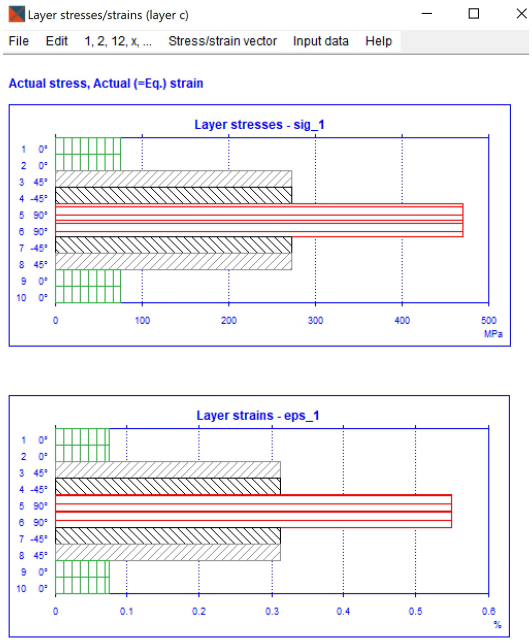
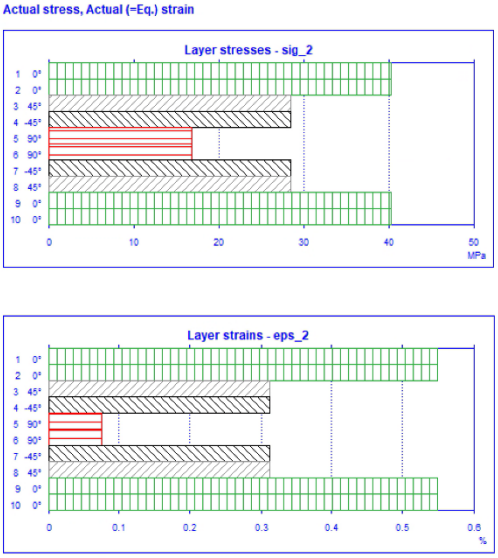
Par exemple : Lay-up de 10 plis de 0,45 et 90.
Force Nx de 375000 N/m et Ny de 750000 N/m

Contraintes et déformations dans chaque pli dans la direction des fibres et des forces.





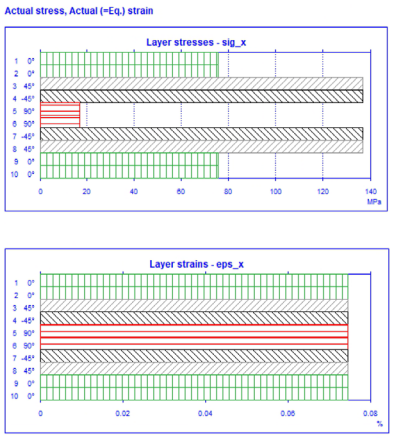
Laminate : **04590G**
Modified : Mon Dec 16 18:07:27 2024

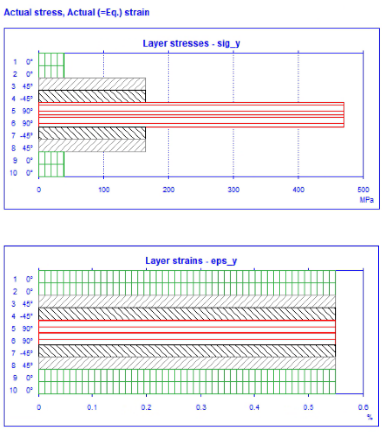
Lay-up : (0a/0a/+45a/-45a/90a/90a/-45a/+45a/0a/0a) h = 4.25 mm

Ply
a T300;Epoxy;UD-.425/298/40

Load : **Nx Ny**
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var;E)

N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m





Laminate : **04590G**
Modified : Mon Dec 16 18:07:27 2024

Lay-up : (0a/0a/+45a/-45a/90a/90a/-45a/+45a/0a/0a) h = 4.25 mm

Ply
a T300;Epoxy;UD-.425/298/40

Load : **Nx Ny**
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var;E)

N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m

RF pour 10 plis en UD epoxy/fibres de carbon T300

Ply: T300;Epoxy;UD-.425/298/40

Reinf.ply UD;Fiber;Carbon;Toray;Matrix;Epoxy;
t=0.42 mm;m_A=604 g/m²;rho=1420 kg/m³;V_f=40%;f_1/2=100/0;Transv.is.23

Avec un FoSv de 1.

Laminate FPF analysis

Laminate : **04590C**
Modified : Mon Dec 16 18:30:12 2024

Lay-up : (0a/0a/+45a/-45a/90a/90a/-45a/+45a/0a/0a) h = 4.25 mm

Ply
a T300;Epoxy;UD-.425/298/40

Load : **Nx Ny**
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var;E)

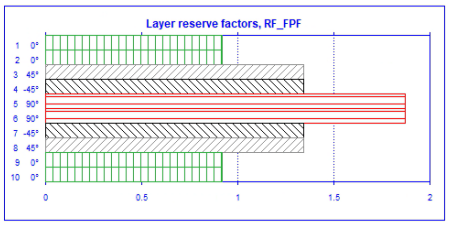
N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m

Q_x = 0 N/m
Q_y = 0 N/m

Factor of safety : FoS^v = 1
Failure criterion : Tsai-Wu; Max strain; Von Mises; Out-of-plane shear; Out-of-plane shear; None (UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate margins of safety

	FPF %	Mode	FPF-only %	Mode	Crit. layers	ILS %	Crit. interf.
MoS =	-8	2t	-8	2t	(0°)	-	-



Avec un FoSv de 1.5

Laminate FPF analysis

Laminate : **04590C**
Modified : Mon Dec 16 18:30:12 2024

Lay-up : (0a/0a/+45a/-45a/90a/90a/-45a/+45a/0a/0a) h = 4.25 mm

Ply
a T300;Epoxy;UD-.425/298/40

Load : **Nx Ny**
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var;E)

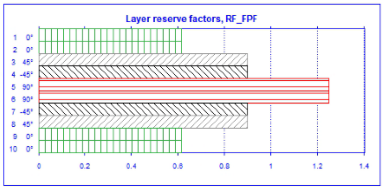
N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m

Q_x = 0 N/m
Q_y = 0 N/m

Factor of safety : FoS^v = 1.5
Failure criterion : Tsai-Wu; Max strain; Von Mises; Out-of-plane shear; Out-of-plane shear; None (UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate margins of safety

	FPF %	Mode	FPF-only %	Mode	Crit. layers	ILS %	Crit. interf.
MoS =	-39	2t	-39	2t	(0°)	-	-



FoSv : factor of safety variable
RF = Frupture / Feffective = Frupture/(Fappliqué. FoSv)

Certains plis ont encore des RF inférieurs à 1.

RF pour 30 plis, avec des plis supplémentaires à 0
Les contraintes sig2 dans ces plis diminuent. Les RF deviennent supérieurs à 1.
L'épaisseur passe de 4.25 à 12.75 mm

Laminate stress-strain state

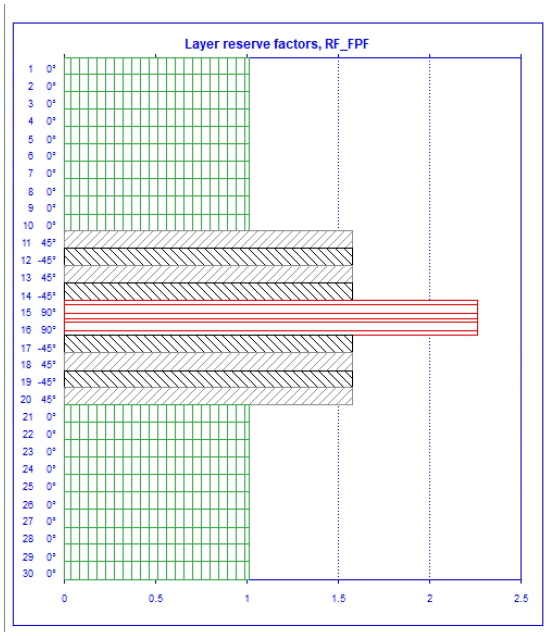
Laminate : **04590C 30p**
Modified : Fri Dec 20 14:36:14 2024

Lay-up : - h = 12.75 mm

Ply
a T300;Epoxy;UD-.425/298/40

Load : **Nx Ny**
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var.;E)

N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m



N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m

Q_x = 0 N/m
Q_y = 0 N/m

	Ply	theta		sig_1	sig_2	tau_12	tau_31	tau_23	sig_x	sig_y	tau_xy	tau_zx	tau_yz
		°		MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
2	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
3	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
4	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
5	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
6	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
7	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
8	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
9	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
10	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
11	a	45	t	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
			b	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
12	a	-45	t	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
			b	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
13	a	45	t	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
			b	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
14	a	-45	t	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
			b	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
15	a	90	t	282.18	7.58	0.00	0.00	0.00	7.58	282.18	0.00	0.00	0.00
			b	282.18	7.58	0.00	0.00	0.00	7.58	282.18	0.00	0.00	0.00
16	a	90	t	282.18	7.58	0.00	0.00	0.00	7.58	282.18	0.00	0.00	0.00
			b	282.18	7.58	0.00	0.00	0.00	7.58	282.18	0.00	0.00	0.00
17	a	-45	t	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
			b	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
18	a	45	t	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
			b	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
19	a	-45	t	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
			b	148.31	15.50	-9.62	0.00	0.00	72.29	91.52	-66.41	0.00	0.00
20	a	45	t	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
			b	148.31	15.50	9.62	0.00	0.00	72.29	91.52	66.41	0.00	0.00
21	a	0	t	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00
			b	14.44	23.41	0.00	0.00	0.00	14.44	23.41	0.00	0.00	0.00

16 plis avec une autre répartition des contraintes, plus de plis à 90 où les fibres reprennent plus les contraintes radiales. Ainsi les contraintes sigma2 sur les 4 plis à 0 sont diminuées et leur RF devient supérieur à 1. L'épaisseur et donc le poids du composite sont plus petits que le stratifié à 30 plis.

Laminate FPF analysis

Laminate : 04590C
Modified : Fri Dec 20 14:53:41 2024

Lay-up : (0a/0a/+45a/-45a/+45a/-45a/90a/90a/90a/-45a/+45a/-45a/+45a/0a/0a) h = 6.8 mm

Ply
a T300;Epoxy;UD- 425/298/40

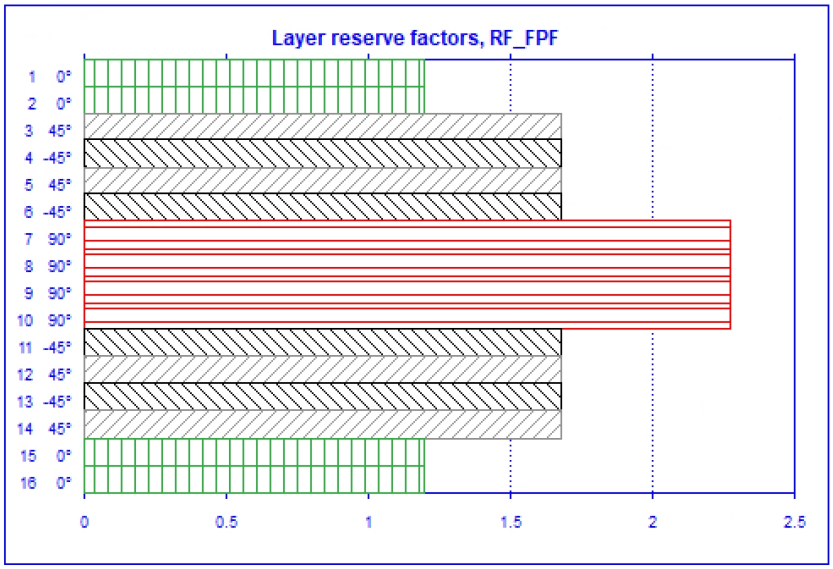
Load : Nx Ny
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var;,E)

N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m

Q_x = 0 N/m
Q_y = 0 N/m

Factor of safety : FoS^v = 1.5
Failure criterion : Tsai-Wu; Tsai-Wu; Von Mises; Out-of-plane shear; Out-of-plane shear; None (UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

	Ply	theta		sig_1	sig_2	tau_12	tau_31	tau_23	sig_x	sig_y	tau_xy	tau_zx	tau_yz
		°		MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	a	0	t	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
			b	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
2	a	0	t	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
			b	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
3	a	45	t	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
			b	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
4	a	-45	t	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
			b	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
5	a	45	t	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
			b	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
6	a	-45	t	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
			b	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
7	a	90	t	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
			b	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
8	a	90	t	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
			b	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
9	a	90	t	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
			b	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
10	a	90	t	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
			b	241.49	10.23	0.00	0.00	0.00	10.23	241.49	0.00	0.00	0.00
11	a	-45	t	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
			b	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
12	a	45	t	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
			b	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
13	a	-45	t	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
			b	149.79	15.65	-6.59	0.00	0.00	76.13	89.31	-67.07	0.00	0.00
14	a	45	t	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
			b	149.79	15.65	6.59	0.00	0.00	76.13	89.31	67.07	0.00	0.00
15	a	0	t	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
			b	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
16	a	0	t	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00
			b	58.09	21.07	0.00	0.00	0.00	58.09	21.07	0.00	0.00	0.00



18 plis dont 2 plis externes en Kevlar pour la résistance aux chocs.

Layer stresses

Laminate : **04590 CK**
Modified : Fri Dec 20 15:17:21 2024

Lay-up : (0a/0b/0b/+45b/-45b/+45b/-45b/90b/90b/90b/90b/-45b/+45b/-45b/+45b/0b/0b/0a) h = 7.2 mm

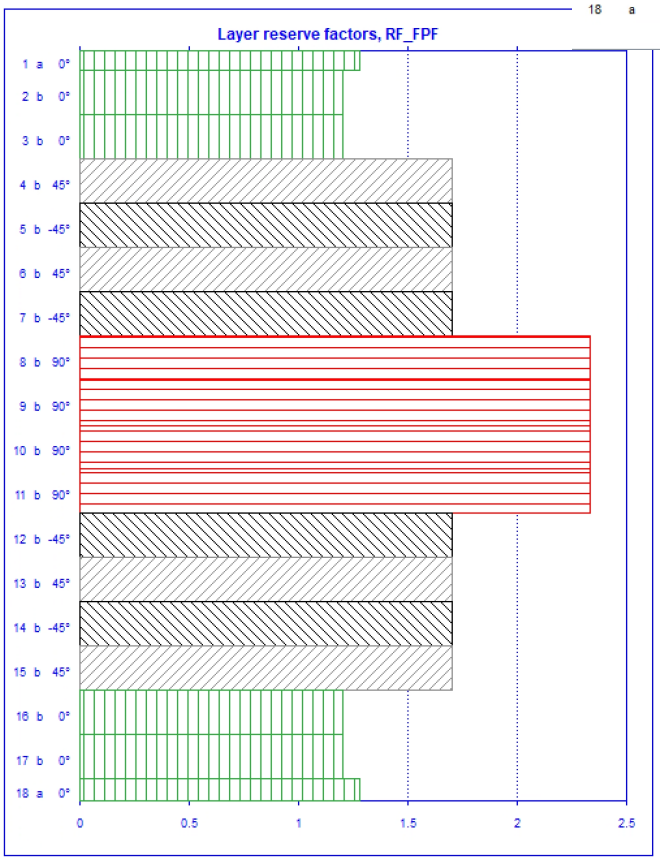
Ply
a Kevlar 49;Epoxy;UD-.200/173/60
b T300;Epoxy;UD-.425/298/40

Load : **Nx Ny**
Modified : Mon Dec 16 11:57:49 2024
Type : Forces and moments (Var.;E)

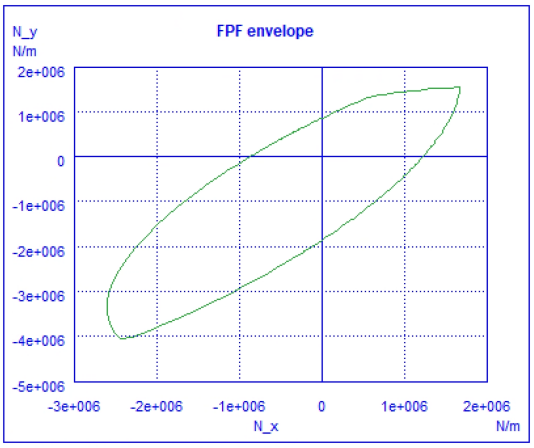
N_x = 375000 N/m M_x = 0 Nm/m
N_y = 750000 N/m M_y = 0 Nm/m
N_xy = 0 N/m M_xy = 0 Nm/m

Q_x = 0 N/m
Q_y = 0 N/m

	Ply	theta		sig_1	sig_2	tau_12	tau_31	tau_23	sig_x	sig_y	tau_xy	tau_zx	tau_yz
		°		MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
1	a	0	t	45.89	16.55	0.00	0.00	0.00	45.89	16.55	0.00	0.00	0.00
			b	45.89	16.55	0.00	0.00	0.00	45.89	16.55	0.00	0.00	0.00
2	b	0	t	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
			b	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
3	b	0	t	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
			b	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
4	b	45	t	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
			b	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
5	b	-45	t	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
			b	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
6	b	45	t	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
			b	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
7	b	-45	t	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
			b	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
8	b	90	t	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
			b	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
9	b	90	t	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
			b	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
10	b	90	t	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
			b	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
11	b	90	t	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
			b	241.03	9.71	0.00	0.00	0.00	9.71	241.03	0.00	0.00	0.00
12	b	-45	t	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
			b	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
13	b	45	t	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
			b	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
14	b	-45	t	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
			b	146.47	15.30	-6.79	0.00	0.00	74.09	87.68	-65.58	0.00	0.00
15	b	45	t	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
			b	146.47	15.30	6.79	0.00	0.00	74.09	87.68	65.58	0.00	0.00
16	b	0	t	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
			b	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
17	b	0	t	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
			b	51.90	20.89	0.00	0.00	0.00	51.90	20.89	0.00	0.00	0.00
18	a	0	t	45.89	16.55	0.00	0.00	0.00	45.89	16.55	0.00	0.00	0.00
			b	45.89	16.55	0.00	0.00	0.00	45.89	16.55	0.00	0.00	0.00



Enveloppe de rupture



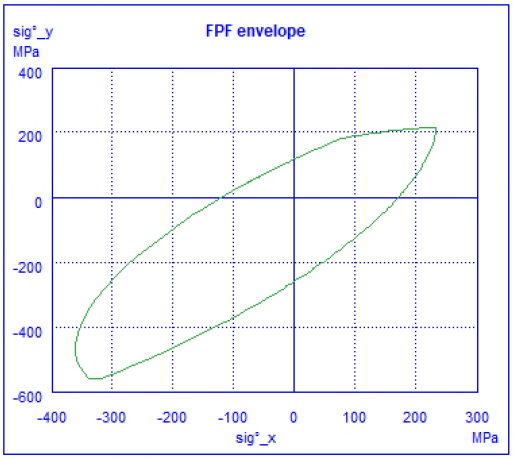
Plot x- and y-components not in the same scale.

Failure criterion : Tsai-Wu; Tsai-Wu; Von Mises; Out-of-plane shear; Out-of-plane shear; None
(UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate : **04590 CK**
Modified : Fri Dec 20 15:17:21 2024

Lay-up : (0a/0b/0b/+45b/-45b/+45b/-45b/90b/90b/90b/90b/-45b/+45b/-45b/+45b/0b/0b/0a) h = 7.2 mm

Ply
a Kevlar 49;Epoxy;UD-.200/173/60
b T300;Epoxy;UD-.425/298/40



Plot x- and y-components not in the same scale.

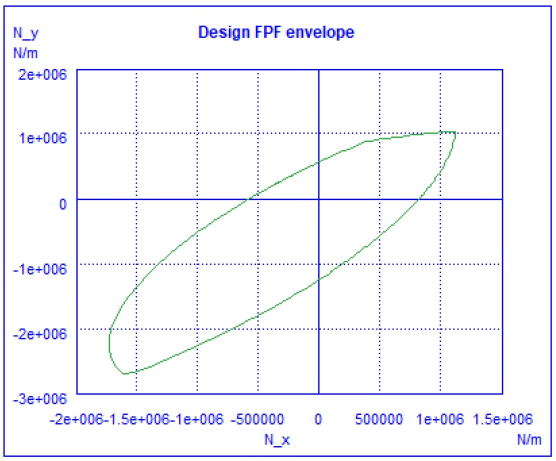
Failure criterion : Tsai-Wu; Tsai-Wu; Von Mises; Out-of-plane shear; Out-of-plane shear; None
(UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate : **04590 CK**
Modified : Fri Dec 20 15:17:21 2024

Lay-up : (0a/0b/0b/+45b/-45b/+45b/-45b/90b/90b/90b/90b/-45b/+45b/-45b/+45b/0b/0b/0a) h = 7.2 mm

Ply
a Kevlar 49;Epoxy;UD-.200/173/60
b T300;Epoxy;UD-.425/298/40

Enveloppe de rupture avec FoSv de 1.5.



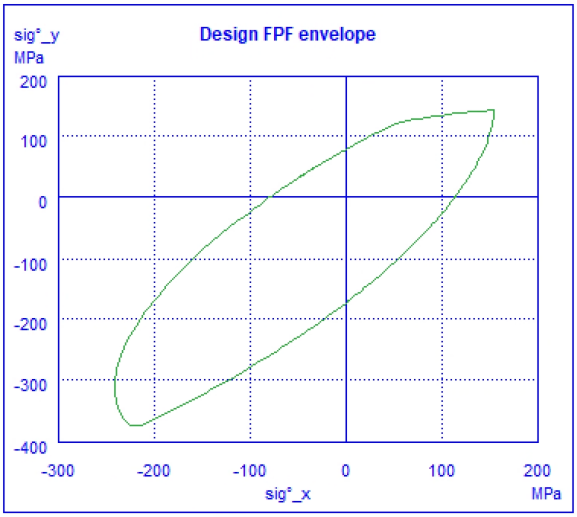
Plot x- and y-components not in the same scale.

Factor of safety : FoS^v = 1.5
Failure criterion : Tsai-Wu; Tsai-Wu; Von Mises; Out-of-plane shear; Out-of-plane shear; None
(UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate : **04590 CK**
Modified : Fri Dec 20 15:17:21 2024

Lay-up : (0a/0b/0b/+45b/-45b/+45b/-45b/90b/90b/90b/90b/-45b/+45b/-45b/+45b/0b/0b/0a) h = 7.2 mm

Ply
a Kevlar 49;Epoxy;UD-.200/173/60
b T300;Epoxy;UD-.425/298/40



Plot x- and y-components not in the same scale.

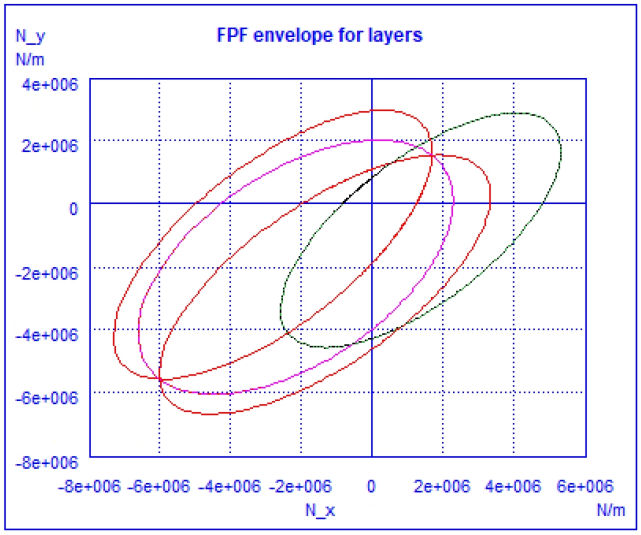
Factor of safety : FoS^v = 1.5
Failure criterion : Tsai-Wu; Tsai-Wu; Von Mises; Out-of-plane shear; Out-of-plane shear; None
(UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate : **04590 CK**
Modified : Fri Dec 20 15:17:21 2024

Lay-up : (0a/0b/0b/+45b/-45b/+45b/-45b/90b/90b/90b/90b/-45b/+45b/-45b/+45b/0b/0b/0a) h = 7.2 mm

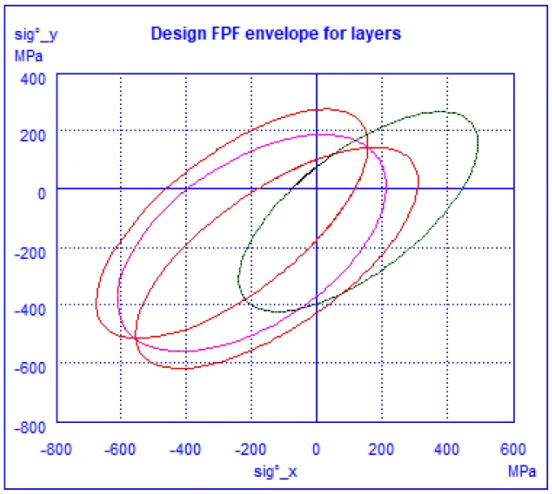
Ply
a Kevlar 49;Epoxy;UD-.200/173/60
b T300;Epoxy;UD-.425/298/40

Enveloppes de rupture pour chacun des plis.



1 a 0°
2 b 0°
3 b 0°
4 b 45°
5 b -45°
6 b 45°
7 b -45°
8 b 90°
9 b 90°
10 b 90°
11 b 90°
12 b -45°
13 b 45°
14 b -45°
15 b 45°
16 b 0°
17 b 0°
18 a 0°

Plot x- and y-components not in the same scale.



1 a 0°
2 b 0°
3 b 0°
4 b 45°
5 b -45°
6 b 45°
7 b -45°
8 b 90°
9 b 90°
10 b 90°
11 b 90°
12 b -45°
13 b 45°
14 b -45°
15 b 45°
16 b 0°
17 b 0°
18 a 0°

Plot x- and y-components not in the same scale.

Factor of safety : FoS^v = 1.5
Failure criterion : Tsai-Wu; Tsai-Wu; Von Mises; Out-of-plane shear; Out-of-plane shear; None
(UD; non-UD; homogeneous; honeyc. core; foam/other core; adhesive)
Failure crit. param. : Tsai-Wu F_12*=-0.5
Stress/strain recovery : layer top/bottom

Laminate : **04590 CK**
Modified : Fri Dec 20 15:17:21 2024