Tsai-wu positive or negative?

thread327-298806

Hi all,

When calculating the tsai-wu, shall the material strengths be all positive? I mean the compressive strength, should i use the positive value when I am calculating the Tsai-Wu failure criteria.

And also, if the Tsai-Wu failure criteria is -50 for example, will it fail or will it just fail if it is larger than or equal to 1?

Thank you

The sign of the strength value should be consistent with the sign of the applied stress values. E.g, if a compression stress is entered as -X, then you should enter the compression allowable as -F; if a compression stress is entered as +X then you should enter the compression allowable as +F.

I don't think it is correct to get a negative failure index.

Note also that the Tsai-Wu failure criteria does not correlate well to laminate strength data. See the many past discussions on this forum and the Aircraft engineering forum.

SW

I apply a force oh 46kN acting in one direction on my geometry. The other load case is that the whole geometry is exposed to an acceleration acting on the whole geometry. So, if I apply positive values on the force and on the other load case acceleration, the strengths shall be positive aswell?

I dont have so much choice when choosing criterion because I have not any experimental data available. My main problem is also that Im using tsai-wu and maximum strain criteria and I get completely different answers. With Tsai-wu a large amount of elements fail while the max strain says that almost nothing fails. Don't know which one to believe lol.

Why would it not be correct to get a negative Tsai-Wu index?

In order to have some idea how to help, please post for one element in your model for one load case for one ply:

- the complete set of stress and strain values
- the allowables you entered for Tsai-Wu
- the allowables you entered for max strain
- the Tsai-wu failure index output
- the max strain failure index output

SW

For max stress/strain the sign of the allowable should match the applied, as SW says.

However, I find it quite confusing for criteria like Tsai-Wu. It has both the tension allowable and the compression allowable present, which makes it a bit complicated. Generally the allowable seems to need to be unsigned, which more or less makes sense when one has just a single axial stress applied to the ply. If you try it with signed allowables you get less sensible values for the FI (failure index) than otherwise.

Also confusing is the presence of both linear terms and squared terms. To get an actual MS or RF out of it you have to solve a quadratic equation. (Not true for ones like Tsai-Hill, where all terms are squared and one can just square root the FI for the RF.)

lavecchiasignora, I must agree with SW when he says that a negative FI means something is wrong. (Though one can achieve this with negative allowables.)

I also agree with SW when he asks for an example. It will still be quite complicated with Tsai-Wu, but is probably the only way to be clear.

I dont know why a negative tsai-wu index would mean that something is wrong?

Tensile strength 1-diretion 800 MPa
Compressive strength 1-direction 500 MPa
Tensile strength 2-direction 20 MPa
Compressive strength 2-direction 300 MPa
Shear strength 12-direction 30 MPa

In tsai-wu, sigma1 and sigma2 could be negative, so why should tsai-wu not be negative?

Have a look at post #2 again.

Brian
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At the risk of getting into a complicated situation:

The point of a failure index is that if it's 1.0 or **more** it indicates failure. A failure index of less than zero (or maybe -1 or something) does not indicate failure.

(NB: I misspoke in my earlier post when I said that just square-rooting Tsai-Hill gave the RF; it's **one over** the square-root for the RF. A big FI means a low RF/MS. A negative Tsai-Hill is meaningless as it cannot be turned into a MS; a negative Tsai-Wu **might** not be.)

Generally, adding in a stress, be it positive or negative, increases the FI (it makes matters worse (more likely to fail), not better). However, it **is** possible to et Tsai-Wu to give a -ve FI which corresponds to a sensible RF (I think).

I will check a few sums for representative FIs and RFs, but it won't be pretty.

We could do with some sort of Mathcad-like facility. A monospaced font will have to do.

If we have just a -ve s2 applied:

sigma1/s1 applied, say 0
sigma1AT/s1AT 1-direction Allowable Tension, 800 MPa
sigma1AC/s1AC 1-direction Allowable Compression stress, 500 MPa
Sigma2/s2 applied, say -290 MPa
sigma2AT/s2AT 2-direction Allowable Tension, 20 MPa
sigma2AC/s2AC 2-direction Allowable Compression stress, 300 MPa
tau12/t12 applied, say 0
tau12A/t12A allowable 12-shear stress, 30 MPa

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      0     0    -290   -290     0^2     (-290)^2    0^2          0*-290
FI = --- - --- + ---- - ---- + ------- + -------- + ---- - --------------------
     800   500    20    300    800*500    20*300    30^2   Sqrt(800*500*20*300)

   = 0 - 0 + -14.5 - -0.967 + 0 + 14.0167 + 0 - 0 = 0.483 (agrees with LAP)

[If s1AC and s2Ac are negative, I think FI comes to -29.483.]

     -b + Sqrt(b^2 + 4*a)
RF = --------------------
               2.a
a = s1^2/(s1at*s1ac) + s2^2/(s2at*s2ac) + t12^2/t12a^2 - s1*s2/SQRT( s1at.s1ac.s2at.s2ac )
b = s1/s1at - s1/s1ac + s2/s2at - s2/s2ac
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(c = -1.0)

     -(-13.533) + Sqrt(13,533^2 + 4*14.0167)
RF = --------------------------------------- =  1.034482759 (agrees with TheLaminator)
                    2*14.0167

sigma2/s2 applied now -200

      0     0    -200   -200     0^2     (-200)^2    0^2          0*-200
FI = --- - --- + ---- - ---- + ------- + -------- + ---- - --------------------
     800   500    20    300    800*500    20*300    30^2   Sqrt(800*500*20*300)

   = 0 - 0 + -10 - -0.667 + 0 + 6.667 + 0 - 0 = -2.667 (LAP can't handle -ve FIs and reports 0)

     -(-9.333) + Sqrt(9.333^2 + 4*6.667)
RF = ---------------------------------- =  1.50 (agrees with TheLaminator)
                  2*6.667
```

That's it.

Thank you for your valuable answers.

One last question: If I am analyzing a contact problem in Ansys and I want to use tsai-wu on the ply level and not at the laminate level. Should I use tsai-wu 3D or 2D? I mean for contact between teo bodies it should be 3D right? But since Im only looking at the ply level, i.e. each ply is considered at a time it is asumed to be under plane stress because it is so thin?

Thank you

Have another look at this thread:

http://www.eng-tips.com/viewthread.cfm?qid=294778&page=1

The point being that Tsai-Wu is not a well accepted general failure criterion for a laminate in the first place. It was developed as a 2D failure criterion of a SINGLE PLY (which in turn often yields poor results for a laminate).

That being said, the extension to 3D would just be a theory that many have abandoned long ago (though academia has lagged behind). Long story short, you are probably barking up the wrong tree if you expect Tsai-Wu to give an enhanced result by extending it to 3D.

The next logical question would be if there is any reasonable affect due to the contact force (and more specific details about the problem). But that would be better served in another thread.

Brian
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I know that tsai-wu is not appropriate for analyzing laminates but I dont have any choice right now.

The only thing I want to check with you if it is more appropriate to check the failure between a ball and a laminate in 3d or 2d.

Theoretically, a 3D failure criterion would be more appropriate...if you had one. But extending Tsai-Wu to 3D and saying it would be more appropriate would not be a reasonable statement. SIFT might be a reasonable candidate for something like that.

And why don't you have a choice? Is this an academic/homework problem? Early on in the study of composites, most people think/want to have a nice failure criterion for the types of problems you are asking. In the metals world, we often have good criteria. Unfortunately, this does not translate to composites and you have to adjust your approach accordingly.

Typically, we supplement test data to compensate for the known shortcomings. This is not to say analysis is pointless, but rather it should be limited to its capable domain.

In fact, extension of criteria and methods beyond their useful domain is often a red flag to checkers/approvers.

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I didn't know anyone had bothered to develop a 3D version of Tsai-Wu. It's applicability to a non-2D-lamina is quite likely to be a matter of chance...

3D theories for composite are not exactly rare, but they're not all that common either. You could try **http://www.tara.tcd.ie/bitstream/2262/43093/1/PEER_stage2_10.1016%252Fj.compscitech.2008.05.004.pdf**
(accessed from **http://www.tara.tcd.ie/handle/2262/43093** .)

This was developed by Jens Wiegand as part of his doctorate at Oxford quite recently (paper title "An algorithm for determination of the fracture angle for the three dimensional Puck matrix failure criterion for UD composites"). It has an implementation in LS-Dyna.