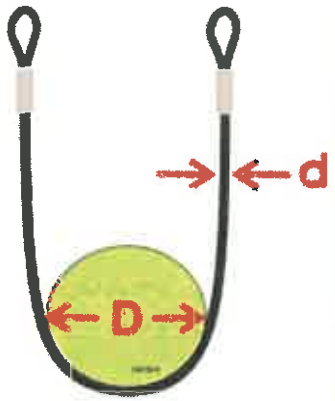
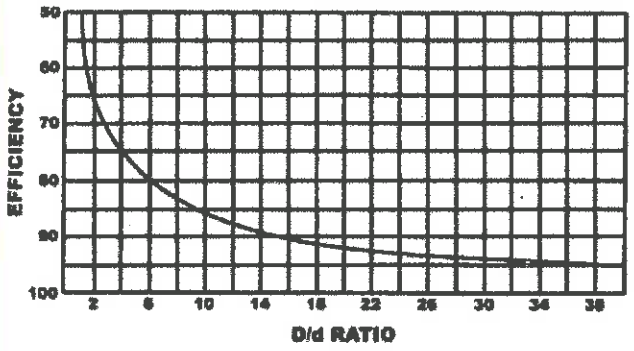
Is D/d Ratio Crucial in Use of Non-Wire Rope Slings?

The popularity of synthetic slings has led to confusion as users try to apply their understanding of D/d ratio for wire rope slings to other types of slings, including synthetic web, synthetic round, and alloy chain slings.

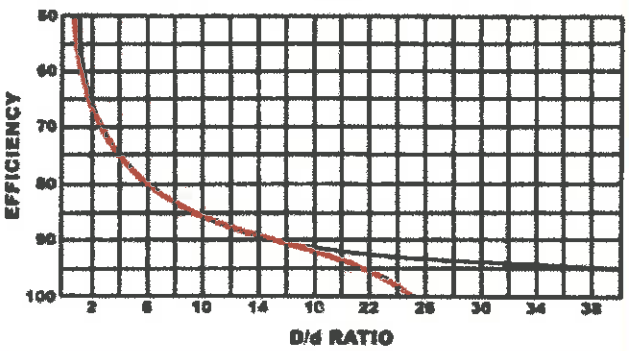
The term "D/d ratio" describes the load size versus the size of sling placed on the load. The upper case 'D' refers to the diameter of the object to which the sling hitch is applied, and the lower case 'd' represents the diameter of the sling. The D/d ratio determines the sling's efficiency or capacity reduction (normally in the basket hitch) due to tight bending of a sling. D/d ratio has always been considered when determining the usable capacity of a wire rope sling. The diameter of curvature around which a sling is bent affects its capacity. Though Graph 1 is most commonly used for reduction calculations of wire rope slings, this table represents the efficiency of a running rope's life on a crane. Slings must be looked at differently. The reduction is not on sling life but on sling capacity. The red line in Graph 2 more closely reflects the efficiencies of a sling.



Graph 1



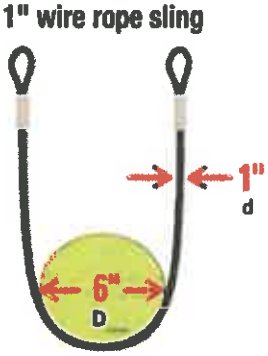
Graph 2



Wire rope

To determine the D/d ratio of a wire rope sling, the sling diameter is divided into the diameter of the load. The result determines efficiency of the sling's basket capacity, as demonstrated in this illustration. A good rule is to maintain a minimum of a 6:1 D/d. This will equate into an 80-percent efficiency of the sling's maximum basket capacity. A 1:1 D/d reduces the capacity by 50 percent.

The D/d strength efficiency table shown at right is for six-strand mechanical splice slings only. You will find different strength efficiencies for different types of wire rope slings. For example, most grommet sling strengths are based on a 5:1 D/d ratio, while hand-tucked sling strengths are based on a 15:1 ratio. Cable-laid sling strengths are generally based on a 10:1 ratio, yet multi-part slings are most often based on a 5:1 ratio of the finished diameter or a 25:1 ratio on component part diameter.



D/d ratio = 6 + 1 = 6

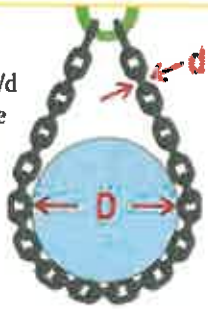
6:1 ratio = Approx. 80% efficiency

D/d Ratio	Wire Rope Sling Strength Efficiencies
25:1	100%
20:1	92%
15:1	88%
10:1	86%
8:1	84%
6:1	80%
4:1	75%
2:1	65%
1:1	50%

D/d ratio is also designated for the eyes of the sling. This is normally a pin diameter which is no larger than the natural eye width or less than the nominal diameter of the wire. ANSI B30.9 states that the pin or hook in the eye of a wire rope sling should be no greater than half of the eye length. One still must consult the manufacturer's literature to verify what D/d ratio is required for full efficiency of the sling's capacity. Softeners should always be used to help create a better D/d ratio or radius of contact at 90° corners.

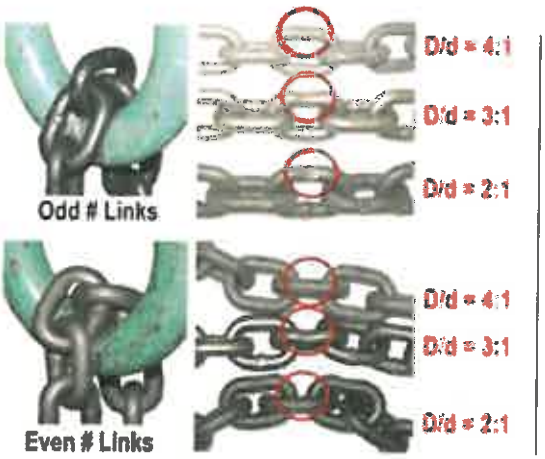
This article is excerpted from a presentation by Mike Riggs of the Rigging Institute, Knoxville, Tenn., made at CRC Canada, held Oct. 12-13, 2011 in Edmonton, Alberta.

Chain



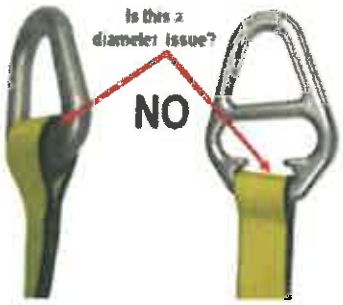
Recently, the National Association of Chain Manufacturers (NACM) sponsored testing to determine the effect D/d ratio has on a chain sling. Four NACM manufacturers supplied 9/32", 3/8", and 1/2" grade 100 chain, while three manufacturers supplied 3/8" grade 80, for testing. As with wire rope, the upper case 'D' represents the diameter of the load and the lower case 'd' represents the diameter of the chain.

Chain is considerably different than wire rope. Where all wire rope parts are flexible, chain has a flexible inter-link and a rigid intra-link of a particular length. However, because the inside length to the chain diameter is relatively constant for alloy chain, the D/d is consistent. Below are pictures of link deformation at proof test load for odd and even number of links. NACM recommended de-rating D/d as follows. You should also apply this recommendation for the edge width of a load that chain sling is wrapped around.

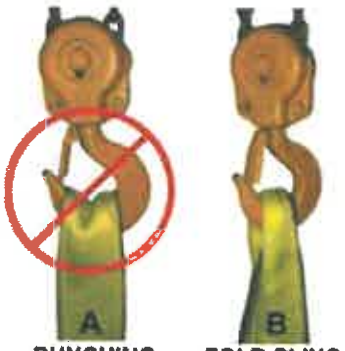


Alloy Chain D/d Ratio Efficiency	
D/d Ratio	% of Rated Capacity
6:1 and greater	100%
5:1	90%
4:1	80%
3:1	70%
2:1	60%
Less than 2:1	Not Recommended

Web



D/d ratios are not a concern when it comes to synthetic web slings. If this were a concern then the hardware used on ANSI Type 1 and Type 2 slings would require a reduction in capacity. Instead, their rating is the same as Type 3 and Type 4 slings. Normally the web width is the problem, which develops when too much material is bunched up in too small a space. When webbing is bunched over a hook, such as shown in sling A, only a small percent of the webbing supports the load. In small fittings, folding the sling over itself (B) will regain the original webbing strength. This is the same process a manufacturer uses to taper wide sling eyes so they fit more symmetrically over a hook or shackle. One area of the sling where diameter is an issue is in the sling eye. The shackle, hook, or trunion should be no greater than 1/3 of the web sling eye length.



Round

When considering D/d ratios for roundslings, the manufacturer's recommendations for the sling must be followed. Roundsling load fibers are of many different types and deniers, or strengths. Different fiber types and component sizes react differently around pin diameters. For example, when referring to pin size, Slingmax Rigging Solutions instructs the users of K-Spec high-performance fiber slings that "Sling ratings are based on a commercial fitting of equal or greater capacity."

The Web Sling & Tie Down Association (WSTDA) references pin size when breaking polyester round slings to verify rated capacities. When selecting hardware to use with polyester roundslings, the WSTDA recommends diameters that will create a bearing stress not to exceed 7,000 psi. To determine the sling's bearing stress, determine the sling's load value (sling's share of the load), then divide it by the load bearing area. The result will be the sling's bearing stress. An RS90 roundsling with a vertical work load limit of 8,400 pounds is connected to the rounded bow of a 5/8" shackle.

The shackle has an inside opening of 2", but an effective contact width of 1.5" and a stock diameter of 0.62". When the sling load value (6,000 pounds) is divided by the sum of the diameter times the effective contact width (.62 x 1.5 = .93) we find the bearing stress is 6,451 psi. This is less than WSTDA's recommended maximum of 7,000 psi.

To most accurately determine how much a sling's capacity is affected by D/d, be sure to apply the correct de-ratings based on the sling's material and construction.