PNQM

Programa Nacional de Qualidade da Madeira
National Program for Wood Quality

Pine Plywood

Technical Catalogue - # 1

Rev. 0 – September 2002

ABIMCI

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Associação Brasileira da Indústria de Madeira Processada Mecanicamente
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Introduction

The *Associação Brasileira da Indústria de Madeira Processada Mecanicamente* (Brazilian Association for Mechanically Processed Timber) – ABIMCI has more than 150 members, including producers of sawn wood, veneers, plywood and value added wood products.

In 1999, based on a request made by members and in response to market demand, ABIMCI decided to develop a national system for pine plywood quality certification. To develop the system it was created the *Programa Nacional da Qualidade do Compensado* (National Program for Plywood Quality) - PNQC. The main objective of the Program is to make available to market products with know specifications, produced under controlled parameters.

During the year 2000, the program was structured. It was also established a Council, involving in the process several stakeholders, including plywood producers, consumers, trades and experts of the sector. Among the Council responsibilities are to establish policies and strategies for the Program, as well as to ensure the independence and credibility of the quality certification process.

Based on experience gained and considering the members and the market demands, the Program was enlarged to involve all kind of solid wood products, being transformed in the *Programa Nacional da Qualidade da Madeira* (National Program for Wood Quality) – PNQM. Within this new enlarged scope the Program is now involved with others wood products, including tropical plywood and doors. Other products will be covered in the future.

This Technical Catalogue cover specifically pine plywood. At the first part this document is presented the general structure and operational aspects of the PNQM. In the sequence is presented information on the quality certification process, quality parameters, Brazilian pine plywood proprieties, and tables with bending deflection to be considered when using the panels in structural applications.

At the annex I is presented the terminology, defined based on the Brazilian and international standards for plywood.

National Program for Wood Quality

Program framework

To define the Program policies and strategies, while at the same time to ensure the independence of the certification activities and the process credibility it was created a *Conselho Nacional da Qualidade da Madeira* (National Council of Wood Quality) - CNQM. The Statute establishes that the CNQM is a fully independent body and Members of the council are appointed by stakeholders. The Council members are representatives of:

- producers;
- trading and distribution chain agents;
- consumers associations;
- universities and research organizations;
- suppliers of consumables.

The specific responsibilities of the Council, as stated in the statute, are:

- to define the guidelines for the National Program for Wood Quality;
- to coordinate the work related to the definition of technical standards and quality procedures related to the production process of products to be certified;
- to define the certification criteria of producers and suppliers;
- to select and to accredit quality auditors;
- to approve the auditors reports and to issue the quality certificates;
- to take decisions in case of consumers complains and claims.

To implement the guidelines and Council decisions, as well as to coordinate the operational part of the program it was established an Executive Secretariat, supported by technical departments and independent consultants.

Independent external auditors, selected by CNQM based on several criteria including their technical qualification and experience are responsible for the auditing work.

The external auditors qualified by CNQM are trained on aspects related to the Program including the parameters, criteria, requirements and procedures to be taken into consideration in the audit work.

The Program is financially support by contributions from producers, suppliers and other entities interested in cooperating. Based in the rules set financial resources are allocated to specific funds:

- administration fund;
- promotion fund;
- technical assistance and development fund;
- claims fund.

Certification process

Figure 01 presents a general view of the certification process.

Before a producer makes a formal request to be audited, the Executive Secretariat makes available the necessary technical assistance. The objective of technical assistance is to clearly on parameters, procedures and requirements set by the PNQM to be certified.

The quality certificate shall be necessarily renewed every 6 months, however audits can be carried out at any moment based on decisions of the CNQM, in case of consumers complains and/or when there are evidences that the certified producer is not fulfilling the Program requirements.

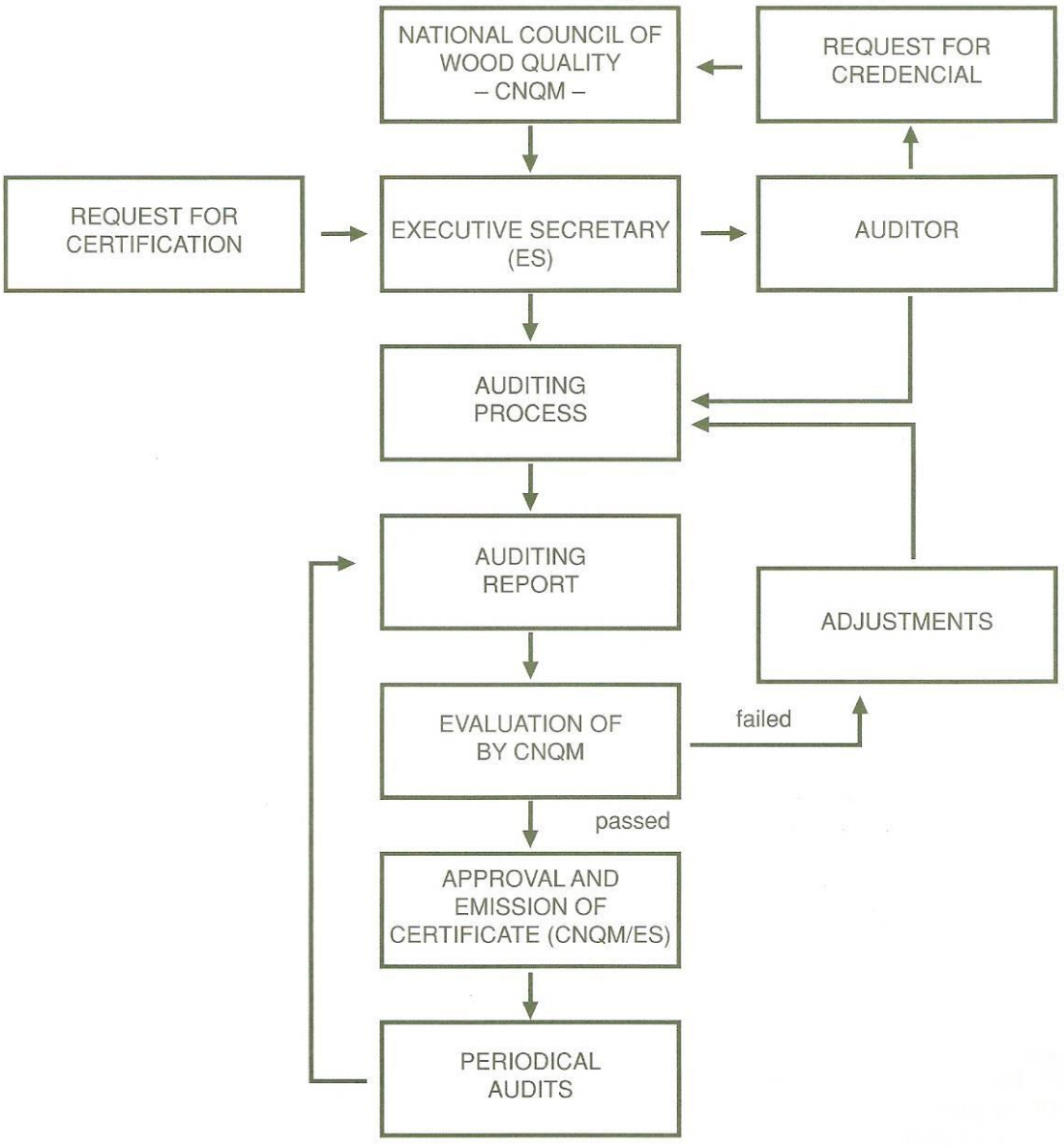


Figure 01 – Process workflow.

More details on the PNQM structure and process are available in the publication "Documents of National Program of Wood Quality". Copies of this publication can be obtained from the Executive Secretariat.

Certifications stamp

Companies that have successfully passed in the certification process are allowed to print at the plywood face, or at the edge, the Certification Stamp considering the standards defined by the CNQM

The Certification Stamp has the basic information, necessary to identify the product, including: producer, grade, dimensions, recommended use and others aspects.

Figure 02, presents the Certification Stamp used by the National Program for Wood Quality (PNQM).

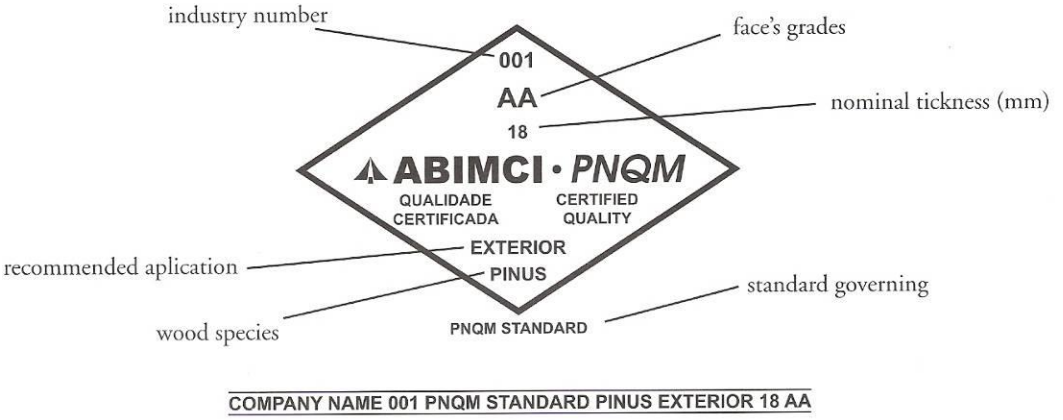


Figure 02 – Certification stamp.

Quality standards

Basics types of panels

For pine plywood the Program considers two basic panels' types, they are:

Interior – IR

Plywood bonded with interior glue type. The plywood produced with this glue is recommended for uses in protected places, without direct contact with water or even relative humidity. In most cases the glue is based in urea-formaldehyde resins.

Exterior – EX

Plywood bonded with exterior glue type. The plywood produced with this kind of glue can be used outside or in places with high relative humidity, or in direct contact with water. The phenolic based resins are largely used, but there are another resin types that can be applied.

Dimensions and constructive features

Table 01 presents the dimensions and the main constructive features adopted by PNQM for plywood panels, including: thickness, minimum number of plies and tolerances.

Table 01 – Dimensions and constructive features for pine plywood.

Panel thickness (mm)	Minimum number of plies	Tolerances		
		Tickness (%)	Length (mm)	Width (mm)
09	05	+/-5	+0.0/-2.0	+0.0/-2.0
12				
15				
18	07			
21				
22	09			
25	11			

The standard panel has 2440 mm (8 ft) in length and 1220 mm (4 ft) in width. Others dimensions are considered specials.

Panel grades

The pine plywood panels are graded based in their face and back face quality. The grading criteria take into consideration the type, quantity and dimensions of defects. Grading is held on a visual inspection.

The grades and requirements established by PNQM for pine plywood are presented in table 02. Figure 03 presents the pictures of the examples of pine veneers (plywood faces) from de different grades defined by PNQM.

Table 02 – Criteria for grading pine plywood.

TYPE OF DEFECT	FACE VENNER GRADE				
	A	B	C+	C	D
SOUND KNOTS	Not accepted.	Less than 10 mm in diameter and maximum 10 units/face are allowed.	No limitation.		
OPEN KNOT/OPENINGS	Not accepted.	Open knots and openings caused by machinery instruments not bigger than 6 x 12,5 mm and repaired with filler.	No limits for open knots and holes caused by machinery instruments. However it size shall not exceed 65 mm in diameter with average under 50 mm and repaired with filler	No limitation.	
CORE GAP	Gaps under 20 mm are allowed		Gaps under 50 mm are allowed		No limitation.
OPEN JOINTS	Not accepted.		Open Joints not large than 2 mm in width and repaired with filler are allowed	Open Joints not large than 5 mm in width and repaired with filler are allowed	No limitation.
CRACKS	Not accepted.	Cracks less than 5 mm in width and 300 mm in length, and repaired with filler, are allowed.	Cracks less than 10 mm in width and 600 mm in length, and repaired with filler, are allowed.	Cracks less than 15 mm in width and 700 mm in length, and repaired with filler, are allowed.	No limitation.
NUMBER OF FACE JOINTS	None.	Only one		Maximum two	Maximum four
LAP	Not allowed	One per m^2, not exceeding 100 mm in length	Maximum two per m^2, not exceeding 400 mm in length	Maximum two per m^2, not exceeding 600 mm in length	No limitation
BLUE STAIN	Not allowed.		Maximum 10% of faces area	Maximum 20% of faces area	No limitation.

Table 02 (cont.) – Criteria for grading pine plywood.

TYPE OF DEFECT	FACE VENNER GRADE				
	A	B	C+	C	D
WOOD REPAIR/PATCHING	Not exceeding 25 mm in width and 200 mm in length, combined in color and grain, glued with same resin of the panel production.	Not exceeding 100 mm in width and 600 mm in length, combined in color and grain, glued with same resin of the panel production.	Not exceeding 100 mm in width and 700 mm in length, combined in color and grain, glued with same resin of the panel production.	No limitation. However glued with de same resin of the panel production.	
SUM OF FACE DEFECTS (OPENED JOINTS + CRACKS + WOOD REPAIR / PATCHING + OPEN KNOT)	The number of repairs shall not exceed 6 of the total panel surface.	The number of repairs shall not exceed 8 of the total panel surface.	The number of repairs shall not exceed 30 of the total panel surface.	No limitations.	

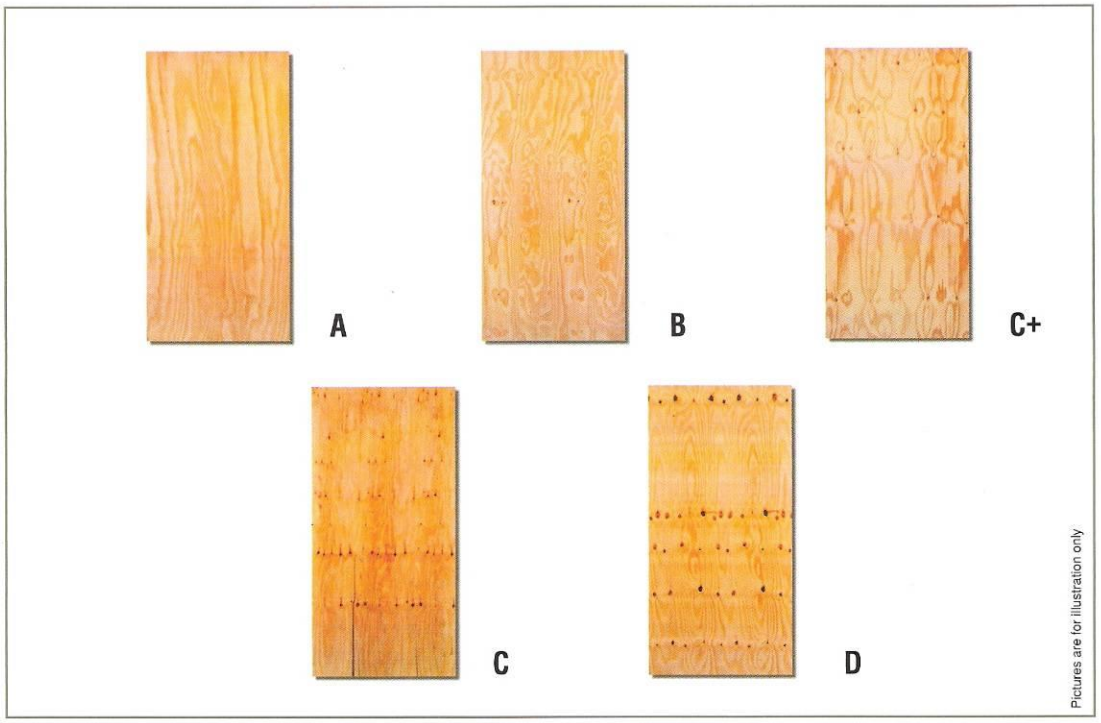


Figure 03 – Plywood grades.

Panel proprieties

Source of information

The information in the physical and mechanical proprieties presented in this document is based on material collected at the mills involved in the Program. Material collection started at the first months of 2000.

The tests have been carried out in the Laboratory of Engineering and Forestry Technology Department of the Federal University of Paraná – UFPR, located in Cutitiba, Brazil. This laboratory has all the equipment needed to test wood panels in accordance with national and international standards. It also has highly qualified staff.

The pine plywood proprieties, presented in this document are based on more than 20.000 tests obtained from material collected in 18 producers. All tested panels are exterior type, graded as C+/C and unsanded.

Normative references

National and international standards were used to determine the physical and mechanical proprieties of pine plywood.

The procedures and methodologies adopted by the UFPR laboratory to determine the proprieties of the pine plywood panels are in agreement with the following standards:

- **ASTM-D-3500-90. Standard Methods of Testing Structural Panels in Tension.**
- **ASTM-D-3043-95. Standard Methods of Testing Structural Panels in Flexure.**
- **ABNT NBR-9484 – Plywood – Determination of Moisture Content.**
- **ABNT NBR-9485 – Plywood – Determination of Density.**
- **ABNT NBR-9488 – Sampling for Plywood Tests.**
- **ABNT NBR-9489 – Conditioning of Plywood Samples for Testing.**
- **ABNT NBR-9490 – Wood Plies and Plywood.**
- **ABNT NBR -9531 – Plywood Panel.**
- **ABNT NBR-9532 – Plywood Panel.**
- **ABNT NBR-9534 – Plywood – Determination of Glue Line Resistance under Shear Strength.**

Results

The physical and mechanical proprieties considered as a basic standard by PNQM for the Brazilian pine plywood are presented on tables 03 to 07.

For each propriety is presented the average and the maximum and minimum values. The maximum and minimum values were calculated considering one standard deviation in relation to the average.

Table 03 – Density of Brazilian pine plywood(1).

THICKNESS (mm)	NUMBER OF PLIES	*kg/m³	
09	05	MAXIMUM	614
		AVERAGE	**565**
		MINIMUM	516
12	05	MAXIMUM	573
		AVERAGE	**532**
		MINIMUM	491
15	05	MAXIMUM	547
		AVERAGE	**512**
		MINIMUM	477
15	07	MAXIMUM	591
		AVERAGE	**554**
		MINIMUM	517
18	07	MAXIMUM	564
		AVERAGE	**528**
		MINIMUM	492
18	09	MAXIMUM	596
		AVERAGE	**559**
		MINIMUM	522
20	07	MAXIMUM	554
		AVERAGE	**523**
		MINIMUM	492
20	09	MAXIMUM	585
		AVERAGE	**538**
		MINIMUM	491

(1) C+/C panels, exterior type, unsanded, 10 – 11% moisture content.
(*) The maximum and minimum values represent one standard deviation in relation to the average.

Table 04 – Static bending strength of Brazilian pine plywood[1].

THICKNESS (mm)	NUMBER OF PLIES		VALUES – *kgf/cm²			
			PARALLEL		PERPENDICULAR	
			MOE [2]	MOR [3]	MOE [2]	MOR [3]
09	05	MAXIMUM	118,016	683	30,417	307
		AVERAGE	**85,477**	**498**	**22,734**	**224**
		MINIMUM	52,939	313	15,052	142
12	05	MAXIMUM	89,212	527	37,742	348
		AVERAGE	**68,990**	**381**	**28,389**	**253**
		MINIMUM	48,768	234	19,036	158
15	05	MAXIMUM	92,132	441	35,435	338
		AVERAGE	**69,331**	**329**	**26,334**	**227**
		MINIMUM	46,529	217	17,233	116
15	07	MAXIMUM	89,978	528	45,739	405
		AVERAGE	**69,130**	**395**	**33,729**	**295**
		MINIMUM	48,282	263	21,719	184
18	07	MAXIMUM	81,373	459	48,526	410
		AVERAGE	**63,383**	**347**	**36,228**	**300**
		MINIMUM	45,392	234	23,931	189
18	09	MAXIMUM	82,201	466	44,605	351
		AVERAGE	**70,949**	**369**	**36,337**	**270**
		MINIMUM	59,696	273	28,069	189
20	07	MAXIMUM	74,188	444	47,482	370
		AVERAGE	**60,660**	**329**	**36,447**	**274**
		MINIMUM	47,132	213	25,412	177
20	09	MAXIMUM	76,426	419	58,064	438
		AVERAGE	**59,520**	**326**	**43,869**	**328**
		MINIMUM	42,613	232	29,674	218

(1) C+/C panels, exterior type, unsanded, 10 – 11% moisture content.
(2) MOE – Modulus of elasticity.
(3) MOR – Modulus of ruptures.
(*)The maximum and minimum values represent one standard deviation in relation to the average.

Table 05 – Tension strength resistance of Brazilian pine plywood[1].

THICKNESS (mm)	NUMBER OF PLIES	VALUES – *kgf/cm²		
			PARALLEL	PERPENDICULAR
09	05	MAXIMUM	429	303
		AVERAGE	**317**	**215**
		MINIMUM	205	126
12	05	MAXIMUM	344	313
		AVERAGE	**254**	**220**
		MINIMUM	165	126
15	05	MAXIMUM	306	269
		AVERAGE	**226**	**196**
		MINIMUM	146	123
15	07	MAXIMUM	338	339
		AVERAGE	**262**	**245**
		MINIMUM	185	151
18	07	MAXIMUM	295	294
		AVERAGE	**227**	**214**
		MINIMUM	160	135
18	09	MAXIMUM	350	267
		AVERAGE	**284**	**204**
		MINIMUM	219	142
20	07	MAXIMUM	283	298
		AVERAGE	**221**	**223**
		MINIMUM	159	147
20	09	MAXIMUM	293	309
		AVERAGE	**233**	**243**
		MINIMUM	174	177

(1) C+/C panel, exterior type, unsanded, 10 – 11% moisture content.
(*) The maximum and minimum values represent one standard deviation in relation to the average.

Table 06 – Glue line test for Brazilian pine plywood[1].

THICKNESS (mm)	NUMBER OF PLIES		VALUES			
			DRY TEST*		HUMITY TEST*	
			TENSION (kgf/cm²)	WF [2] %	TENSION (kgf/cm²)	WF [2] %
09	05	MAXIMUM	38	96	22	68
		AVERAGE	**29**	**62**	**17**	**36**
		MINIMUM	21	28	11	5
12	05	MAXIMUM	37	97	21	77
		AVERAGE	**28**	**65**	**15**	**43**
		MINIMUM	18	33	10	9
15	05	MAXIMUM	31	89	19	79
		AVERAGE	**22**	**54**	**13**	**39**
		MINIMUM	13	19	8	0
15	07	MAXIMUM	39	98	20	87
		AVERAGE	**29**	**68**	**15**	**54**
		MINIMUM	19	37	9	20
18	07	MAXIMUM	36	95	19	83
		AVERAGE	**28**	**62**	**14**	**48**
		MINIMUM	19	30	8	14
18	09	MAXIMUM	37	74	20	78
		AVERAGE	**27**	**43**	**14**	**46**
		MINIMUM	17	12	7	15
20	07	MAXIMUM	34	100	18	96
		AVERAGE	**25**	**73**	**13**	**64**
		MINIMUM	16	43	8	31
20	09	MAXIMUM	42	78	22	55
		AVERAGE	**30**	**45**	**15**	**29**
		MINIMUM	19	12	9	4

(1) Quality C+/C, exterior, unsanded, 10 – 11% moisture content.
(2) WF = wood failure.
(*) The maximum and minimum values represent one standard deviation in relation to the average.

Table 07 – Compression resistance for Brazilian pine plywood[1].

THICKNESS (mm)	NUMBER OF PLIES		*kgf/cm²	
			PARALELL	PERPENDICULAR
09	05	MAXIMUM	333	232
		AVERAGE	**250**	**169**
		MINIMUM	168	106
12	05	MAXIMUM	266	243
		AVERAGE	**205**	**180**
		MINIMUM	143	118
15	05	MAXIMUM	255	207
		AVERAGE	**193**	**168**
		MINIMUM	130	129
15	07	MAXIMUM	277	256
		AVERAGE	**207**	**194**
		MINIMUM	137	132
18	07	MAXIMUM	248	250
		AVERAGE	**192**	**195**
		MINIMUM	136	140
18	09	MAXIMUM	268	217
		AVERAGE	**216**	**174**
		MINIMUM	163	130
20	07	MAXIMUM	240	250
		AVERAGE	**181**	**194**
		MINIMUM	123	137
20	09	MAXIMUM	249	266
		AVERAGE	**194**	**208**
		MINIMUM	140	151

(1) C+/C panel, exterior type, unsanded, 10 – 11% moisture content.
(*) The maximum and minimum values represent one standard deviation in relation to the average.

Information for structural aplications

Parameters and methodology

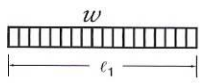
The bending deflection of pine plywood panels took into consideration the test results, and were based in structural calculations procedures, taking in considering international standards. Details of methodology applied can be found in the text book "Materials Resistance" (Ferdinad P. Beer and E. Russel Johnston Jr, 1999).

The deflections were calculated considering the application of the plywood panels for concrete forms, supporting pressures equal to concrete slabs with 8, 10, 12 and 15 cm thick. Concrete density was considered 2,700 kg/m³. As a result of these assumptions pressures equal to 220 kgf/m², 270 kgf/m², 330 kgf/m² and 410 kgf/m² were obtained.

Equations used in the deflections calculations are presented below:

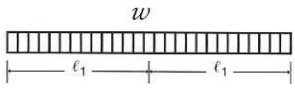
For one spam (equation 1)

$$f = \frac{w \times \ell^4}{76{,}8 \times E \times I}$$



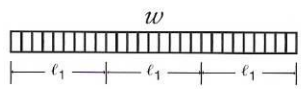
For two spans (equation 2)

$$f = \frac{w \times \ell^4}{185 \times E \times I}$$



For three or more spans (equation 3)

$$f = \frac{w \times \ell^4}{145{,}25 \times E \times I}$$



where:

f = deflection (m)

w = pressure (N/m²)

ℓ = span length (m)

E = modulus of elasticity (N/m²)

I = moment of inertia (m⁴/m)

Deflection tables

The deflections for the Brazilian Pine plywood obtained from the calculations are presented on tables 08 to 11. The gray cells represent deflection values under $\ell/360$, where ℓ is the span length. This deflection limit is considered as acceptable based in international standards.

Table 08 – Brazilian pine plywood(1) deflection (pressure 220 kgf/m²).

DEFLECTION IN MILLIMETERS FOR ONE SPAN									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.48	0.25	0.13	0.13	0.08	0.07	0.06	0.06
16	406.40	1.51	0.79	0.40	0.40	0.25	0.23	0.19	0.20
20	508.00	3.68	1.92	0.98	0.98	0.62	0.55	0.47	0.48
24	609.60	7.62	3.98	2.03	2.04	1.28	1.15	0.98	1.00
32	812.80	24.08	12.59	6.41	6.43	4.06	3.63	3.09	3.15
DEFLECTION IN MILLIMETERS FOR TWO SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9P)
12	304.80	0.20	0.10	0.05	0.05	0.03	0.03	0.03	0.03
16	406.40	0.62	0.33	0.17	0.17	0.11	0.09	0.08	0.08
20	508.00	1.53	0.80	0.41	0.41	0.26	0.23	0.20	0.20
24	609.60	3.16	1.65	0.84	0.84	0.53	0.48	0.41	0.41
32	812.80	10.00	5.23	2.66	2.67	1.69	1.51	1.28	1.31
40	1016.00	24.41	12.76	6.50	6.52	4.11	3.68	3.13	3.19
DEFLECTION IN MILLIMETERS FOR THREE SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.25	0.13	0.07	0.07	0.04	0.04	0.03	0.03
16	406.40	0.80	0.42	0.21	0.21	0.13	0.12	0.10	0.10
20	508.00	1.94	1.02	0.52	0.52	0.33	0.29	0.25	0.25
24	609.60	4.03	2.11	1.07	1.08	0.68	0.61	0.52	0.53
32	812.80	12.73	6.66	3.39	3.40	2.15	1.92	1.64	1.67
40	1016.00	31.09	16.25	8.28	8.30	5.24	4.68	3.99	4.07

(1) C+/C panel, exterior type, unsanded, parallel to grain.

(*) The gray cells represents bending deflection values under $\ell/360$.

(P) Number of plies.

Table 09 – Brazilian pine plywood[1] deflection (pressure 270 kgf/m²).

DEFLECTION IN MILLIMETERS FOR ONE SPAN									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.58	0.31	0.16	0.16	0.10	0.09	0.08	0.08
16	406.40	1.85	0.97	0.49	0.49	0.31	0.28	0.24	0.24
20	508.00	4.51	2.36	1.20	1.20	0.76	0.68	0.58	0.59
24	609.60	9.35	4.89	2.49	2.50	1.58	1.41	1.20	1.22
32	812.80	29.56	15.45	7.87	7.89	4.98	4.45	3.80	3.87
DEFLECTION IN MILLIMETERS FOR TWO SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.24	0.13	0.06	0.06	0.04	0.04	0.03	0.03
16	406.40	0.77	0.40	0.20	0.20	0.13	0.12	0.10	0.10
20	508.00	1.87	0.98	0.50	0.50	0.32	0.28	0.24	0.25
24	609.60	3.88	2.03	1.03	1.04	0.65	0.58	0.50	0.51
32	812.80	12.27	6.41	3.27	3.28	2.07	1.85	1.58	1.61
40	1016.00	29.96	15.66	7.98	8.00	5.05	4.51	3.85	3.92
DEFLECTION IN MILLIMETERS FOR THREE SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.31	0.16	0.08	0.08	0.05	0.05	0.04	0.04
16	406.40	0.98	0.51	0.26	0.26	0.16	0.15	0.13	0.13
20	508.00	2.38	1.25	0.64	0.64	0.40	0.36	0.31	0.31
24	609.60	4.95	2.58	1.32	1.32	0.83	0.74	0.63	0.65
32	812.80	15.63	8.17	4.16	4.17	2.63	2.35	2.01	2.05
40	1016.00	38.16	19.94	10.16	10.19	6.43	5.75	4.90	4.99

(1) C+/C panel, exterior type, unsanded, parallel to grain.
(*) The gray cells represents bending deflection values under ℓ/360.
(P) Number of plies.

Table 10 – Brazilian pine plywood[1] deflection (pressure 330 kgf/m²).

DEFLECTION IN MILLIMETERS FOR ONE SPAN									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.71	0.37	0.19	0.19	0.12	0.11	0.09	0.09
16	406.40	2.26	1.18	0.60	0.60	0.38	0.34	0.29	0.30
20	508.00	5.51	2.88	1.47	1.47	0.93	0.83	0.71	0.72
24	609.60	11.43	5.97	3.04	3.05	1.93	1.72	1.47	1.50
32	812.80	36.13	18.88	9.62	9.65	6.09	5.44	4.64	4.73
DEFLECTION IN MILLIMETERS FOR TWO SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.30	0.16	0.08	0.08	0.05	0.04	0.04	0.04
16	406.40	0.94	0.49	0.25	0.25	0.16	0.14	0.12	0.12
20	508.00	2.29	1.20	0.61	0.61	0.39	0.34	0.29	0.30
24	609.60	4.75	2.48	1.26	1.27	0.80	0.71	0.61	0.62
32	812.80	15.00	7.84	3.99	4.01	2.53	2.26	1.93	1.96
40	1016.00	36.62	19.14	9.75	9.78	6.17	5.51	4.70	4.79
DEFLECTION IN MILLIMETERS FOR THREE SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.38	0.20	0.10	0.10	0.06	0.06	0.05	0.05
16	406.40	1.19	0.62	0.32	0.32	0.20	0.18	0.15	0.16
20	508.00	2.91	1.52	0.78	0.78	0.49	0.44	0.37	0.38
24	609.60	6.04	3.16	1.61	1.61	1.02	0.91	0.78	0.79
32	812.80	19.10	9.98	5.09	5.10	3.22	2.88	2.45	2.50

(1) C+/C panel, exterior type, unsanded, parallel to grain.
(*) The gray cells represents bending deflection values under ℓ/360.
(P) Number of plies.

Table 11 – Brazilian pine plywood(1) deflection (pressure 410 kgf/m²).

DEFLECTION IN MILLIMETERS FOR ONE SPAN									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.89	0.46	0.24	0.24	0.15	0.13	0.11	0.12
16	406.40	2.81	1.47	0.75	0.75	0.47	0.42	0.36	0.37
20	508.00	6.85	3.58	1.82	1.83	1.15	1.03	0.88	0.90
24	609.60	14.20	7.42	3.78	3.79	2.39	2.14	1.82	1.86
DEFLECTION IN MILLIMETERS FOR TWO SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.37	0.19	0.10	0.10	0.06	0.06	0.05	0.05
16	406.40	1.16	0.61	0.31	0.31	0.20	0.18	0.15	0.15
20	508.00	2.84	1.49	0.76	0.76	0.48	0.43	0.37	0.37
24	609.60	5.90	3.08	1.57	1.57	0.99	0.89	0.76	0.77
32	812.80	18.63	9.74	4.96	4.98	3.14	2.81	2.39	2.44
DEFLECTION IN MILLIMETERS FOR THREE SPANS									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.80	0.47	0.25	0.12	0.13	0.08	0.07	0.06	0.06
16	406.40	1.48	0.78	0.40	0.40	0.25	0.22	0.19	0.19
20	508.00	3.62	1.89	0.96	0.97	0.61	0.55	0.47	0.47
24	609.60	7.51	3.93	2.00	2.01	1.27	1.13	0.96	0.98
32	812.80	23.73	12.41	6.32	6.34	4.00	3.57	3.05	3.11

(1) C+/C panel, exterior type, unsanded, parallel to grain.
(*) The gray cells represents bending deflection values under ℓ/360.
(P) Number of plies.

To facilitate the application of the information provided by this Technical Catalogue, maximum acceptable pressure (load/m²) considering the deflection limitation of ℓ/360 is presented in table 12. The data is also presented in graphic form in figure 04.

Table 12 – Maximum pressure for Brazilian pine plywood(1) to attend ℓ/360.

PRESSURE LIMIT (kgf/m²) FOR ℓ/360 BENDING DEFLECTION									
Span		Panel Thickness (mm)							
(in)	(mm)	9	12	15 (5 P)	15 (7 P)	18 (7 P)	18 (9 P)	20 (7 P)	20 (9 P)
12	304.8	739.9	1415.5	2778.3	3425.4	4389.1	4845.4	5762.1	5653.8
16	406.4	312.1	597.2	1172.1	1445.1	1851.7	2044.1	2430.9	2385.2
20	508.0	159.8	305.8	600.1	739.9	948.0	1046.6	1244.6	1221.2
24	609.6	92.5	176.9	347.3	428.2	548.6	605.7	720.3	706.7
32	812.8	39.0	74.6	146.5	180.6	231.5	255.5	303.9	298.1
40	1016.0	20.0	38.2	75.0	92.5	118.5	130.8	155.6	152.7
48	1219.2	11.6	22.1	43.4	53.5	68.6	75.7	90.0	88.3

(1) C+/C Panel, exterior type, unsanded, parallel to grain.
(P) Number of plies.

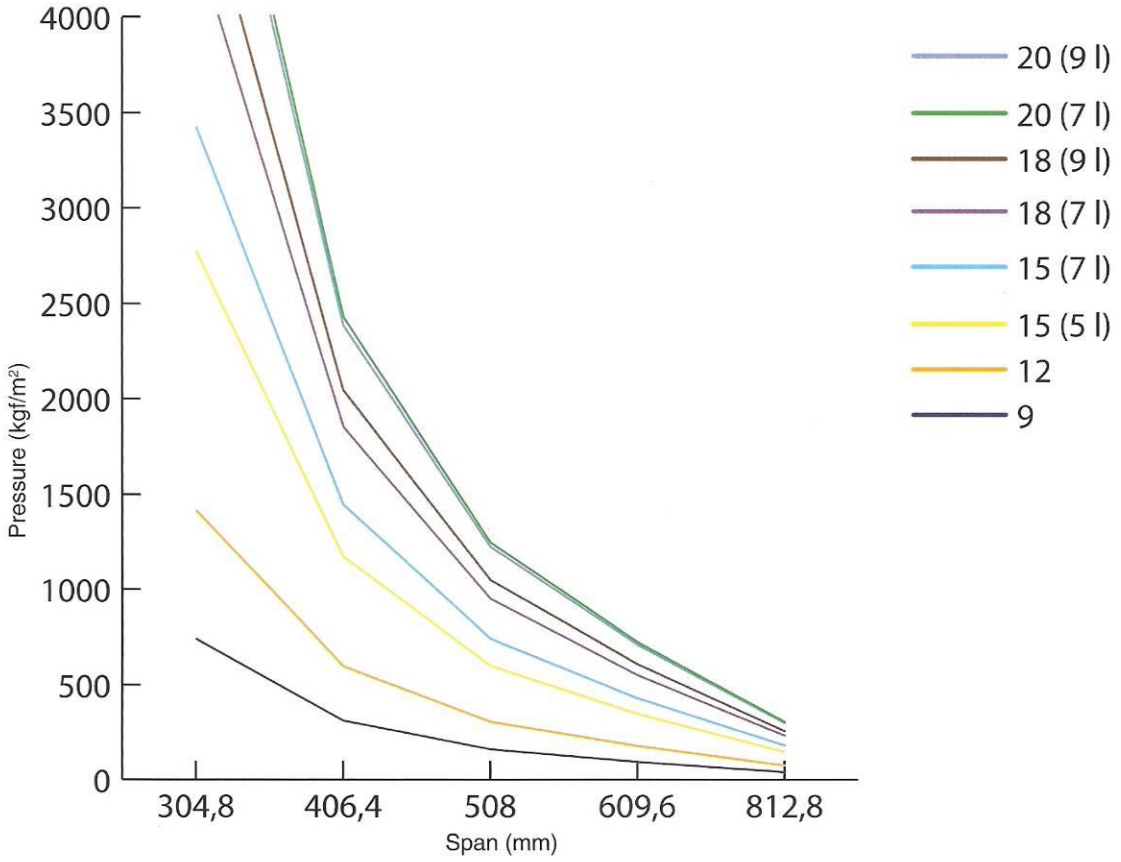


Figure 04 – Maximum pressure for Brazilian pine plywood(1) to attend ℓ/360.
(1) Quality C+/C, exterior, unsanded, parallel to grain.

Example of practical application of the information

What is the maximum bending deflection for a 12 mm pine plywood panel supported by four equidistant studs with a cross section of 150 x 150 mm? This panel is supporting a uniform pressure of 350 kgf/m².

1. Spans calculation:

Considering that, the panel has 2.44m in length and will have use four equidistant 150 x 150 mm studs, the spans will be 613 mm. Figure 05 presents the projected situation.

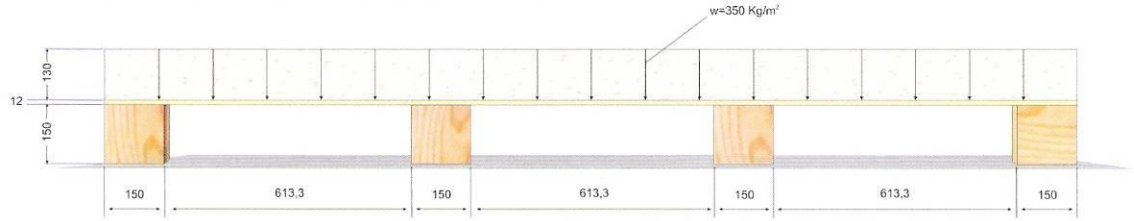


Figure 05 – Configuration layout.

2. Bending deflection calculation

The calculation is based on a direct application of the equation for three or more spans previously presented (equation 3). The following input data are to be considered:

w = 350 kgf/m²

E = 68990 kgf/cm² (from table 04)

ℓ = 0.613 m

e = 12mm

The result obtained from the calculation is:

f = 3.42 mm (deflection)

The deflection value obtained is higher than the limited recommended (ℓ/360 = 1.7 mm). Taking as a principle that the span adopted (613 mm) can not be changed. What should be the panel thickness to ensure that the deflection will be with in the recommended limit (ℓ/360)?

The definition of the adequate panel thickness to be used is facilitated by the use of the data presented in graphic form. As can be observed in figure 6 for the case under analysis a 15 mm panel will be required.

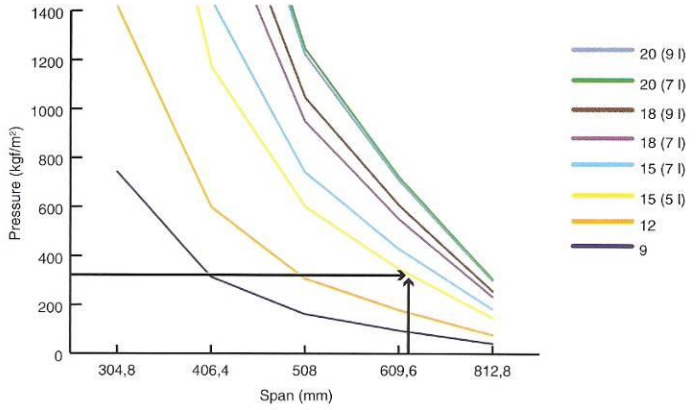


Figure 06 – Determination of the minimal plywood thickness.

Relevant literature and documents

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  - Procedure for plywood producers certification.
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Annex I

Terminology

Back face - the side of a panel that is of lower veneer quality an any panel whose outer piles are different veneer grades.
Blue satin - alteration of natural wood color by fungi action.
Center Gap - see *core gap*.
Composition - plies arrangement on plywood fabrication.
Core gap (center gap) - an open veneer joint extending trough, or partially through, a plywood panel.
Crack - lengthwise separation of wood fibers through panel thickness, caused by mechanical agents or drying conditions.
Defects - irregularities that can cause reduction of mechanical resistance.
Face - the side of a panel that is of higher veneer quality on any panel whose outer plies are of different veneers grades; either side of a panel where the grading rules draw no distinction between outer plies.
Filler - composite material with high performance on compatibility in relation to adhesive quality.
Gluing - union by a composition or adhesive substance.
Grade - within each plywood type (internal or external) classification, there are a number of panel grade based on the grade of the veneers and the panel construction.
Joints - a union formed by two plies.
Lap (overlap) - a condition where the veneers are so placed that one piece overlaps the other.
Moisture content - the weight of the water in wood expressed as percent of the weight of the oven-dry wood.
Open defect - irregularities such as splits, open joints, knotholes, that interrupt the smooth continuity of the veneer.
Open joints - opening resulted by joint failure on adjacent plies. It does usually occur on the edges of jointed plies.
Open knot - emptiness caused by knot untying.
Overlap - see *lap*
Patches/Wood repair - inserts of sound wood or synthetic material in veneers or panels for replacing defects.
Phenolic resin - synthetic resin made by condensation of phenol (phenol, cresol), with one aldehyde (formaldehyde, furfuraldehyde)
Ply - a single veneer lamina in glued plywood panel
Plywood - panel normally composed by crossed grain plies (layers)
Pugs - sound wood of various shapes, including among others, circular and dog-bone, for replacing defective portions of veneers.
Repair - any patch, plug, or shim.
Sample - one part of a whole (panel) in accordance with the test to be realized.
Shim - a long, narrow repair of wood or suitable synthetic.
Sound knot - natural characteristic of wood that occurs where a branch base is embedded in the trunk of tree.
Urea formaldehyde resin - synthetic resin derived from the reaction of urea, with formaldehyde.
Veneer - thin sheets of wood of which plywood is made. Also referred to as "plies" in the glued panel.
Wood failure - the area of wood fiber remaining at the glue line following completion of the specified shear test.

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