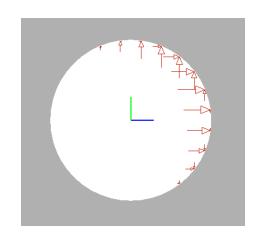


Formulae for Directional Components of Bearing Traction Load

Andrew Ledbetter ESRD 2019





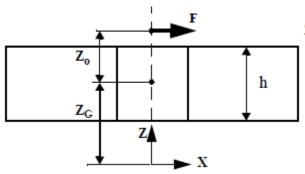


In-Plane Bearing Load Formula



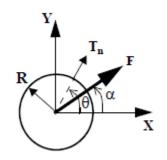


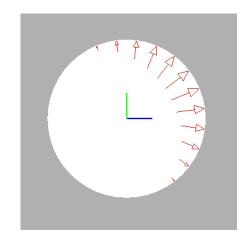
- The bearing load is defined as a cosine traction distribution oriented <u>normal</u> to the bore surface of a hole.
 - In 3D, the formula is defined as follows:



$$T_n = -\frac{2F}{\pi Rh} \cos(\theta - \alpha) \left[1 + \frac{12}{h^2} Z_o(Z - Z_G) \right] \text{ if } (T_n < 0)$$

$$T_n = 0 \text{ if } (T_n > 0)$$





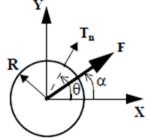
Directional Components

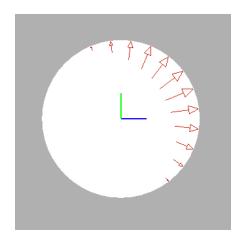


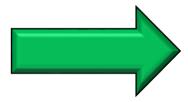


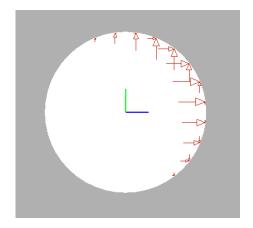
 We would like to represent this normal traction as a combination of its directional components:

$$\boldsymbol{T_n} = T_x \, \widehat{\boldsymbol{x}} + T_y \, \widehat{\boldsymbol{y}}$$







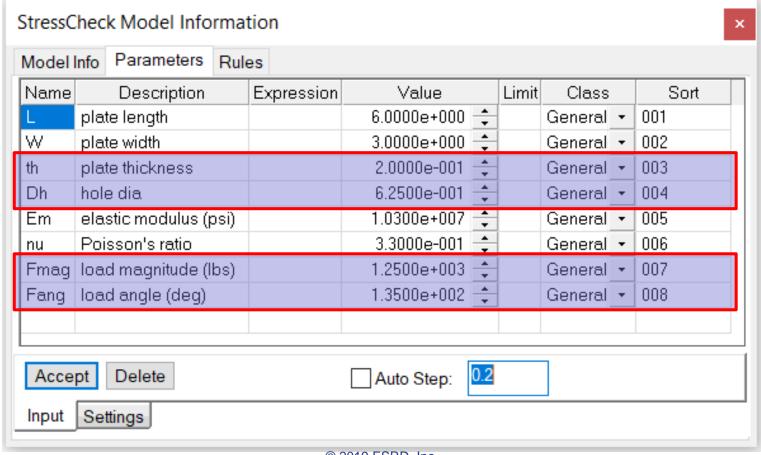


Bearing Load and Hole Parameters





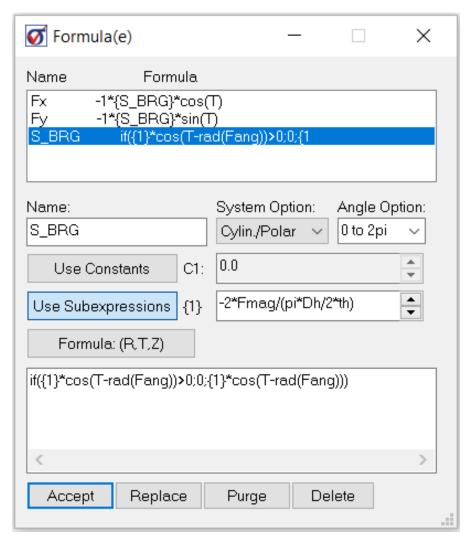
We can introduce the following parameters to control aspects of the bearing load and hole:

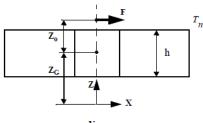


Normal Bearing Traction Formula



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$$T_n = -\frac{2F}{\pi R h} \cos(\theta - \alpha) \left[1 + \frac{12}{h^2} Z_o(Z - Z_G) \right] \text{ if } (T_n < 0)$$

$$T_n = 0 \text{ if } (T_n > 0)$$

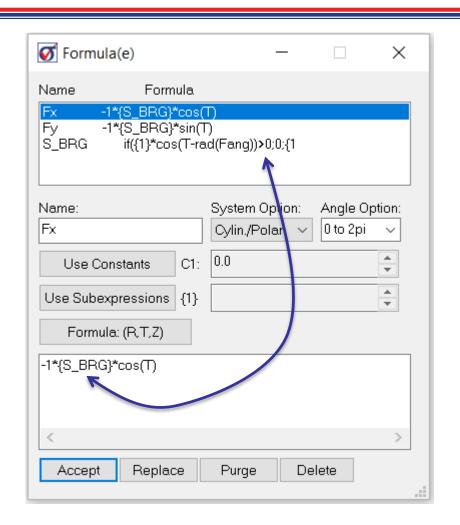


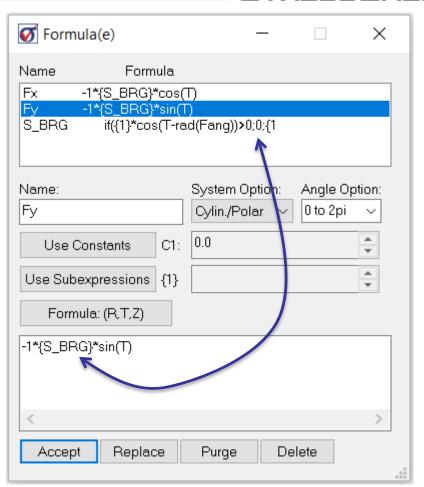
Note: The values of h and Z_G are computed automatically by StressCheck from the location of the nodes on the selected faces.

Directional Components



STRESSCHECK[®]



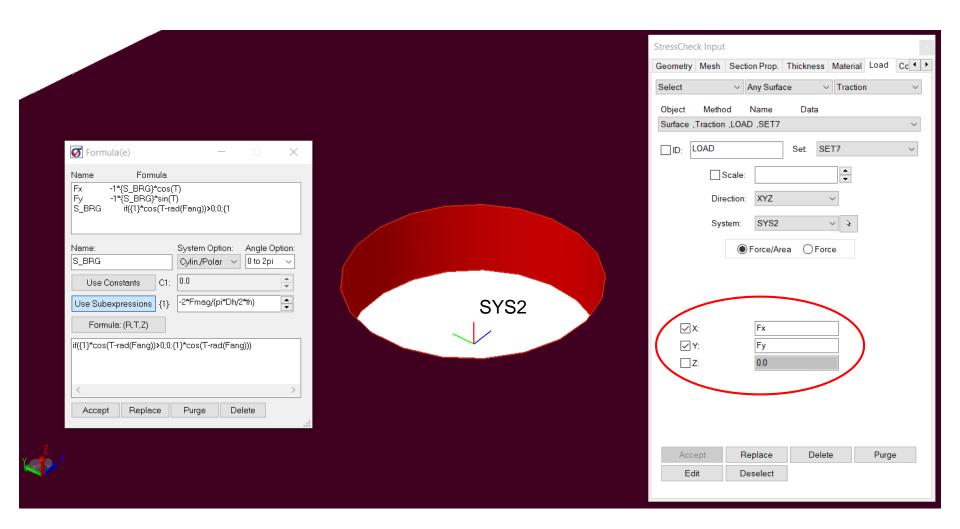


Note: Use curly brackets {} when referencing other formulae within a formula expression

Apply a Directional Traction

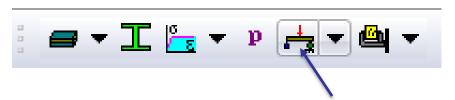


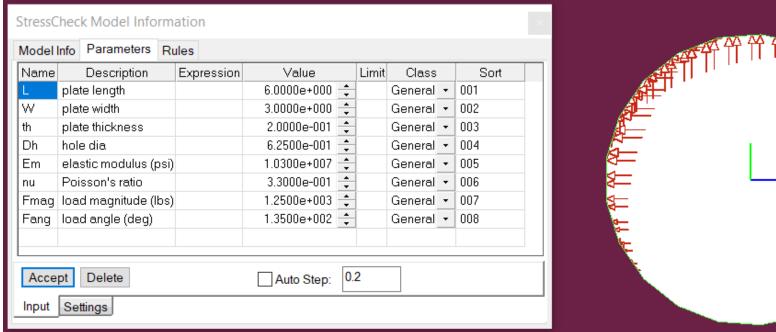
STRESSCHECK®

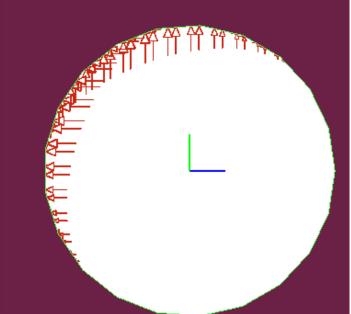


Display Load Arrows





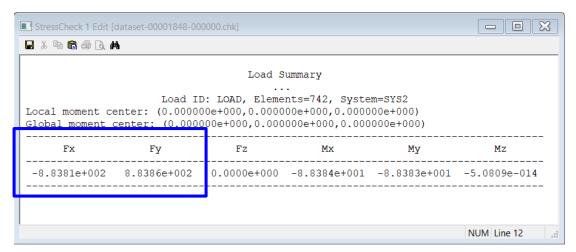




Check Loads



STRESS CHECK



$$F_x = F_b \cos(theta) = 1250 \cos(135^\circ)$$

$$\rightarrow F_x = -883.9 \ lbs$$

$$F_y = F_b \sin(theta) = 1250 \sin(135^\circ)$$

$$\rightarrow F_y = 883.9 \ lbs$$

Note: This method is applicable for any load angle $0^{\circ} < \theta < 360^{\circ}$

StressCheck	c Input							×
Geometry	Mesh	Section	n Prop.	Thickne	ss	Material	Load	Cc ◀ ▶
Check		~ A	All Eleme	nts	~	Selection	on	~
Object	Method	d 1	Name	Data	9			
Surface ,T	raction	LOAD	SET7,					~
✓ID: LC	DAD			Set	Nev	vset		>
	S	cale:				A		
	Direc	ction:	None		~	e e		
	Syste	em:	SYS2		~	4 3		
✓ M	oment-X	:	0.0					
✓ M	oment-Y	:	0.0					
M	Moment-Z:		0.0					
Acce	pt	Re	place	De	elete		Purge	е
Edit			select					

BONUS: INCORPORATING BENDING MOMENT EFFECTS

Bending Component





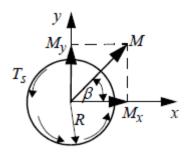
 A <u>bending</u> component can be included in the bearing normal traction formula for "heel and toe" effects

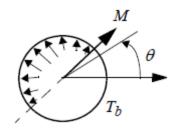
Bending moment

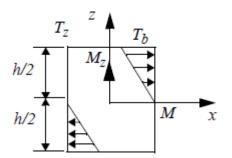
$$T_b = \frac{24M}{\pi Rh^3} Z \sin(\theta - \beta)$$

Twisting moment (not used in this example)

$$T_s = -\frac{M_z}{2\pi R^2 h}$$







Bending Moment Parameter (M)





StressChe	eck Model Information						х
Model Inf	Parameters Rules						
Name	Description	Expression	Value	Limit	Class		Sort
L	plate length		6.0000e+000 🖯	-	General	•	001
W	plate width		3.0000e+000 ÷	-	General	•	002
th	plate thickness		2.0000e-001	-	General	•	003
Dh	hole dia		6.2500e-001	-	General	•	004
Em	elastic modulus (psi)		1.0300e+007	-	General	•	005
nu	Poisson's ratio		3.3000e-001	-	General	•	006
Fmag	load magnitude (lbs)		1.2500e+003	-	General	•	007
Fang	load angle (deg)		1.3500e+002	r	General		888
М	Bending moment (lb-in)		1.7500e+002		General	Ŧ	009
Accept	Delete	Auto Step:	0.2				
		□ Auto Step.					
Input Settings							

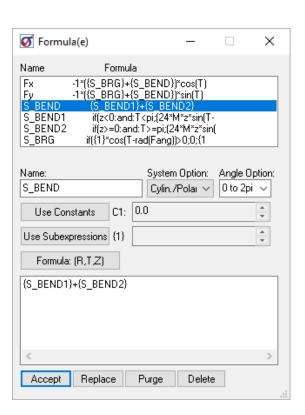
Bending Formulae





 Formula(€	<u>:</u>)		_		×
Name	Formula				
Fx -1'	({S_BRG}+{9	_BEND}	*cos(T)		
Fy -1° S BEND	({S_BRG}+{9} (S_BEND1)				
S_BEND1	if(z<0:and:	[kpi;(24*N	//z*sin(T-		
S_BEND2 S_BRG	if(z>=0:and if({1}*cos(T-r			[
0_0110	11((1) 000(11	aa(r arig))	, 0,0,(1		
Name:		Sustem	Option:	Angle O	ntion:
S BEND1			Polar V	0 to 2pi	
_			. o.a.		
Use Consta	nts C1: (0.0			* T
Use Subexpre	ssions {1}				A .
F 1 (D	T =>				
Formula: (R	,1 2)				
if(z<0:and:T <pi< td=""><td>;(24*M*z*sin(</td><td>T-rad(Fan</td><td>g)))/(pi*Dl</td><td>h/2*th^3);</td><td>:0)</td></pi<>	;(24*M*z*sin(T-rad(Fan	g)))/(pi*Dl	h/2*th^3);	:0)
					.
<					>
Accept	Replace	Purge	Delete		
			_ = = = = = = = = = = = = = = = = = = =		

of Formula(e)		_	-		×
Name Fo	ormula				
Fx -1*({S BR	G}+{S	BEND})*co:	s(T)		
Fy -1*({S_BR	G}+{S_	BEND})*sin	(T)		
		(S_BEND2)			
		(pi;(24*M*z*:			
		[>=pi;(24*M* d(Fang))>0;0			
[3_B)1G (()) C	,US(11a	u(i arig))zo,i	<i>5</i> ()		
Name:		System Opt	tion:	Angle Op	otion:
S_BEND2		Cylin./Pola	ai V	0 to 2pi	~
	6				
Use Constants	C1: 0.	U			*
Use Subexpressions	as E				
Ose Subexpressions					Ψ.
Formula: (R,T,Z)					
1 omidia. (11,1)=)					
if(z>=0:and:T>=pi;(24*	M*z*sin	(T-rad(Fang))))/(pi*	Dh/2*th^	3);0)
<					>
Accept Replace	e F	Purge D	elete		

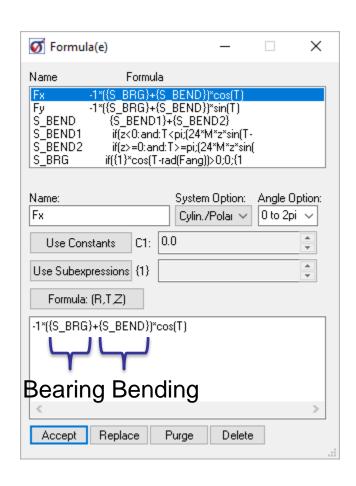


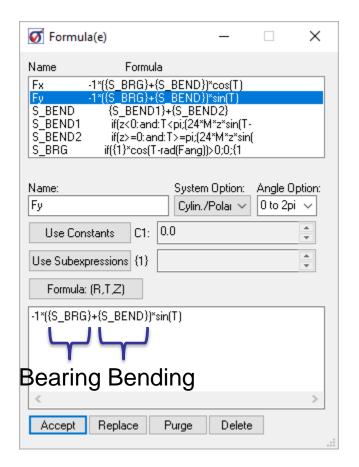
Total Bending Stress: $S_{BEND} = S_{BEND1} + S_{BEND2}$

Directional Traction Formulae







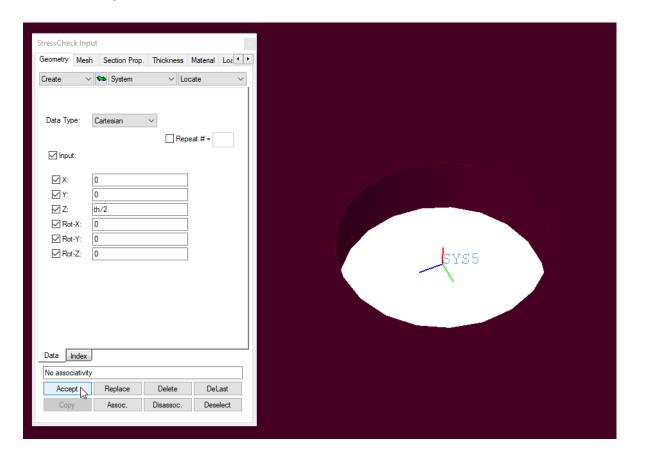


Create a Local System





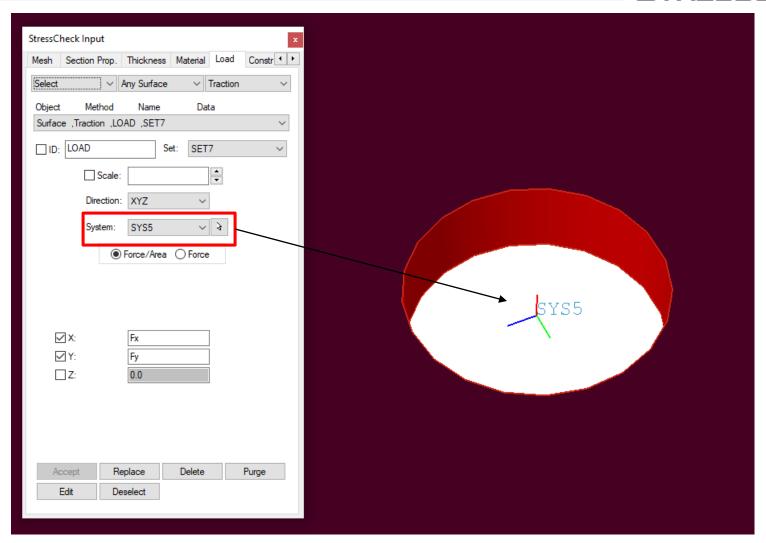
 Create a Cartesian system in the middle (mid-height) of the hole, with the Z-axis parallel to the hole



Update the Traction Load Assignment



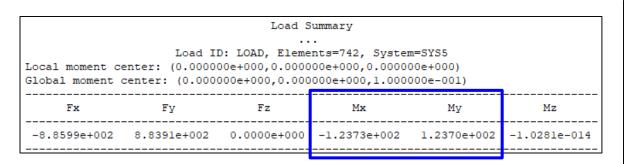
STRESSCHECK



Check Loads



STRESSCHECK

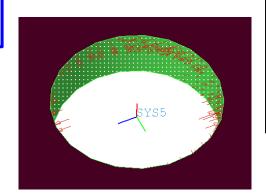


$$M_x = M\cos(theta) = 175\cos(135^\circ)$$

$$\rightarrow M_x = -123.7 \ lb - in$$

$$M_y = M\sin(theta) = 175\sin(135^\circ)$$

$$\rightarrow M_y = 123.7 lb - in$$



StressCheck Input
Mesh Section Prop. Thickness Material Load Constr
Check \checkmark All Elements \checkmark Selection \checkmark
Object Method Name Data
Surface ,Traction ,LOAD ,SET7 ~
☑ ID: LOAD Set: New set ✓
Scale:
Direction: None V
System: SYS5 V 3
Moment-X: 0.0
Moment-Y: 0.0
Moment-Z 0.0
Accept Replace Delete Purge
Edit Deselect