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What is the relationship between yield strength and shear strength for steel and why is it so?

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5 Answers

**Rajat Arora**, PhD Student, Computational Mechanics

Updated September 10, 2016

I think you mean the difference between the yield strength of a material in tensile (σ_{yt}) and yield strength of a material in shear (σ_{ys}).

Take a bar of a metal subjected to the forces as in two scenarios below. For simplicity, [J2 \(Von-Mises\)](#) [plasticity model](#) will be used. It says that the body yields when the absolute value of second invariant of the deviatoric part of the stress tensor reaches a critical value, and this critical value is the square of shear yield strength of the material.

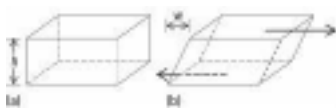
For simplicity, $J2(\sigma') = 0.5 * (\sigma'_{ij} \cdot \sigma'_{ij})$

where σ' = deviatoric part of stress.

$$\sigma' = \sigma - 1/3 * \text{trace}(\sigma) * \text{IdentityTensor}$$

Lets look at the two scenarios:

1. Apply simple shear like the one shown in the picture below.



The stress tensor will now have only σ_{12} and σ_{21} as the non-zero components.

$$|J2| = \sigma_{12}^2 = \sigma_{ys}^2$$

2. Apply force only in the x direction like the one shown in the picture below.



Assuming uniaxial stress state, the stress tensor will now has only one component σ_{11} .

[Second invariant](#) [t](#), $|J2| = \sigma_{11}^2 / (3) = \sigma_{ys}^2$

If it yields at $\sigma_{11} = \sigma_{yt}$,

then,

$$\sigma_{yt} = \sqrt{3} * \sigma_{ys}$$

Hence, at the onset of yielding, the magnitude of the shear yield stress in pure shear is $(\sqrt{3})$ times lower than the tensile yield stress in the case of simple tension.

Image souce: [Google](#) [t](#)

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Eric Jonsson, PhD Materials Science and Engineering (2021)

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Let me see do I remember this one, the exact relationship can be rather complicated so I leave it up to you to research it for your specific application but as for the second part why is the relationship what it is is simply the fact that tensile stress can be resolved as a shear stress.

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Tony Martin, M.S.M.E. Mechanical Engineering & Materials Science and Engineering, University of Michigan (1987)

Answered May 31, 2017 · Author has **4.1K** answers and **1.3M** answer views

Hi!

What is Yield and Shear strength relationship?

The easy answer is that Shear Yield is close to 50% of Tensile.

The hard answer means you study Mohr's circle, various failure theories (Tresca, Distortion Energy, etc.), and understand what shear and tensile yield mean at the micro level.

And to back up the hard answer, do some searching on the Google

https://www.researchgate.net/post/Is_there_any_relationship_between_shear_strength_and_tensile_strength_of_a_metal2

[Calculating Shear Strength of a Material?](#)

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Mayank Shridhar, studied Civil Engineering at Rajiv Gandhi Proudhyogiki Vishwavidyalaya, Bhopal (2015)

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The relationship between shear strength and tensile strength (yield) is characterized by the criteria of plasticity. There is a lot of criteria, but the most known and applied in metals are VON MISES and TRESCA. The Von Mises criterion is more conservative. We could say to the relationship as $1/\sqrt{3}$ if we consider the Von Mises criterion.

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Robert Pawulski

Answered October 18, 2019

numbers and just look up where it comes from.

Young's modulus, shear modulus and Poisson's ratio have a relation. The way I remember, it is $E=2G(1+\mu)$.

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How has an astrologer or a prediction helped you change your life? What happened? Do you still believe in astrology and astrologers?



Alisha Desai, Consultant

Updated July 8, 2020

The following is a detailed story, so bear with me. So, I was in the final year of my engineering degree in Mumbai, and all my friends were getting ready for placements and some tearful goodbyes. There were six of us in my friend circle, 3 [\(Continue reading\)](#)

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