



FEDERATIVE REPUBLIC OF BRAZIL

ALEX CARDOSO CUNHA

PUBLIC SWORN TRANSLATOR AND COMMERCIAL INTERPRETER – Enrollment 057/2010

Rua Marquês do Pombal, 783/501 – CEP 90.540-001 – Porto Alegre/RS/Brazil

Tel.: 55 51 3222-2277 – Cell.: 55 51 99212-7939 – E-mail: juramentados@traduzca.com.br

Duly commissioned by the Board of Trade, Industry and Services of the State of Rio Grande do Sul, Brazil, and qualified according to legislation in force, I, Alex Cardoso Cunha, hereby certify that the document described below was presented to me for translation from Portuguese into English.

Book No. 39 - Translation No.: 0601/2026

This document is a Finite Element Analysis Report.

[Logo applied to all pages: Nexa Projetos]. [Date on all pages: 02/28/2024]. [Page numbering: 1 to 17].

CORE CASE.

FEA - G2 BOX (HWL).

28/Feb/2024.

Scope.

Main objective: To assess the mechanical response of the PP injection-molded G2 BOX (HWL).

Methodology: To identify, through FEA (Finite Element Analysis), weak points that may lead to failure, rupture or plastic deformation of the component studied when subjected to the applied loads.

Material properties - PP 40% Long Fiber.

PP - Artplast PP CZ 415*

Properties:

Density: 0.918 g/cm³.

Flexural modulus = 1,400 MPa.

Yield stress = 32 MPa.

Rupture stress = 36 MPa*.

Considerations:

Linear material behavior;

Viscoelastic / thermal / creep effects disregarded;

Fastening force/torque and localized effects disregarded (ideal fixed support).

*Value estimated based on library material data.

Geometry - G2 Box (HWL).

[Image].

G2 Box - HWL.

2.778 kg.

Loading simulation (single unit).

Boundary conditions - Loading.

Static Structural.

A Fixed Support.

B Force: 2000 N.

[Images].

Fixing points.

(02 points).

Distributed load applied.

~ 200 kgf.

Force applied to determine the loads supported at the yield and rupture stresses.

Results - Deformation - Loading.

Type: Total Deformation.

Unit: mm.

[Chart].

14.464 Max.

12.857.

11.25.

9.643.

8.0358.

6.4286.

4.8215.

3.2143.

1.6072.



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0 Min.
 [Images].
 Maximum displacement found: 14.464 mm.
 Results - Equivalent stress - Loading.
 Type: Equivalent (von-Mises) Stress.
 Unit: MPa.
 [Chart].
 44.817 Max.
 39.838.
 34.858.
 29.878.
 24.899.
 19.919.
 14.939.
 9.9594.
 4.9797.
 1.6217e-5 Min.
 [Images].
 Maximum stress found: 44.817 MPa.
 Summary of Results - Loading.

Force (kgf)	Deformation (mm)	Maximum stress (MPa)
10	0.780	2.568
20	1.556	5.097
30	2.325	7.587
40	3.088	10.040
50	3.845	12.453
60	4.596	14.828
70	5.341	17.166
80	6.080	19.465
90	6.812	21.726
100	7.539	23.95
Yield [orange highlight on the 140 kgf row].		

Force (kgf)	Deformation (mm)	Maximum stress (MPa)
110	8.259	26.137
120	8.973	28.287
130	9.681	30.400
140	10.382	32.476
150	11.078	34.517
160	11.767	36.522
170	12.451	38.492
180	13.128	40.573
190	13.799	42.702
200	14.464	44.817
Rupture [red highlight on the 160 kgf row].		

Considerations - Loading.
 The study is based on the HWL model of the G2 Box. A distributed load was applied to identify the strength of the box until the yield and rupture limits of the material **PP - Artplast PP CZ 415** were reached. The results are limited to this material only; for other materials with different properties, the results will change. To simplify the analysis and ensure its convergence, the material behavior was considered linear. The fixed support (fastening) point was considered ideal (disregarding possible variations in fastening). As a result, it was observed that the part withstands up to ~ **140 kgf** of load before yielding and ~ **160 kgf** of load before rupture.
 Stacking simulation.



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Boundary conditions - Stacking.

Static Structural.

Time: 14 s.

Fixed Support.

Force: 28000 N.

Anchoring points.

Base of the ribs in contact with the floor.

[Images].

Distributed load applied. Considered ~ 50 kgf for each stacked box.

Force applied to determine the loads supported at the yield and rupture stresses.

Results - Deformation - Stacking.

Type: Total Deformation.

Unit: mm.

[Chart].

0.48232 Max.

0.42873.

0.37514.

0.32155.

0.26796.

0.21437.

0.16077.

0.10718.

0.053592.

0 Min.

Maximum displacement found: 0.48232 mm (56 boxes ~ 2800 kgf).

Results - Equivalent stress - Stacking.

Type: Equivalent (von-Mises) Stress.

Unit: MPa.

[Chart].

77.604 Max.

68.981.

60.359.

51.736.

43.114.

34.491.

25.868.

17.246.

8.6232.

0.00059482 Min.

[Images].

Maximum stress found: 77.604 MPa (56 boxes ~ 2800 kgf).

Summary of Results - Stacking.

Force (kgf)	Qty. (Boxes)	Maximum stress (MPa)
100	2	2.772
200	4	5.543
300	6	8.315
400	8	11.086
500	10	13.858
600	12	16.629
700	14	19.401
Yield [orange highlight on the 1200 kgf row].		
Force (kgf)	Qty. (Boxes)	Maximum stress (MPa)
800	16	22.173
900	18	24.944
1000	20	27.716



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1100	22	30.487
1200	24	33.259
1300	26	36.030
1400	28	38.802
Rupture [red highlight on the 1300 kgf row].		

Considerations - Stacking.

The study is based on the HWL model of the G2 Box. A distributed load was applied to the region where one box comes into contact with another during stacking, in order to identify the strength of the box until the yield and rupture limits of the material **PP - Artplast PP CZ 415** were reached. The results are limited to this material only; for other materials with different properties, the results will change.

To simplify the analysis and ensure its convergence, the material behavior was considered linear. The contact points between the boxes were considered ideal (disregarding possible variations in the fastening and displacement of the boxes).

As a result, it was observed that the part withstands up to ~ **1200 kgf** of load (24 stacked boxes) before yielding and ~ **1300 kgf** of load (26 stacked boxes) before rupture.

[Contact details: [Logo: Nexa Projetos]. (47) 3436-3030. Rua Florianópolis, 1315 – Guanabara. Joinville/SC – Postal Code: 89207-000. www.nexaprojetos.com].

In witness whereof I declare that there was nothing else in the original document presented to me and it was fully and faithfully translated by me on this public instrument of translation on October 09th 2026, in Porto Alegre, Rio Grande do Sul, Brazil. This translation has legal force in Brazil and all foreign countries.

ALEX CARDOSO CUNHA:72755296020

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