be lost. In order to reduce the friction between the rope elements and to protect the wire surfaces against corrosive environment, the ropes should be relubricated during service at regular intervals. Fig. 23 shows different methods of relubricating steel wire ropes.

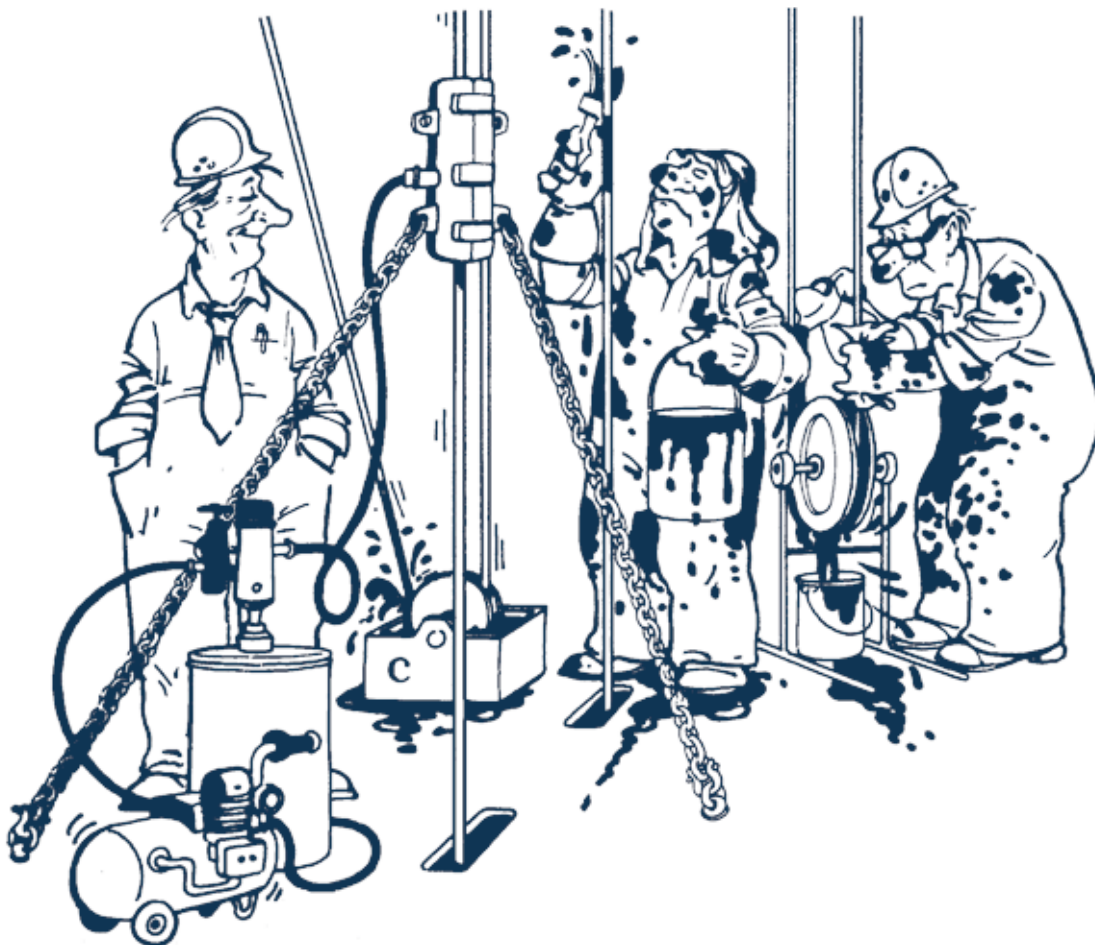


Fig. 23: *Different methods of relubricating steel wire ropes*

7 Problem: Unsatisfactory wire rope fatigue life

Running wire ropes on cranes are subjected to bending fatigue and tension-tension fatigue. Sometimes the service life of the ropes is unsatisfactory.

7.1 Solution 1: Use wire ropes with a higher fatigue resistance.

Wire ropes of different designs have different levels of fatigue resistance. Because of their greater number of elements – resulting in lower bending stresses – and their greater number of contact points in the sheaves – resulting in lower bearing pressures – 8-strand ropes are far more resistant to bending fatigue than 6-strand ropes (Fig. □24). Wire ropes with compacted outer strands (Fig. □25) have a greater metallic cross-section than ropes made of conventional strands and therefore work under a lower specific line pull. They also have much more favourable contact conditions with the sheave than ropes with conventional outer strands (Fig. □26). Therefore ropes with compacted outer strands normally have a greater fatigue resistance than wire ropes with conventional outer strands.

Wire ropes with a plastic layer between the steel core and the outer strands are not only far more resistant to bending fatigue than comparable ropes without a plastic layer, they also show a far better tension-tension fatigue resistance. Under shock-loads, the plastic layer acts like a shock absorber, reducing the peak tensions in the wires.

As the shock-loads are usually introduced into the crane structure via the steel wire rope, this built-in shock absorber does not only increase the service life of the wire rope, it also provides more favourable conditions for the other crane components.

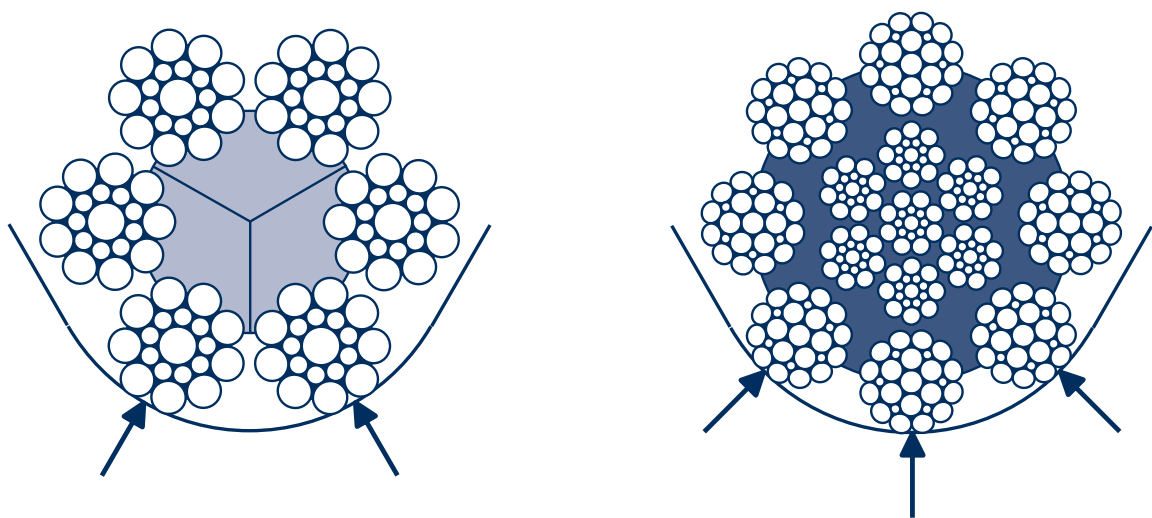


Fig. 24: *Because of their greater number of contact points in the sheaves – resulting in lower bearing pressures – 8-strand ropes (e. g. Casar Stratoplast, right) are far more resistant to bending fatigue than 6-strand ropes (left).*

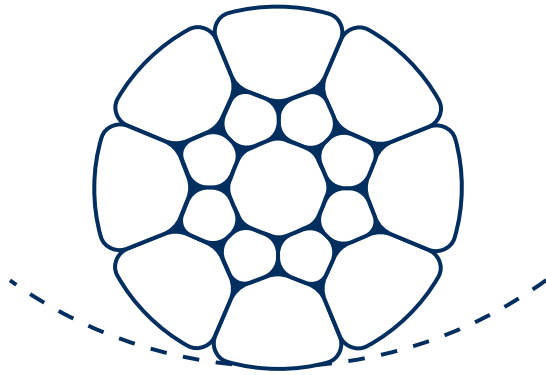


Fig. 25: *Good contact conditions for compacted outer strand*

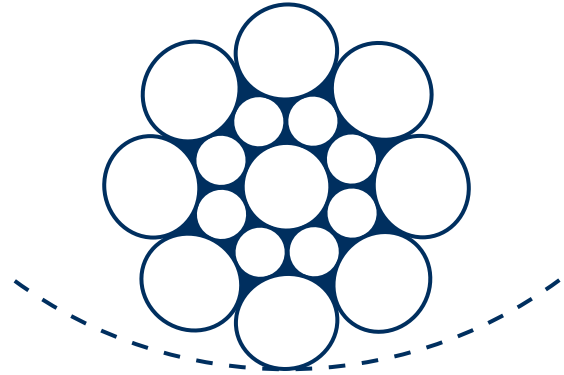


Fig. 26: *Bad contact conditions for conventional outer strands*

7.2 Solution 2: Optimize your rope diameter

Prof. Feyrer from the University of Stuttgart has developed a formula for predicting wire rope service life:

$$\lg N = b_0 + (b_1 + b_4 \sum \lg \frac{D}{d}) \sum (\lg \frac{S d_0^2}{d^2 S_0} \pm 0.4 \sum \lg \frac{R_0}{1770}) + b_2 \sum \lg \frac{D}{d} + b_3 \sum \lg \frac{d}{d_0} + \frac{1}{b_5 + \lg \frac{1}{d}}$$

The rope specific parameters b_0 to b_5 must be determined for every single rope design in a great number of bending fatigue tests. These parameters have already been determined for a great number of standard wire ropes and for Casar Special Wire Ropes.

The author has written a program which calculates the wire rope bending fatigue performance depending on the rope design, the nominal rope diameter, the sheave diameter and the line pull. If the geometry and the working conditions of the crane are known, the number of lifts until wire rope discard and wire rope break can be predicted.

Even if the absolute number of bending cycles is of no interest, the program can be used to compare the fatigue life of different designs.

One interesting option of the program is its ability to determine the *optimal* nominal rope diameter. Fig. 27 shows the number of bending cycles until discard (lower curve) and until break (upper curve) as a function of the nominal rope diameter for a given rope construction, a line pull of 40,000N and a sheave diameter of 600mm.

A rope of a nominal diameter of 10mm will have to be discarded after only 50,000 bending cycles. The D/d -ratio of 60 is very favourable for the 10mm rope, but

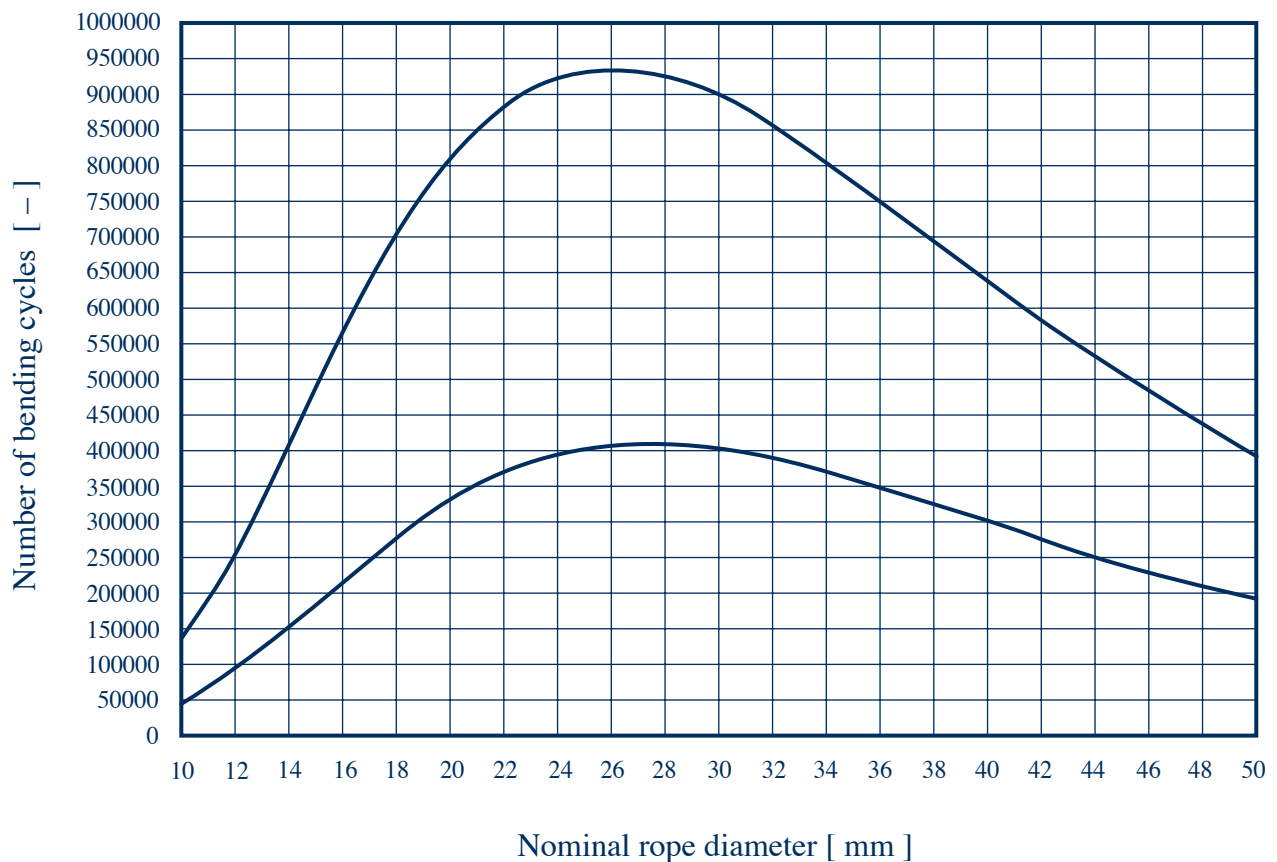


Fig. 27: *Number of bending cycles until discard (lower curve) and until break (upper curve) as a function of the nominal rope diameter*

obviously the line pull of 40,000N is much too high for a rope of such a small diameter.

If the nominal rope diameter is doubled to 20mm, the number of bending cycles increases to 340,000, almost 7 times the previous figure. The D/d-ratio has been reduced to 30, but the metallic cross-section of the rope has increased by a factor of 4 and the specific line pull has been reduced accordingly. The 20mm rope can cope much better with the line pull of 40,000N than the 10mm rope.

If the rope diameter is doubled again to 40mm, the number of bending cycles no longer increases. The 40mm rope achieves 300,000 cycles, which is lower than the result obtained by the 20mm rope. The 40mm rope has a metallic cross-section 16 times as large as the 10mm rope. It does not fatigue because of the line pull of 40,000N, but because of the unfavourable D/d-ratio of 15.

In the left part of the curves in Fig. 27 the wire ropes have favourable D/d-ratios. They fail because of high specific line pulls.

In the right part of the curves the ropes have favourable specific line pulls. They fail because of the high bending stresses resulting from low D/d-ratios.

In between the two zones we find the maximum of the fatigue life curve, where the sum of the negative influences of the line pull and the bending stresses are minimal. The rope diameter for which the number of cycles achieves a maximum is called the “optimal nominal rope diameter”. In Fig.□27 the optimal nominal rope diameter is 27mm. For this rope diameter, an average number of cycles of 410,000 is achieved.

A crane designer should not choose a nominal rope diameter greater than the optimal nominal rope diameter. He would only spend more money and get a shorter service life in return. On the contrary, he should choose a nominal rope diameter slightly smaller than the optimal nominal rope diameter: In our example (Fig.□27), for a nominal rope diameter of 24mm almost the same service life is achieved as for a nominal rope diameter of 27mm. The nominal rope diameter of 24mm, however, is 10% smaller than the optimal nominal rope diameter. This means that for almost the same number of bending cycles a much cheaper wire rope can be used. In addition, when using the smaller rope diameter the width of the drum can be reduced tremendously, reducing the overall costs even further.

The *most economic* nominal rope diameter is always slightly smaller than the *optimal* nominal rope diameter, e.g. 90% of the optimal nominal rope diameter.

With steel structures, *bigger* always means *longer-lasting*. With wire ropes, often *the opposite* is true.

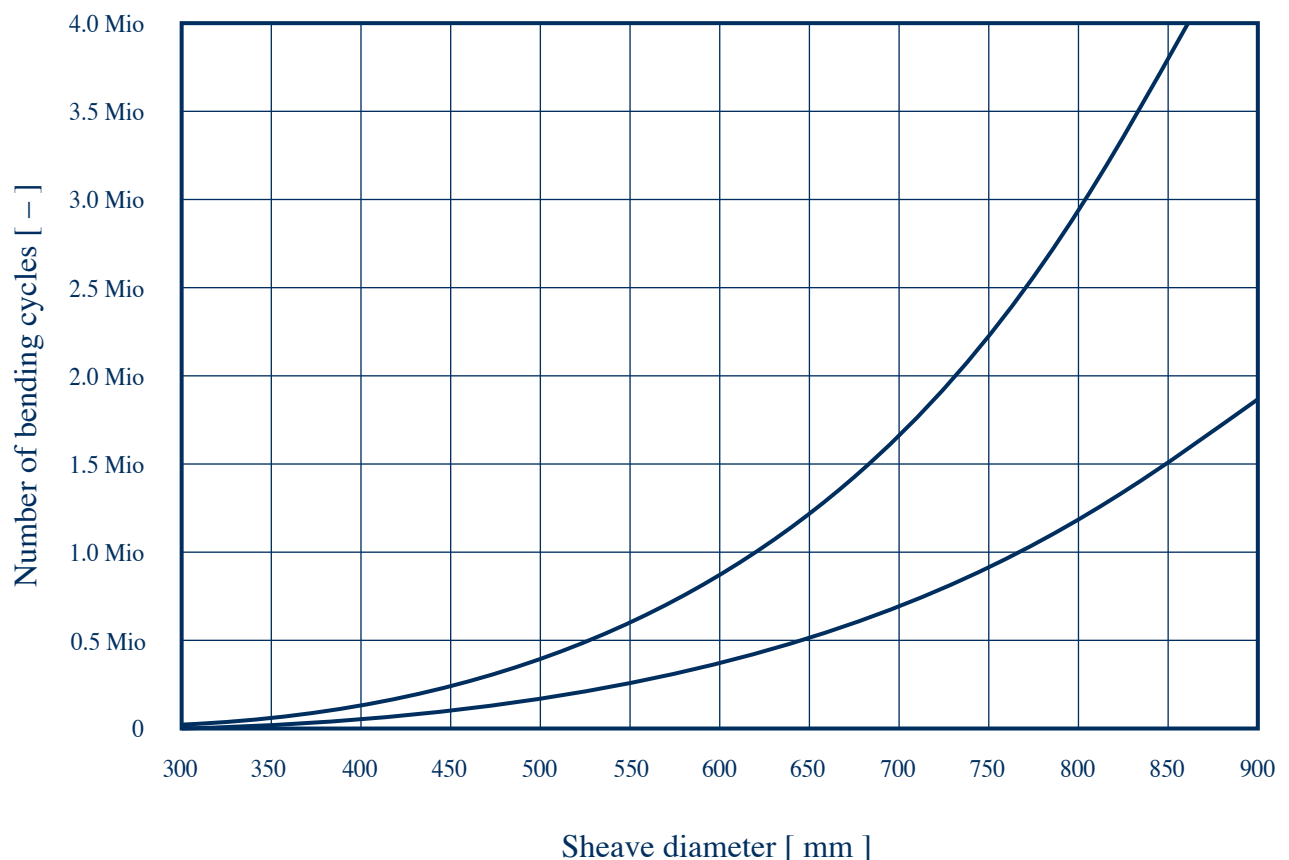


Fig. 28: *Number of cycles until discard (lower curve) and until break (upper curve) as a function of the sheave diameter*

7.3 Solution 3: Optimize your sheave diameter.

The service life of a wire rope can always be extended by increasing the sheave diameters. The aforementioned program calculates by how much a sheave diameter must be increased in order to obtain the desired result.

Fig.□28 shows the number of cycles until discard (lower curve) and until break (upper curve) as a function of the sheave diameter. For a sheave diameter of 600mm, the number of cycles until discard is 400,000. Increasing the sheave diameter, for example, by 150mm (+25%) will increase the number of cycles to 900,000 (+125%).

7.4 Solution 4: Avoid unnecessary bending fatigue

Quite often, wire ropes are subjected to unnecessary bending fatigue. As an example, the fatigue life of two wire ropes which are operated under the same conditions, but with different crane blocks, is compared.

Fig.□29 shows a crane block with two small sheaves. During every lifting operation the rope travelling through the block is subjected to *two* bending cycles.

Fig.□30 shows a crane block with only one large sheave. During every lifting operation, the rope travelling through the block is subjected to only *one* bending cycle. This fact alone would already double the wire rope service life. The sheave diameter, however, is 2.5 times as big as in the first block, and the number of cycles which can be achieved on this large diameter is 9 times as high as on the small sheave. Therefore

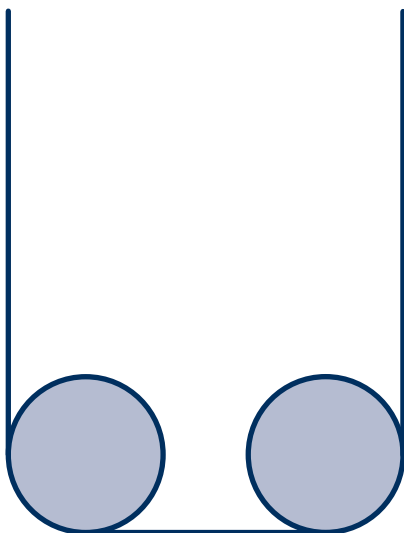


Fig. 29: Crane block with two small sheaves

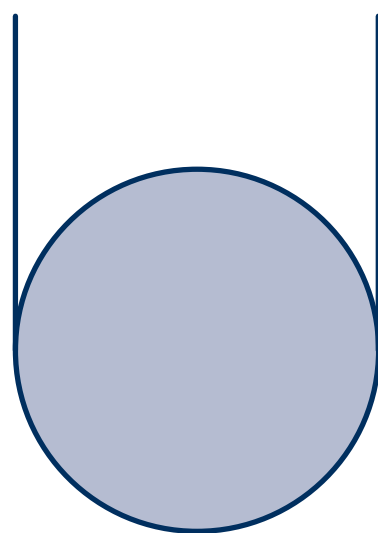


Fig. 30: Crane block with only one large sheave

the service life will again be increased by a factor of 9, resulting in a service life 18 times as long as in the first case!

Depending on the conditions, a reverse bend will fatigue a wire rope 2 to 7 times as much as a simple bend. The wire of the hoist shown in Fig.□31 will therefore last 1.5 to 4 times as long as the rope of the hoist shown in Fig.□32.

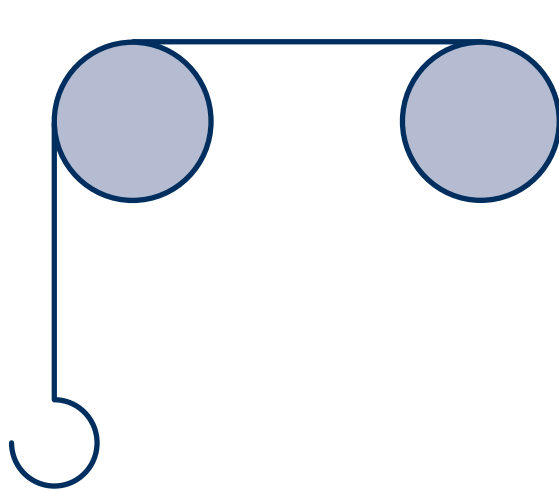


Fig. 31: *Hoist with simple bends*

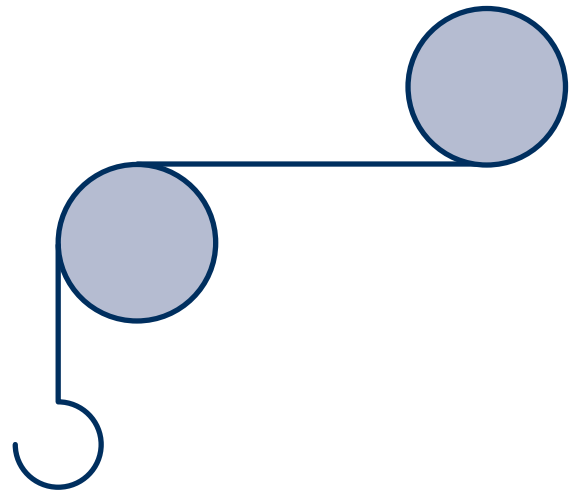


Fig. 32: *Hoist with reverse bend*

7.5 Solution 5: Optimize wire rope tension-tension fatigue by reducing the rope diameter.

In tension-tension fatigue tests with a given load amplitude, the life of a test specimen normally decreases with increasing mean load. Recent tension-tension fatigue tests carried out at the University of Stuttgart, however, indicate that up to a total load of about 50% of their breaking loads, wire ropes behave just the opposite way: With increasing mean loads, wire ropes achieve higher tension-tension fatigue lives (Fig.□33). One explanation for this phenomenon could be the fact that in contrast to the typical solid-body test specimen, wire ropes are composites constructed of many elements which move relative to each other during load changes. As can be seen in a typical wire rope load-elongation curve (Fig.□34), for the same load amplitude the displacements are much smaller for higher mean loads.

This means that the service life of crane suspension ropes could be increased by reducing the rope diameter and by working with a smaller design factor!

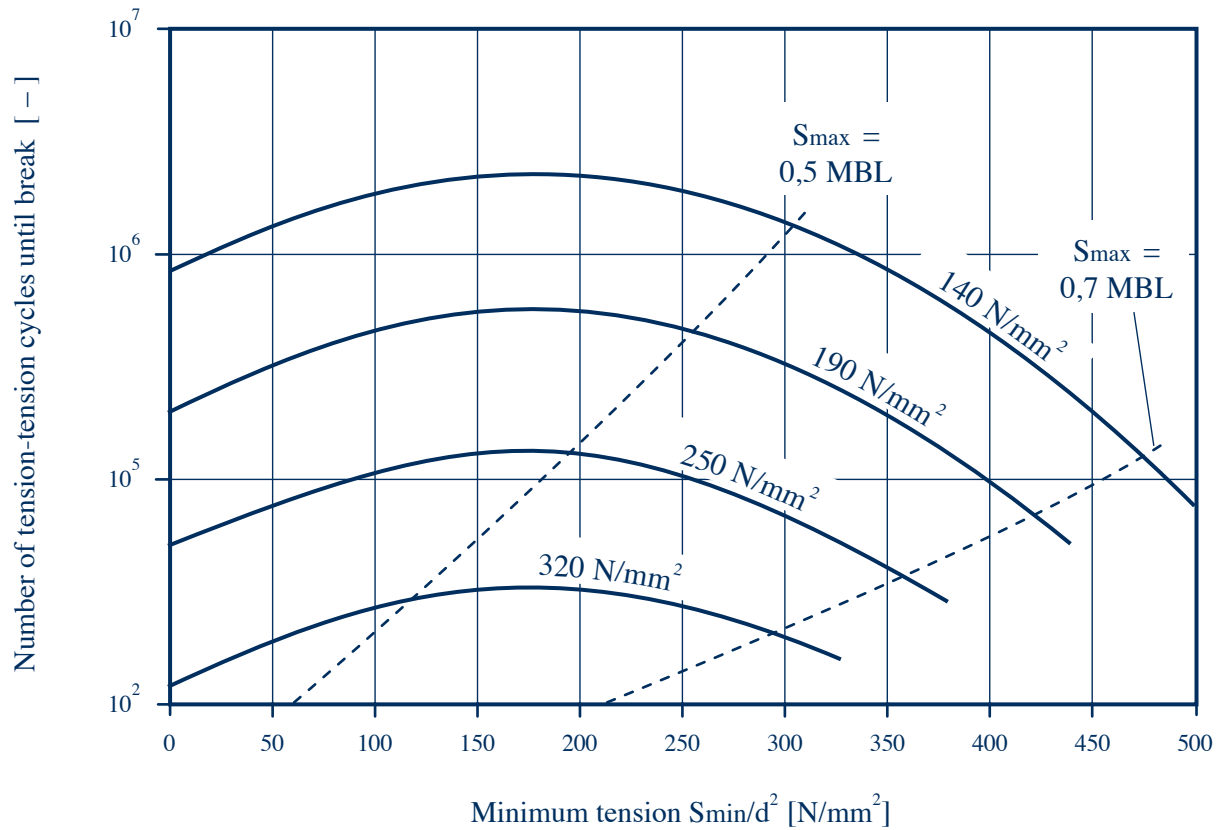


Fig. 33: With increasing mean loads, up to a total load of about 50% of their breaking loads, wire ropes achieve higher tension-tension fatigue lives.

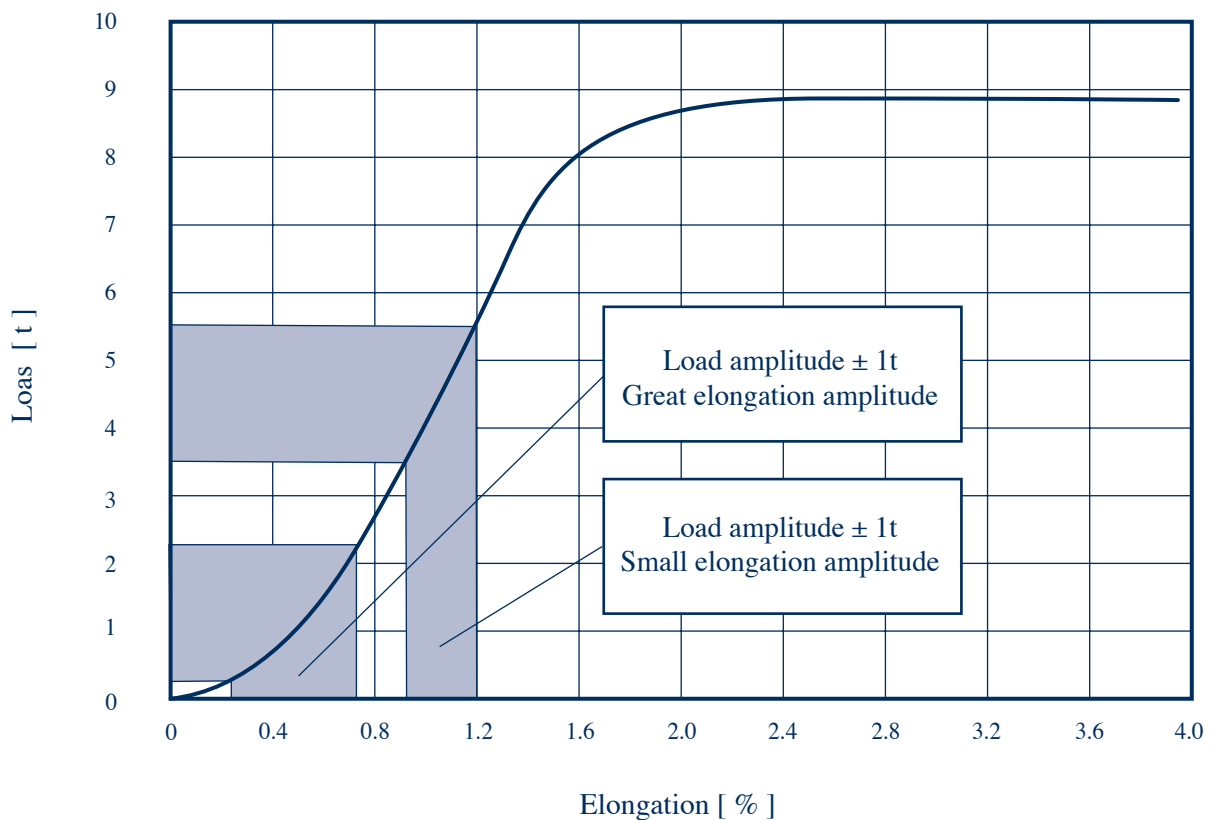


Fig. 34: Typical wire rope load-elongation curve. Displacements are much smaller for higher mean loads than for small mean loads and the same load amplitude.

8 Problem: Loose strands and birdcages

Sometimes rope deformations, such as loose (“high”) strands or birdcages, can be found on cranes. They are often attributed to shock-loads, but in most cases this is *not* correct.

In most cases, loose strands and birdcages are generated by twisting a wire rope around its own axis. As an example, let us take a look at a rope which is fixed at both rope ends. If we grab this rope in the middle and twist it once (Fig.□35), we will lengthen it on one side and shorten it on the other (Fig.□36)As a result, the outer strands will be too long on the one side (Fig.□37), and the inner strands will be too long on the other (Fig.□38).

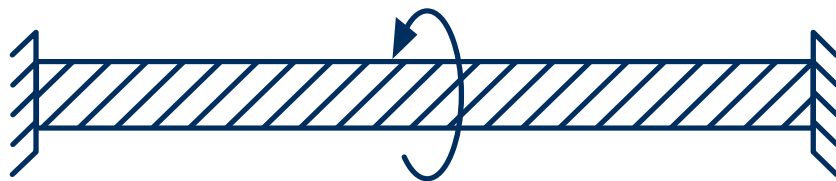


Fig. 35: *Twisting a wire rope by force ...*

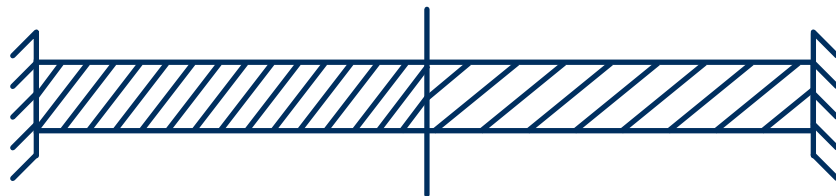


Fig. 36: *... causes lay shortening on the one side (left) and lay lengthening on the other (right).*

But what could possibly twist a rope on a crane around its own axis? Every sheave and every drum could.

If a rope enters a sheave under a fleet angle, it will first touch the flange and then roll down into the bottom of the groove (Fig.□39).The wire rope will be twisted by this procedure.

With increasing fleet angle the amount of twist will increase. Figs.□40 and 41 show a sequence of rope cross sections entering a sheave at a groove angle of 35° (according to US standards).



Fig. 37: Surplus length of the outer strands caused by unlaying the rope



Fig. 38: Surplus length of the inner strands caused by closing the same rope

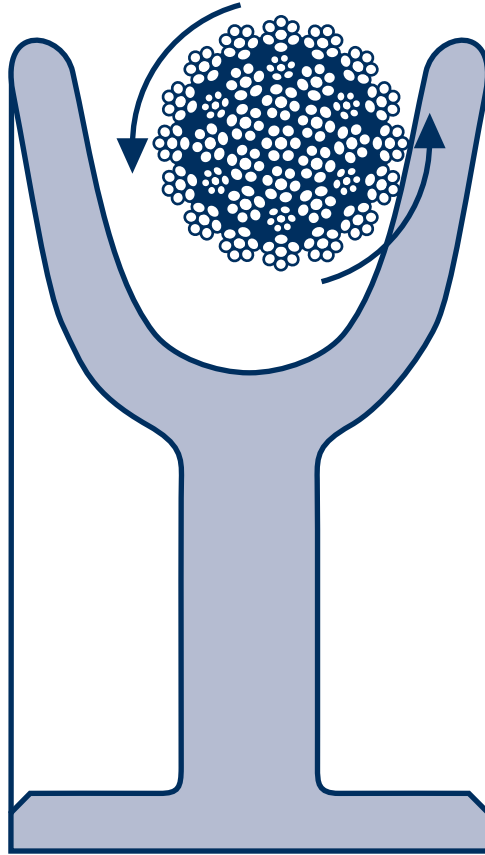


Fig. 39: *The wire rope rolls into the bottom of the groove. It will be twisted by this procedure.*

If the rope enters the sheave at a fleet angle of 1° , it will touch the flange in a very deep position and will only be twisted by 5° .

If the rope enters the same sheave at a fleet angle of 5° , it will touch the flange in a very high position and will be twisted by 50° !

Of course, a wire will not always *roll* down at the flanges like a cog-wheel. The downward motion will be a mixture of rolling and sliding. The amount of twist induced into the rope, therefore, also depends a lot on the amount of friction between the wire rope and the sheave.

8.1 Solution 1: Wire rope lubrication

The easiest way of reducing the coefficient of friction between the wire rope and the sheave is to lubricate the rope. A well-lubricated wire rope will be twisted much less than a dry rope or a corroded one.

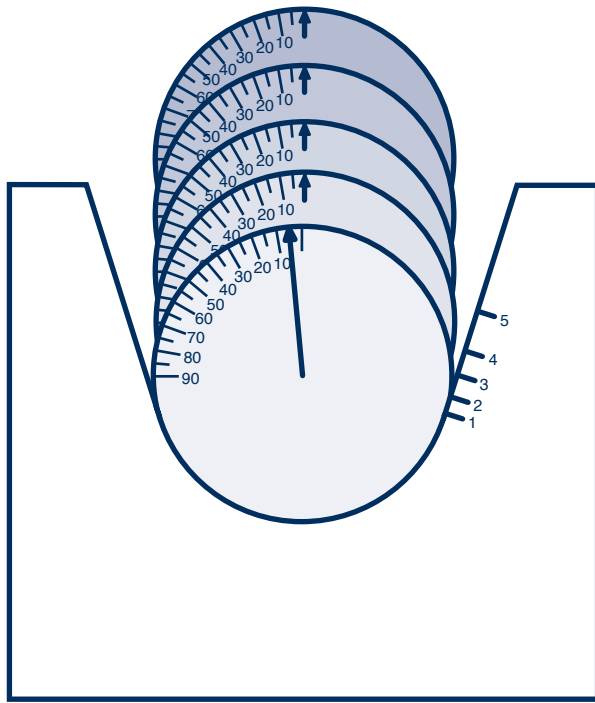


Fig. 40: Groove angle 35° . Slight twist of a rope when the fleet angle is 1°

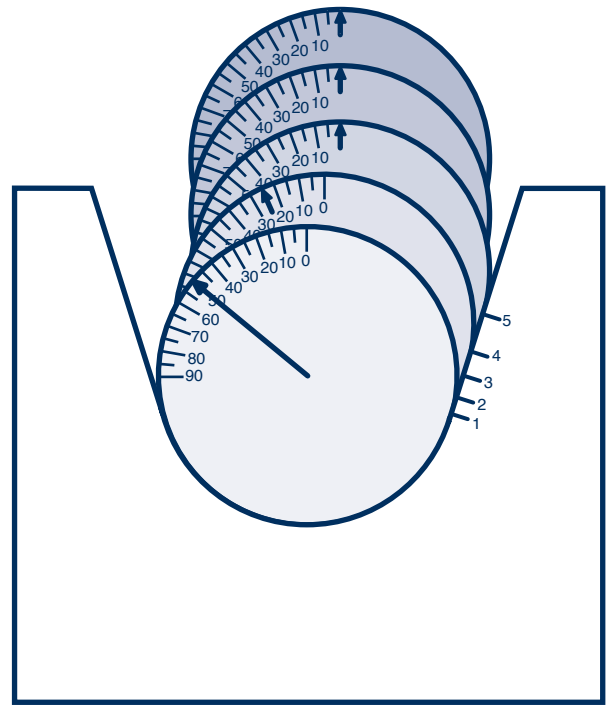


Fig. 41: Groove angle 35° . Great twist of a rope when the fleet angle is 5°

8.2 Solution 2: Steel sheaves instead of plastic sheaves

The coefficient of friction between steel and plastic is higher than between steel and steel. Under the same geometrical conditions, a wire rope will therefore be twisted much less by a steel sheave than by a plastic sheave. Plastic sheaves should only be used in positions where the fleet angles are small.

8.3 Solution 3: Sheaves with wider grooves

If the groove of a sheave is wide, the wire rope will enter much deeper into the groove before touching the flange. Therefore sheaves should have a groove angle of 45° (as e. g. in DIN 15061) as an absolute minimum. A fleet angle of 52° (as in British Standard) is even better.

Fig. 42 shows a sequence of rope cross-sections entering a sheave with a groove angle of 60° at a fleet angle of 5° . The wire rope touches the flange in a much lower position than in Fig. 39 and is twisted by only 25. By increasing the groove angle from 35° to 60° the amount of rope twist is reduced by 50%.

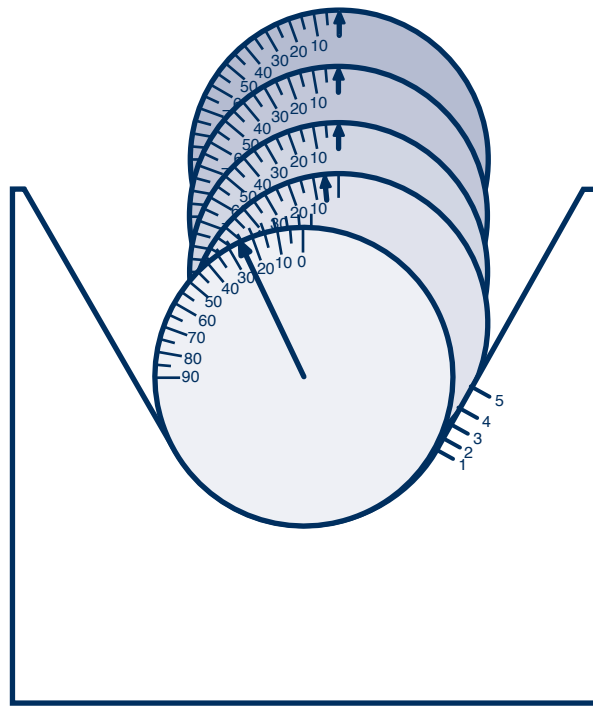


Fig. 42: *Groove angle 60°. Reduced twist of a rope when the fleet angle is 5°*



Fig. 43: *Tight sheave*

8.4 Solution 4: Use steel wire ropes with an internal plastic layer.

Wire ropes with an internal plastic layer (e. g. Casar Stratoplast, Casar Turboplast, Casar Duroplast) are much more resistant to birdcaging than any other rope design.

8.5 Solution 5: Avoid tight sheaves.

Loose strands and birdcages can also be the result of tight sheaves. If the groove radius is too small (Fig. □43), the rope will be compressed when travelling over the sheave. As a result, the outer strands will be too long for the reduced rope diameter, and the superfluous strand length will be accumulated at one point (usually at the end of the sheave motion) where it will stand up as a loose strand or a birdcage.

The groove radius should measure .53 to .54 times the nominal rope diameter. If it measures less, the sheave should either be machined or replaced. If this is not possible, a rope with the same strength, but a smaller nominal rope diameter should be used which will then comply with the required conditions.

9 Problem: Drum crushing

Wire ropes often suffer mechanical damage on the drum. Under the influence of a fleet angle, the wire rope might, for example, be pulled against a neighbouring wrap (Fig. □44), and the outer wires might be damaged at the point of contact.

9.1 Solution 1: Grooved drums and Lebus spooling

Grooved drums should be preferred to ungrooved drums. For multiple-layer spooling, Lebus spooling systems should be used.

9.2 Solution 2: Wire ropes in Langs lay execution with compacted outer strands

The outer wires of two neighbouring wraps of a regular lay rope can form indentations (Fig. □45) because they are all aligned in the direction of the ropes' axis. If the one wrap enters the drum in a downward motion or leaves the drum in an upward motion, the indented outer wires will damage one another.

If Langs lay ropes are used, the outer wires of two neighbouring wraps cannot form indentations because, at the point of contact, the wires are inclined upwards on the



Fig. 44: Under the influence of a fleet angle, the wire rope is pulled against a neighbouring wrap. The outer wires will be damaged at the point of contact.

one side and downwards on the other. Therefore, these wires will damage one another considerably less when one wrap is spooling onto or off the drum.

Compacted outer strands offer additional advantages (Fig. □46): the crowns and valleys of the outer wires are smoothened, and the metallic cross-sectional area is increased to withstand abrasion and mechanical damage.

For multiple-layer spooling, only wire ropes in Langs lay execution with compacted outer strands should be used.

10 Problem: Good wire ropes are expensive.

Sophisticated high-tech wire ropes cost more than conventional bread-and-butter ropes.

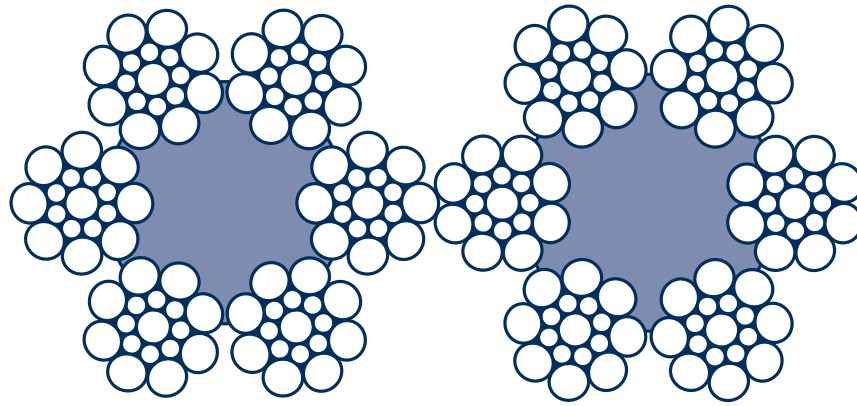


Fig. 45: *The outer wires of two neighbouring wraps of a regular lay rope can form indentations.*

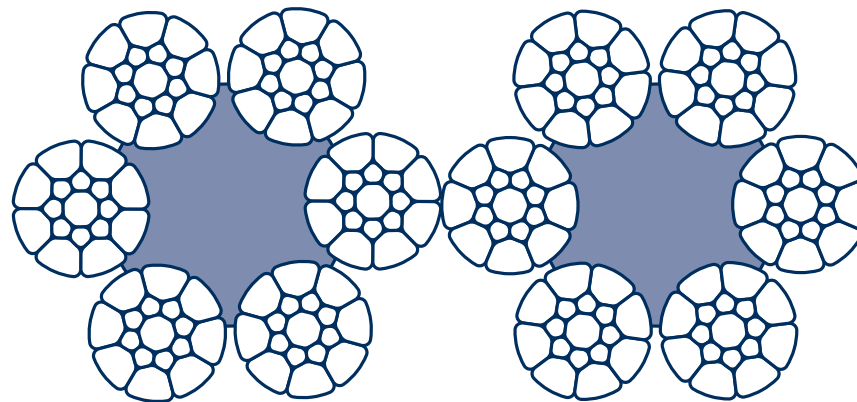


Fig. 46: *The crowns and valleys of the outer wires of compacted outer strands are smoothed. The metallic cross-sectional area is increased to withstand abrasion and mechanical damage.*

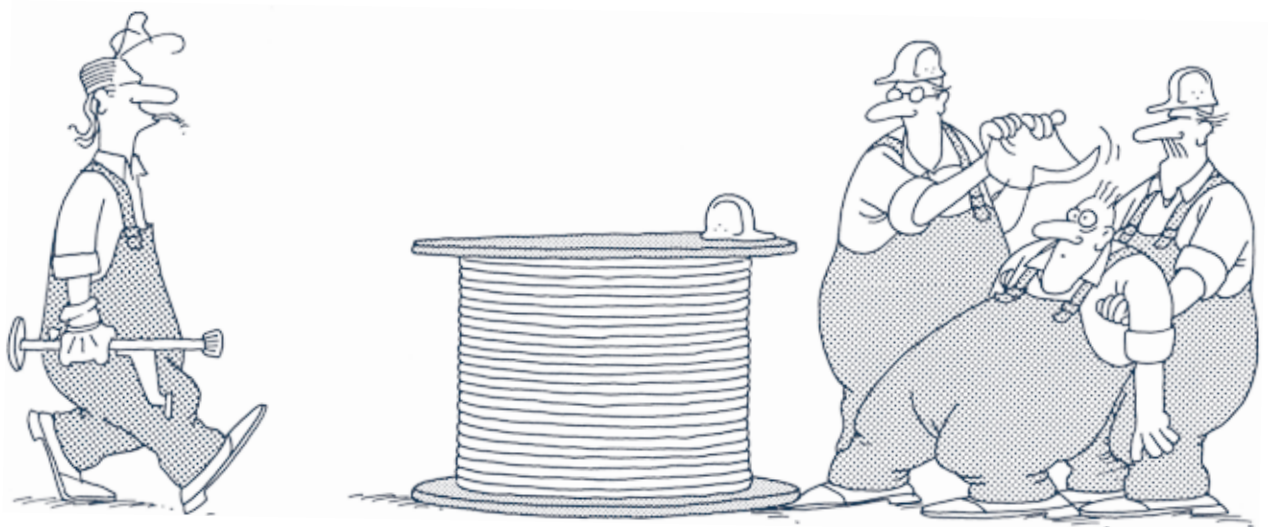
10.1 Solution: Think about the overall costs!

Bad ropes are cheaper than good ones. But after a certain time, you will have bought three bad ropes when you could have done with one good rope.

In addition, transporting a bad rope to the crane costs as much as transporting a good rope. And installing a bad rope costs as much as installing a good rope, but you might have to do it three times with the bad rope and only once with the good one.

So, buying a more expensive rope in the first place will save you a lot of money in the end.

You always get what you pay for. With crane ropes, this is more true than with any other machine element.



There is a solution to every rope problem. Ask us!

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