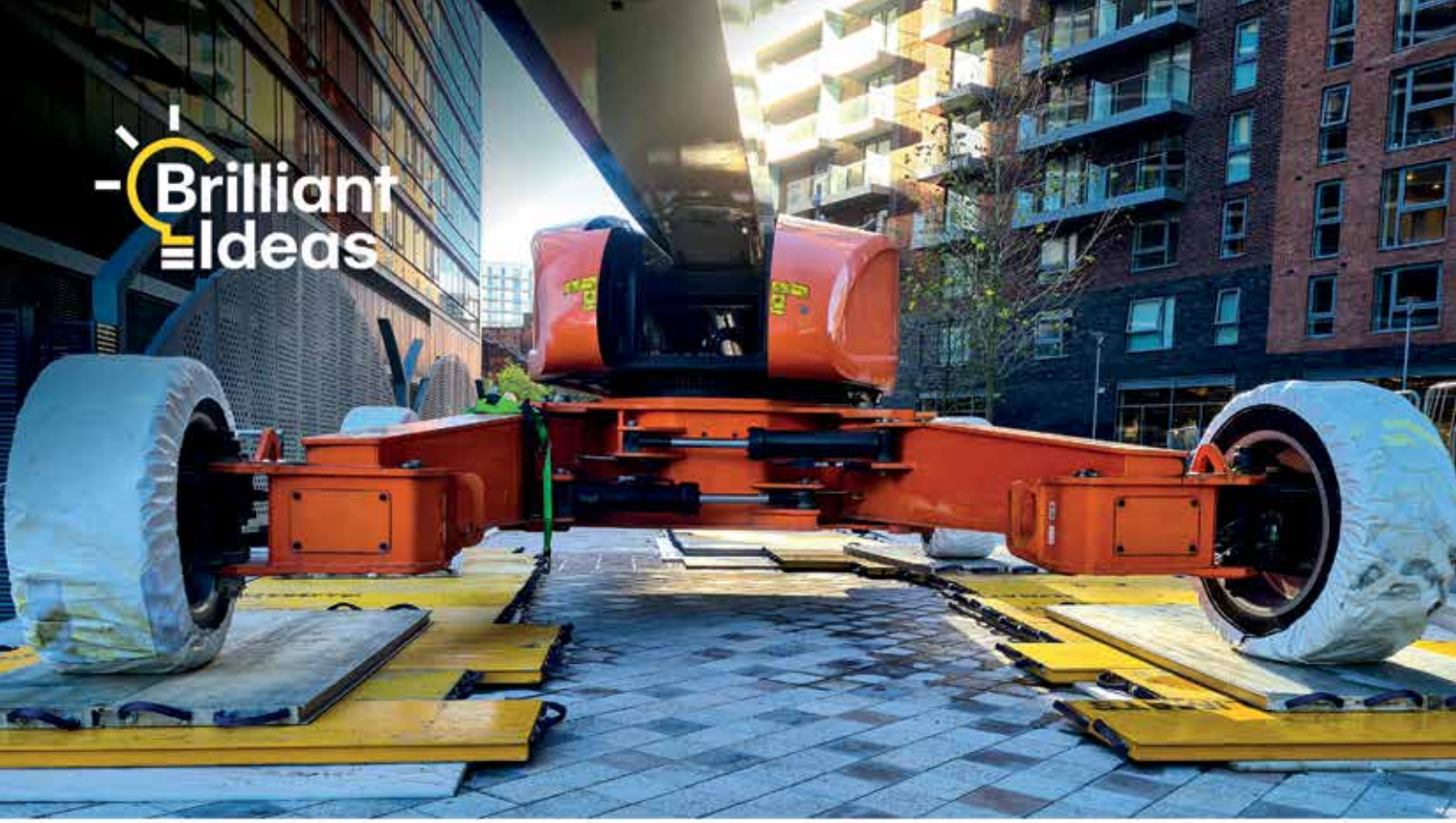

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THE HIDDEN MECHANICAL FACTOR BEHIND MANY SLING FAILURES

Peter Verhoef - managing director of the lifting safety, regulatory compliance and Appointed Person training consultancy Cranes for You based in Utrecht, the Netherlands - delves into a pet subject: 'Why the sling D/d ratio still matters'.

In modern lifting operations, many variables receive attention: load weight, centre of gravity, crane configuration, wind, ground pressure and rigging arrangement. Yet one of the most fundamental mechanical parameters in sling performance - the D/d ratio - still goes unnoticed or is applied inconsistently across the industry.

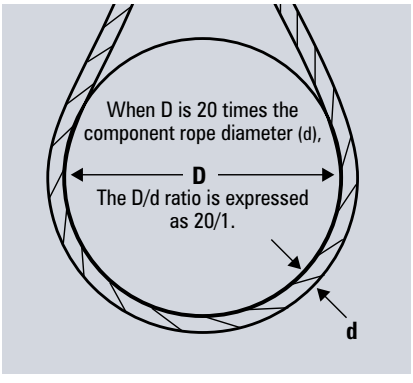
The D/d ratio defines the relationship between the diameter of the object a sling is bent over (D) and the diameter of the sling itself (d). Although simple in appearance, this ratio governs the actual strength, fatigue life and reliability of wire rope, chain or synthetic slings. However, when incorrectly applied, it causes capacity loss that cannot be seen externally, making it one of the most deceptive risks in rigging.

WHAT IS THE D/D RATIO?

The D/d ratio is calculated by dividing the diameter of the pin, hook, shackle or pipe by the diameter of the sling body.

When a wire rope sling is bent around a diameter that is too small, it experiences internal bending stresses, which increase dramatically as the D/d ratio decreases.

D/d Ratio	Approx. remaining strength
25:1	100%
20:1	92%
15:1	88%
10:1	86%
6:1	80%
4:1	75%
2:1	65%
1:1	50%



This bending action causes four issues:

- Tensile strain in the outer wires
- Compression in the inner wires
- Strand distortion
- Core deformation

Even when slings appear visually undamaged, these internal stresses permanently reduce strength. And the smaller the D/d ratio, the faster the sling loses efficiency.

Quantified strength loss:

THE DATA BEHIND THE RISK

International industry testing has repeatedly demonstrated the same behaviour:

Immediate 50% drop

A sling wrapped around a diameter equal to its own diameter (1:1) immediately loses half its capacity, even before dynamic forces or cyclical loading are considered.

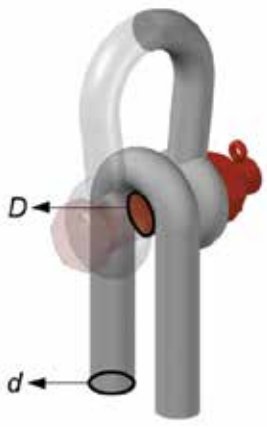
These values are not theoretical but come from decades of destructive testing conducted by rope manufacturers, heavy lift engineering firms and certification bodies.

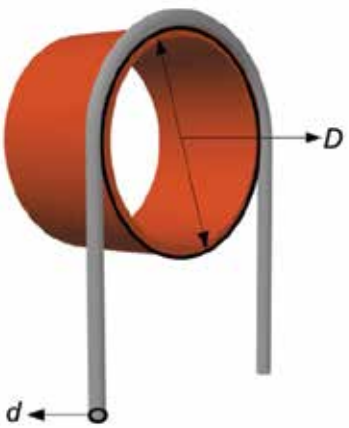
BASKET AND CHOKER HITCHES: THE MOST CRITICAL APPLICATIONS

The most common misunderstanding arises in basket and choker hitches, where riggers often assume that a sling with a certified Working Load Limit (WLL) can safely adapt to the load geometry. But catalogue WLL values are almost always based on D/d ≥ 25:1.

Consider a 24 mm wire rope sling used in a basket hitch around a 300mm pipe:

Required D = 24mm × 25 = 600mm
Actual pipe diameter D = 300mm





The sling is therefore bent over half the required diameter.

This seemingly small geometric difference causes massive internal stress increases, resulting in severe derating. In heavy industry, this is one of the most frequent hidden causes of sling damage and near-miss or actual incidents.

Additional confusion

Different sling constructions respond differently to D/d, which often causes additional confusion.

Eye & Eye Slings

The eye contains twice the rope strength of the body, so the D/d effect is less critical at the eye than in basket configurations. However, pins must still match the eye size, and overfilling the eye reduces contact area and increases stress.

Endless Slings and Grommets

These have no reinforced loop, making them highly sensitive to small bending diameters. Many manufacturers rate them for D/d = 5:1, but this is often insufficient for repetitive or dynamic lifting operations.

Multi-Part Slings

The determining factor is the component rope diameter, not the finished braided sling diameter. This detail is frequently overlooked in lift planning.

Chain Slings: Not exempt from D/d effects

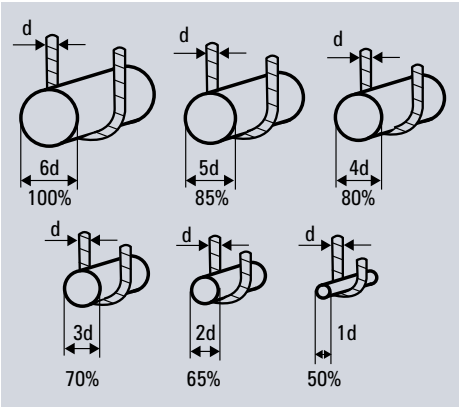
Chain links deform when bent over undersized pins. The effects include:

- Reduced internal bearing area
- Link ovalisation
- Plastic deformation under load
- Accelerated fatigue.

Typical remaining capacities in basket configuration:

D/d = 2 → ~65%
D/d = 3 → ~70%
D/d = 4 → ~80%
D/d ≥ 6→ ~100%

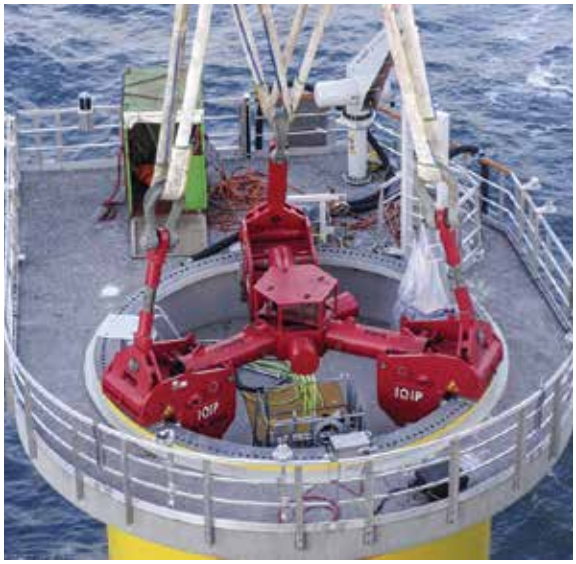
Chain slings may look robust, but physics applies equally to steel links.



SHACKLE BEARING WIDTH: THE OVERLOOKED COMPANION TO D/D

Even when the shackle diameter seems appropriate, the bearing width determines how the load is transferred into the sling. Standard bow shackles provide limited surface contact, resulting in:

- High localised pressure
- Rope flattening
- Increased internal fatigue.



Wide body shackles significantly reduce this effect by increasing the bearing radius and improving load distribution. For many lifts, using a wide body shackle is the single most effective way to reduce sling damage.

SYNTHETIC ROUND SLINGS: A DIFFERENT FAILURE MECHANISM

Synthetic slings fail mainly due to bearing stress and not due to wire fatigue. Small hardware creates extremely high localised pressure on fibres, sometimes leading to sudden catastrophic failure while the sling still appears undamaged. Effective bearing width is often only 75 percent of the hardware width, making proper hardware selection critical.

WHO DETERMINES THE D/D RATIO?

This is an important point and is often misunderstood.

- Manufacturers - define the minimum D/d ratio for which their WLL applies
- Standards - define additional safety requirements
- Users and lift planners - create the actual D/d ratio through the selection of shackles, hooks, trunnions or pipes

If a sling fails because of inadequate bending diameter, it is almost always classified as a rigging configuration error, not a manufacturing defect.

The Real Risk: D/d failure is invisible

A sling that has lost 30 to 40 percent of its strength due to bending does not show visible warning signs. There are no broken wires, no discoloration, no distortion.

This invisibility makes the D/d ratio one of the most underestimated hazards in lifting operations.

CONCLUSION

The D/d ratio is not a theoretical concept. It is a fundamental engineering rule that determines whether a sling retains its strength or silently loses up to half its capacity.

For rigging professionals, crane operators, lift planners and safety managers, understanding and applying the D/d ratio correctly is essential - not only for compliance, but for the prevention of sudden, unexpected sling failures.

Peter Verhoef and his business advise companies across Europe on safe and legally compliant lifting operations and develop technical guidance for the heavy lift and hoisting industry. ■

SHACKLES 101

Shackles keep everything securely fastened together, whether you're moving machinery, lifting steel beams, or towing equipment. The correct shackle in rigging guarantees correct load alignment and balance. Using an incorrect shackle for the job, can lead to failures, stress, or damage. Therefore, it is critical to match the type of shackle to the work. Here are a few examples of the types available for those less familiar with the subject.

DEE SHACKLES

The classic shackle shaped like the letter D, available in a variety of sizes and weight restrictions they can withstand pressure and huge loads.

BOW SHACKLES

Bow shackles can move more freely because of their broader 'O' form. This design results in a shackle not overly stressed when the load shifts slightly when being lifted. Bow shackles are ideal for complex rigging setups because of their broader loop which can accommodate several lifting points.

SAFETY BOLT SHACKLES

Not every job requires a standard pin, which is why safety bolt shackles are useful. Even during extended or vigorous lifts, the pin of these shackles is held in place by a locking mechanism. For permanent or semi-permanent lifting points, safety pin shackles are excellent. Safety pin shackles that are designed to withstand continuous strain are perfect for marine lifting operations, floating platforms, and construction cranes. The connection is maintained, and the chance of failure reduced by the additional security.

SCREW PIN SHACKLES

Screw pin shackles are excellent for short-term tasks. When the lifting setup is disassembled frequently.

STAINLESS STEEL SHACKLES

Rust is a major problem in situations that are corrosive or damp. This issue is resolved by stainless steel shackles.