भारतीय मानक

IS 4990 : 2024

Indian Standard

कंक्रीट शटरिंग कार्य के लिए प्लाईवुड — विशिष्टि

(चौथा पुनरीक्षण)

Plywood for Concrete Shuttering Works — Specification

(Fourth Revision)

ICS 79.060.10

भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDARDS

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February 2024 **Price Group 8**

Wood and Other Lignocellulosic Products Sectional Committee, CED 20

FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wood and Other Lignocellulosic Products Sectional Committee had been approved by the Civil Engineering Division Council.

Plywood for concrete shuttering works is a Boiling Water Proof (BWP) Grade plywood, preservative treated and especially suited for use in concrete shuttering and form work. Concrete shuttering plywood is very economic as it can be put to repeated use, depending upon the care taken during erection and dismantling. The main requirements of such plywood are that it should be durable under alternate wetting and drying conditions, its surface should be hard and it should possess adequate strength to withstand the load of concrete and the forces caused by pouring of concrete and vibrations. This standard specifies the requirements of such plywood for use in concrete shuttering and form work and provides guidance in the manufacture and use of the plywood.

This standard on plywood for concrete shuttering works was first published in 1969 and subsequently revised in 1981, 1990 and 2011. In this revision, the following major modifications have been incorporated:

a) Material clause for timber has been modified;

b) Dimension clause has been modified;

c) Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and tensile strength requirements have been modified;

d) Requirements for formaldehyde content for oven dry board and the steady-state formaldehyde emission (optional) have been added; and

e) Marking clause has been modified.

This standard also includes in Annex E, on the recommended method for handling, storing and use of plywood for concrete shuttering and form work.

A scheme of labelling environment friendly products known as ECO-Mark has been instituted at the instance of the Ministry of Environment, Forests and Climate Change, Government of India. The ECO-Mark is administered by the Bureau of Indian Standards (BIS) under the *Bureau of Indian Standards Act*, 2016 as per the Resolution No. 71 dated 21 February 1991 and Resolution No. 425 dated 20 October 1992 published in the Gazette of the Government of India. For a product to be eligible for ECO-Mark, it shall also carry the Standard Mark (ISI Mark) of BIS besides meeting additional environment friendly requirements. For this purpose, the Standard Mark of BIS would be a single mark being a combination of the ISI Mark and the ECO-Mark. Requirements to be satisfied for a product to qualify for the BIS Standard Mark for ECO-friendliness are optional. Manufacturing units are free to opt for ISI Mark alone also.

The ECO criteria is based on the Gazette Notification No. 170 dated 16 May 1996 for wood substitutes as environment friendly products published in the Gazette of Government of India, as revised/amended from time to time.

This standard contributes to the United Nations Sustainable Development Goal 9 ‘Industry innovation and infrastructure’ Build resilient infrastructure promote inclusive and sustainable industrialization and foster innovation.

The composition of the Committee responsible for the formulation of the standard is given in Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PLYWOOD FOR CONCRETE SHUTTERING WORKS — SPECIFICATION

(Fourth Revision)

1 SCOPE

This standard covers the requirements of plywood for concrete shuttering work and formwork in construction.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 707 shall apply.

4 TYPES

4.1 Plywood for concrete shuttering work shall be preservative treated, of BWP Grade and shall be of three types as given below:

Sl No.	*Description*	*Designation*
(1)	(2)	(3)
i)	Plywood for concrete shuttering work (plain)	CS
ii)	Plywood for concrete shuttering work with polymer coating (coated)	CSC
iii)	Plywood for concrete shuttering work with suitable overlay (film faced)	CSFF

4.2 In terms of formaldehyde class, each type of plywood shall be further classified in two classes as follows:

a) Formaldehyde Class, E_1

b) Formaldehyde Class, E_2

5 MATERIALS

5.1 Timber

Any species of timber may be used for manufacturer of plywood. It is recommended to use wood from sources other than natural forests includes, Tree Outside Forest (TOF), rubber, coconut, cashew, walnut, agroforestry, farm forestry, industrial and social forestry plantations, etc and shade trees from tea and coffee estates in plywood manufacturing. A list of timber species is given in Annex B for guidance purpose. Imported timber may also be used in manufacturing of plywood.

5.2 Adhesives for Bonding of Veneers

The adhesives used for bonding the veneers shall be based on any suitable synthetic resin conforming to BWP Grade of IS 848. Extender shall not be added to the adhesive by the plywood manufacturer. Addition of a dye to the adhesive to check that all parts of the veneer are completely covered by adhesive shall be permissible. Addition of a filler not exceeding 5 percent shall be permissible provided the filler does not detract from the water resistance of the adhesive.

6 MANUFACTURE

6.1 Veneers for the manufacture of plywood for concrete shuttering works shall be either rotary cut or sliced, but preferably rotary cut. The veneers shall be reasonably smooth to permit an even spread of glue. The veneers shall be dried to a moisture content in a range of 6 percent to 10 percent before bonding. The glue shall be evenly spread. The veneers shall then be assembled with alternate layers at right angles to each other (except in the case of even number of veneers when the two central veneers are in the same direction) and hot pressed under controlled conditions of temperature, pressure and pressing time. The core veneers shall not have open joints or splits beyond the limits prescribed in **8.2**. No unglued area shall be found on separation of the veneers.

The veneers may have sound knots of diameter not exceeding 50 mm. Tight fitted patches, with

distance from one patch to the other not less than 600 mm, shall be permitted, but maximum diameter of any patch shall not exceed 40 mm. The number of pin-holes on face (top) veneers shall not be more than 10 in any square metre of the surface. Discolouration may be permitted, but loose knots and dry-rot shall not be permitted (*see* 8.1).

6.2 The thickness of all individual veneers shall be uniform with a variation of ± 5 percent. The veneer shall be straight grained within a permitted slope of ± 10°.

6.3 Corresponding veneers on either side of the central ply and those of face (top) and back (bottom) veneers shall be of species having similar physical and mechanical properties, such as thickness, density, modulus of elasticity, shrinkage, etc to ensure balanced construction.

6.4 Plywood for concrete shuttering work shall be preservative treated and bonded with BWP Grade adhesive. When required, concrete shuttering plywood may be supplied with or without any polymer coating or suitable overlay (*see* 6.7 and 10.6).

6.5 When boards of a size larger than the available press size are required, these may be made by scarf jointing the finished board, the scarf being through the thickness of the board.

All scarf joints shall be bonded with adhesives conforming to IS 848, having similar properties to those used in the bond of veneers. Scarf joints shall be made with 1 : 8 slope.

6.6 The plywood after manufacture shall be given a preservative treatment as given in IS 5539 and conditioned to a moisture content not exceeding 15 percent. The preservative used shall have a copper-chrome-boron (CCB) composition or acid-copper-chrome (ACC) composition, with retention of not less than 12 kg/m^3.

6.7 Plywood for concrete shuttering work with polymer coating, or with suitable overlay shall be made with a surface film of phenol formaldehyde or creosol formaldehyde resin, either carried by tissue paper or evenly spread by a mechanical spreader with resin content not less than 100 g/m^2 (paper weight: total weight shall be at least 1 : 1.5), which is subsequently cured under heat and pressure to give a smooth and waterproof surface. The film shall be applied on the surface of preservative treated plywood after manufacture. The pressing shall be such that the film uniformly melts and finishes into a smooth and hard surface on the plywood.

7 DIMENSIONS AND TOLERANCES

7.1 Any dimensions (length, width and thickness) and number of ply as agreed to between the manufacturer and the purchaser may be used and shall also be declared by the manufacturer. Prevailing dimensions (length × width) of plywood boards are as given below:

a) 2 440 mm × 1 220 mm;
b) 2 135 mm × 1 220 mm;
c) 2 135 mm × 915 mm;
d) 1 830 mm × 1 220 mm; and
e) 1 830 mm × 915 mm.

7.2 Thickness

The thickness of the plywood boards shall be 3 mm, 4 mm, 5 mm, 6 mm, 9 mm, 12 mm, 15 mm, 19 mm, 22 mm and 25 mm.

NOTE — Any other thickness as agreed to between the manufacturer and the purchaser may also be used.

7.3 Squareness and Edge Straightness

Edge straightness and squareness shall be tested as per Annex C.

7.4 Tolerances

The tolerances on the dimensions of finished plywood boards shall be as given in Table 1.

Table 1 Tolerances on Dimensions of Plywood for General Purposes
(*Clause* 7.4)

Sl No.	Dimension	Tolerance
(1)	(2)	(3)
i)	Length	+ 6 mm – 0 mm
ii)	Width	+ 3 mm – 0 mm
iii)	Thickness	
	a) less than 6 mm	± 10 percent
	b) 6 mm and above	± 5 percent
iv)	Squareness, *Max*	2 mm/1 000 mm or 0.2 percent
v)	Edge straightness, *Max*	2 mm/1 000 mm or 0.2 percent

8 WORKMANSHIP AND FINISH

8.1 The plywood for concrete shuttering work shall be smooth and the face (top) and back (bottom) shall be free from discolouration, pleats, overlaps and loose knots. The edges shall have smooth uniform finish.

8.2 Gaps and open joints shall be permitted as follows:

a) *In face* (*top*) — The gap or opening shall not exceed a width of 0.4 mm. If it exceeds 0.4 mm, this may be rectified by well-fitted veneer inserts of suitable width provided the grain of the veneer insert does not deviate by more than 10 percent from the grain direction of the surrounding veneer.

b) *In core* (*cross-band*) — The width of the opening shall not exceed 1 mm in the case of 3 ply and 5 ply, and 2 mm in the case of plywood of more than 5 ply, provided such openings are not less than 300 mm apart in any veneer and staggered not less than 150 mm between any veneer and the next one with the same grain direction.

8.3 The faces (top/bottom) of plywood for concrete shuttering work with polymer coating, or with suitable overlay, shall be dense, smooth and without blisters and patch marks. It shall be of uniform colour.

9 SAMPLING

The method of drawing representative samples, sample size and the criteria for conformity shall be as prescribed in IS 7638.

10 TESTS

10.1 The plywood shall conform to the requirements given in **10.3** to **10.12**.

10.2 Unless otherwise specified in this standard, six test specimens, cut from each of the plywood selected as in **9** for tests specified in **10.3** to **10.10**. For formaldehyde content and steady-state formaldehyde emission test, specimens shall be taken as per IS 13745 and IS/ISO 12460 (Part 1) respectively.

10.3 Moisture Content

The average moisture content of three test pieces cut out from each board selected as in **9**, when tested in accordance with IS 1734 (Part 1), shall be not less than 5 percent and not more than 15 percent.

10.4 Glue Adhesion in Dry State

10.4.1 *Glue Shear Strength*

Six test specimens from each pair of glue lines shall be tested in accordance with the method described in IS 1734 (Part 4). The average failing load shall be not less than the corresponding values specified in Table 2.

10.4.2 *Adhesion of Plies*

Adhesion shall be tested by knife test method described in IS 1734 (Part 5). The adhesion of plies may also be tested by forcibly separating the layers. The veneers shall offer appreciable resistance to separation and the fractured samples shall show some adherent fibres distributed more or less uniformly.

NOTE — If a definite result is not obtained by the method described in IS 1734 (Part 4), the result of knife test described in IS 1734 (Part 5) shall be considered as decisive. In case of even number of plies, where the grains of central plies follow the same direction the result as obtained from knife test shall be considered as final.

10.5 Resistance to Water Test

Six test pieces each approximately 250 mm × 100 mm, shall be cut from any position in the board such that the grains of the face veneer are parallel to the length of the piece. Six test specimens from each pair of glue lines shall be prepared as given in IS 1734 (Part 4). The specimens shall be subjected to any one of the tests specified in **10.5.1** and **10.5.2**.

10.5.1 The specimens shall be kept submerged horizontally in a pan of boiling water for a period of 72 h. The period of 72 h of boiling may be a continuous period or an aggregate of smaller periods of boiling, if the test piece is left in cold water between these smaller periods. The test pieces shall then be removed from the boiling water and cooled down to room temperature by plunging them in cold water. These test specimens, while still in wet condition, shall be subjected to tests described under **10.5.1.1** and **10.5.1.2**.

10.5.1.1 *Glue shear strength*

When tested for glue shear strength by the method described in IS 1734 (Part 4), the average failing load shall be not less than the corresponding values specified in Table 2.

10.5.1.2 *Adhesion of plies*

Adhesion shall be tested by knife test method described in IS 1734 (Part 5). The adhesion of plies may also be tested by forcibly separating the layers;

the veneers shall offer appreciable resistance to separation and the fractured sample shall show some adherent fibres distributed more or less uniformly.

NOTE — In case a definite result is not obtainable by the method described in IS 1734 (Part 4), the result of knife test described in IS 1734 (Part 5) shall be considered as decisive. In case of even number of plies, where the grains of central plies follow the same direction the result as obtained from knife test shall be considered as final.

10.5.2 The specimens shall be subjected to constant steam pressure for a definite duration inside a vacuum steam pressure test apparatus as described in Annex D and thereafter subjected to tests as per **10.5.1.1** and **10.5.1.2.**

10.6 Plywood for concrete shuttering work with polymer coating or with suitable overlay (*see* **6.4**), after being subjected to 72 h boiling, shall not show any softening, checking, cracking or deterioration of the surface layer.

10.7 Mycological Test

The test for resistance to micro-organisms shall be carried out by the method described in IS 1734 (Part 7). The test piece shall;

a) show no appreciable signs of separation at the edges of the veneers; and

b) comply with the requirements specified in **10.7.1** and **10.7.2**.

10.7.1 *Glue Shear Strength*

When tested for glue shear strength by the method described in IS 1734 (Part 4), the average failing load shall be not less than the corresponding values specified in Table 2.

10.7.2 *Adhesion of Plies*

Adhesion shall be tested by knife test method described in IS 1734 (Part 5). The adhesion of plies may also be tested by forcibly separating the layers; the veneers shall offer appreciable resistance to separation and the fractured sample shall show some adherent fibres distributed more or less uniformly.

NOTE — In case a definite result is not obtainable by the method described in IS 1734 (Part 4), the result of knife test described in IS 1734 (Part 5) shall be considered as decisive. In case of even number of plies, where the grains of central plies follow the same direction the result as obtained from knife test shall be considered as final.

10.8 Tensile Strength

The tensile strength, when determined by the method described in IS 1734 (Part 9), shall comply with the following requirements:

a) Tensile strength shall be not less than 28 N/mm^2 in the direction parallel to the grain direction of the face veneers;

b) Tensile strength shall be not less than 26 N/mm^2 in the direction at right angles to the grain direction of the face veneers; and

c) The sum of the tensile strengths in both directions shall be not less than 60.0 N/mm^2.

10.9 Static Bending Strength

Three test specimens taken in each direction from the sample of plywood, when tested in accordance with IS 1734 (Part 11) shall have an average and a minimum individual modulus of elasticity and modulus of rupture not less than the values specified in Table 3.

10.10 Wet Bending Strength

Three test specimens taken in accordance with IS 1734 (Part 11) and from each direction of a sample of plywood, shall be subjected to cyclic test for 3 cycles, each cycle consisting of 4 h boiling in water and 16 h drying in an oven at 65 °C ± 2 °C or shall be subjected to 72 h of boiling in water. The samples shall be then kept in water at 27 °C ± 2 °C for 1 h and thereafter tested as per IS 1734 (Part 11). The duration of boiling/drying in oven may be split into shorter intervals by keeping the samples at 27 °C ± 2 °C, in water (in case of boiling) or in air (in case of drying). The sample shall have an average and minimum individual modulus of elasticity and modulus of rupture not less than the values specified in Table 4.

Table 2 Minimum Average Failing Load and Percentage Wood Failure Requirements of Structural Plywood

(*Clauses* 10.4.1, 10.5.1.1 *and* 10.7.1)

Sl No.	Average Wood Failure	Average Failure Load, N		
	percent	Dry State	Resistance to Water	Resistance to Micro-Organisms
(1)	(2)	(3)	(4)	(5)
i)	No requirement	≥ 1 350	≥ 1 000	≥ 1 000
ii)	Not less than 60	1 250 to 1 349	900 to 999	900 to 999
iii)	Not less than 80	1 100 to 1 249	800 to 899	800 to 899
iv)	Sample to be considered as failed	< 1 100	< 800	< 800

Table 3 Average and Minimum Individual Values of Modulus of Elasticity (MOE) and Modulus of Rupture (MOR) in Static Bending Strength

(*Clause* 10.9)

Sl No.	Grain Direction	MOE, N/mm^2		MOR, N/mm^2	
		Average	Minimum Individual	Average	Minimum Individual
(1)	(2)	(3)	(4)	(5)	(6)
i)	Along (parallel to the grain direction of the face veneer)	6 400	5 700	43	38
ii)	Across (perpendicular to the grain direction of the face veneer)	4 600	4 100	35	31

Table 4 Minimum Average and Minimum Individual Values of Modulus of Elasticity (MOE) and Modulus of Rupture (MOR) for Wet Bending Strength

(*Clause* 10.10)

Sl No.	Property	Along the Face Grain	Across the Face Grain
(1)	(2)	(3)	(4)
i)	Modulus of Elasticity (MOE), N/mm^2		
	a) Average	3 200	2 300
	b) Minimum individual	2 900	2 100
ii)	Modulus of Rupture (MOR), N/mm^2		
	a) Average	21	17
	b) Minimum individual	19	15

10.11 Retention of Preservative

Plywood shall be treated as per 6.6 and shall have a retention of not less than 12 kg/m^3, when tested in accordance with IS 2753 (Part 1).

10.12 Formaldehyde Content Test

Test of free formaldehyde content in the sample shall be done by perforator method as per IS 13745 and test results of drawn sample shall meet the requirements of formaldehyde content as follows:

a) Formaldehyde Class, E_1 — $\leq$ 8 mg/100 g of oven dry sample; and

b) Formaldehyde Class, E_2 — > 8 mg/100 g of oven dry sample and $\leq$ 30 mg/100 g of oven dry sample.

10.13 Steady-State Formaldehyde Emission Test (Optional Test)

Manufacturer will offer a stack of plywood made under a batch (not less than 50 pieces) bearing the batch number and date of manufacture along with details of plywood that is grade, size and thickness, adhesive used and any other (the manufacture wish to inform). After sampling, the sample shall be immediately covered in airtight polythene with date of sampling on the plywood.

Sample must be taken for test within 24 h of opening the airtight cover and within one month from the date of sampling and test shall be done by the test method as given in IS/ISO 12460 (Part 1). The test results of drawn sample shall meet the requirements of formaldehyde emission value as follows:

a) Formaldehyde Class, E_1 — $\leq$ 0.124 mg/m^3; and

b) Formaldehyde Class, E_2 — > 0.124 mg/m^3.

10.14 Re-test

If any specimen fails to fulfil the test requirements specified under 10.3 to 10.12, a further two sets of samples on the basis prescribed in 9 shall be selected by the purchaser from the same batch and tested in the same manner. Test specimens prepared from these two further samples shall comply with the requirements specified in 10, otherwise the batch shall be rejected.

11 ADDITIONAL REQUIREMENTS FOR ECO-MARK

11.1 General Requirements

11.1.1 The plywood shall conform to the requirements of quality and performance as specified in this standard.

11.1.2 The manufacturer shall produce to Bureau of Indian Standards environmental consent clearance from the concerned State Pollution Control Board as per the provisions of the *Water* (*Prevention and Control of Pollution*) *Act*, 1974 and *Air* (*Prevention and Control of Pollution*) *Act*, 1981 and *Water* (*Prevention and Control of Pollution*) *Cess Act*, 1977 along with the authorization, if required under the *Environment* (*Protection*) *Act*, 1986, while applying for ECO-Mark appropriate with enforced Rules and Regulations of Forest department.

11.2 Specific Requirements

The plywood shall conform to the specific requirements given for ECO-Mark under relevant clauses of the standard.

NOTE — The manufacturer shall provide documentary evidence by way of certificate or declaration to Bureau of Indian Standards while applying for ECO-Mark.

12 MARKING

12.1 Each plywood shall be legibly and indelibly marked or stamped with the following:

a) Manufacturer's name or its initials or his recognized trade-mark, if any;

b) Words 'PLYWOOD FOR SHUTTERING WORKS';

c) Designation of plywood (*see* 4.1) and Formaldehyde Class;

d) Nominal length, width and thickness of plywood;

e) Month and year of manufacture;

f) Batch No.; and

g) Criteria for which the plywood has been labelled as ECO-Mark (if applicable).

12.2 Following additional information may be marked on each plywood:

a) Number of plies; and

b) Trade name of timber species used in manufacturing of plywood (*see* IS 1150).

12.3 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed there under, and the products may be marked with the Standard Mark.

13 DELIVERY

Unless otherwise specified, the plywood boards shall be delivered in a clean condition and shall be suitably packed according to normal trade. For ECO-Mark the material used for packaging of the plywood shall be recyclable, reusable or biodegradable.

14 INFORMATION TO BE SUPPLIED BY THE MANUFACTURER

The manufacturer shall supply on demand to the purchaser full technical data and recommended method of use and loading. This information shall cover in particular the following:

a) Type of preservative used;

b) Radii to which the plywood of given dimensions is recommended as bendable for architectural concrete work;

c) Loading and deflection tables for the purpose of calculating the supports, that is, the sizes of bearers and distances of bearers;

d) Density or mass per square metre of the plywood; and

e) Species of timber.

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 707 : 2011	Timber technology and utilization of wood, bamboo and cane — Glossary of terms (*third revision*)
IS 848 : 2006	Synthetic resin adhesives for plywood (phenolic and aminoplastic) — Specification (*second revision*)
IS 1150 : 2000	Trade names and abbreviated symbols for timber species (*third revision*)
IS 1734	Methods of test for plywood:
(Part 1) : 1983	Determination of density and moisture content (*second revision*)
(Part 4) : 1983	Determination of glue shear strength (*second revision*)
(Part 5) : 1983	Test for adhesion of plies (*second revision*)
(Part 7) : 1983	Mycological test (*second revision*)
(Part 11) : 1983	Determination of static bending strength (*second revision*)
IS 2753 (Part 1) : 1991	Methods for estimation of preservatives in treated timber and in treating solutions: Part 1 Determination of copper, arsenic, chromium, zinc, boron, creosote and fuel oil (*first revision*)
IS 5539 : 1969	Specification for preservative treated plywood
IS 7638 : 1999	Wood/lignocellulosic based panel products — Methods of sampling (*second revision*)
IS/ISO 12460-1 : 2007	Wood based panels — Determination of formaldehyde release: Part 1 Formaldehyde emission by the 1-cubic-metre chamber method
IS 13745 : 2020	Method for determination of formaldehyde content in wood-based panels by extraction method called perforator method (*first revision*)

ANNEX B

(*Clause* 5.1)

LIST OF PREVALENT TREE OUTSIDE FOREST (TOF) SPECIES FOR PLYWOOD

Sl No.	*Botanical Name*	*Trade Name*	*Abbreviation*
(1)	(2)	(3)	(4)
i)	*Acrocarpus fraxinifolius*	Mundani	MUN
ii)	*Ailanthus spp.*	Maharukh	MAH
iii)	*Albizia chinensis Merr.*	Siris	SIR
iv)	*Alstonia scholaris*	Chatian	CHT
v)	*Anacardium occidentale*	Cashew	CAH
vi)	*Bischofia javanica*	Uriam	URI
vii)	*Chukrasia tabularis*	Chickrassy	CHI
viii)	*Delonix spp.*	Gulmohur	GUM
ix)	*Duabanga grandiflora*	Lampati	LAP
x)	*Eucalyptus*	Eucalyptus	EUC
xi)	*Grevillea robusta*	Silver oak	SOA
xii)	*Hevea brasiliensis*	Rubber wood	RUB
xiii)	*Khaya spp.*	Lambu	LAB
xiv)	*Leucaena leucocephala*	Subabul	SUB
xv)	*Macaranga spp.*	Vatta	MCR
xvi)	*Maesopsi seminii*	Umbrella tree	UMB
xvii)	*Melia azedarach Linn.*	Bakain	PLI
xviii)	*Melia composita/dubia*	Malabar neem	MNE
xix)	*Neolamarckea cadamba*	Kadam	KAD
xx)	*Pinus spp.*	Pine	PNE
xxi)	*Populus spp.*	Poplar	POP
xxii)	*Samanea saman*	Saman	SAM
xxiii)	*Toona ciliata*	Toon	TOO
xxiv)	*Swietenia spp.*	Mahogony	MAG

ANNEX C

(*Clause* 7.3)

METHOD OF TEST FOR EDGE STRAIGHTNESS AND SQUARENESS

C-1 PROCEDURE FOR EDGE STRAIGHTNESS

The straightness of the edges and ends of plywood shall be verified against a straight edge not less than the full length of the plywood. If the edge on the end of plywood is convex, it shall be held against the straightedge in such a way as to give approximately equal gap at each end. The largest gap between the straightedge and the edge shall be measured to the nearest millimetre and recorded.

C-2 PROCEDURE FOR SQUARENESS

The squareness of plywood shall be checked with a 1 200 mm × 1 200 mm square, by applying, one arm of the square to the plywood. The maximum width of the gap shall be recorded.

ANNEX D

(*Clause* 10.5.2)

ALTERNATE METHOD FOR WATER RESISTANCE TEST

D-1 Pure water shall be filled in the boiler of the vacuum steam pressure test (VPT) apparatus as shown in Fig. 1 to the marking of minimum water level on glass water level indicator and the boiler shall be switched on with the valve connecting the boiler and main chamber in closed condition. The test specimen(s) shall be placed in the working (main) chamber and shall be closed air tight with cover. The vacuum pump shall then be switched on and vacuum inlet valve shall be kept in open condition. The steam release valve shall be kept in closed condition. After the required vacuum of 110^{+10}_{-0} kPa has been created inside the main chamber, the vacuum pump shall be switched off, the vacuum inlet valve closed and boiler valve connected to main chamber opened. The time shall be noted the moment the steam pressure in the main chamber reaches 220^{+10}_{-0} kPa and same pressure shall be maintained for 6 h. The system and boiler then shall be switched off. The steam release valve and vacuum release value shall slowly be opened until the steam in the chamber is completely evacuated. The samples shall then be kept in water for 1 h at 27 °C ± 2 °C. The samples shall thereafter be tested as per **10.5.1.1** and **10.5.1.2**.

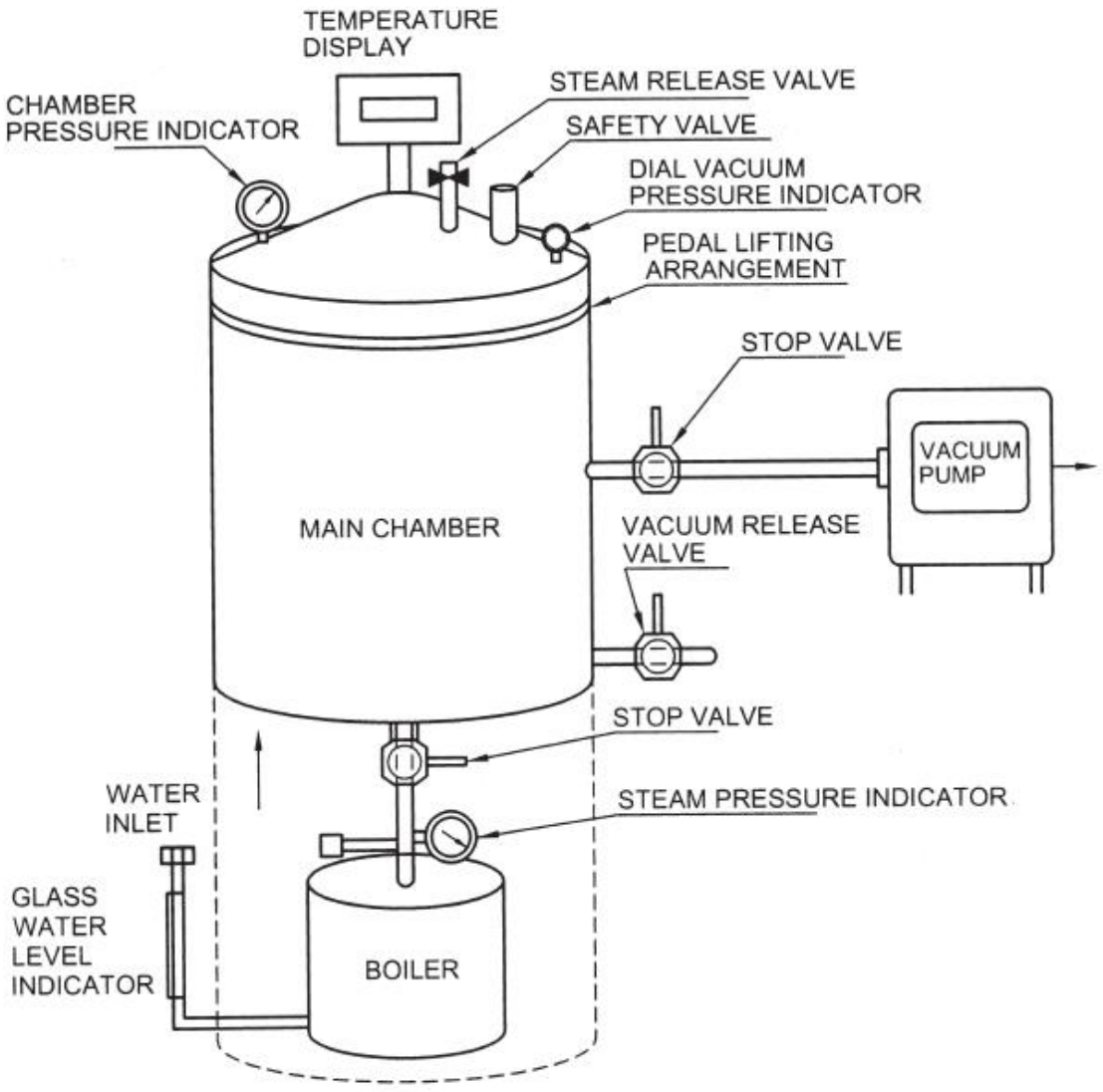

FIG. 1 TYPICAL SKETCH OF VACUUM STEAM PRESSURE TEST (VPT) APPARATUS

ANNEX E

(*Foreword*)

RECOMMENDED METHOD OF HANDLING, STORING AND USE OF PLYWOOD FOR CONCRETE SHUTTERING AND FORM WORK

E-1 GENERAL

E-1.1 Plywood for concrete shuttering work is a preservative treated, BWP-bonded plywood and has its economy in use for concrete shuttering because of its re-use value. It is claimed that concrete shuttering plywood is capable of being re-used many times. However, the re-use value of the plywood depends on the care taken in handling the boards and following the manufacturer's instructions.

E-1.2 Another important advantage claimed for plywood for concrete shuttering works is that it gives to the concrete work smooth surface, requiring very little additional plastering. The retention of this quality of plywood again depends on the care taken during use. Cleaning of the surface of the plywood and oiling occasionally, go a long way in increasing the life of the plywood. The large sized panels in which the plywood is available increases economy, but only if nails and screws are fixed carefully and not allowed to unduly damage the plywood. Plywood for concrete shuttering has an advantage over steel sheeting in very hot or very cold climatic conditions as the external heat or cold does not penetrate through plywood as it does in case of metal sheeting.

E-2 RECEIVING AND STORING

E-2.1 At the time of dispatch from the factory, the plywood panels shall be carefully loaded to prevent any damage. Extra care should be taken in the case of coated and film faced plywood to avoid any scratches. Preferably a sheet of thick water proof paper/polythene sheet may be inserted between the two surfaces to prevent scratches. The plywood should be properly secured and covered with tarpaulin to ensure delivery to destination in clean and serviceable condition.

E-2.2 The plywood panels shall be unloaded carefully from the carrier truck or wagon. These shall be lifted, carried and stacked in a careful manner to avoid damage to the corners of surfaces. These shall be stored in packs on a level, flat and raised surface in a clean, dry and covered place with free circulation of air. The boards and stacks shall be protected from rain and dampness. The edges of a board in a pack shall be in a straight vertical line. The top of the stack shall be covered with a cover board and weighed down suitably.

The plywood panels shall not be dragged, particularly those supplied with polymer coating or with suitable overlay over one another as this would scratch the surface if the edges are dragged on faces or any extraneous matter like sand or small stone particles lie in between the surfaces.

E-3 OILING THE SURFACE

Plywood for concrete shuttering work gives much longer service life if the surfaces are coated with suitable mould oil which acts both as a parting agent and also gives surface protection. The mould oil for use in coating of the plywood should have the following basic characteristics:

a) It shall be a solution of preservative in a heavy mineral oil with a viscosity of 70 centipoise to 80 centipoise; and

b) It shall be free from dark and other suspended particles and shall be of light grey colour.

Some manufacturers supply the boards already shop-coated with mould oil. After 3 to 4 uses and also in cases when plywood has been stored for a long time, it should be re-coated with mould oil before the next use.

Cut edges of the plywood at the time of making concrete former should also be coated with suitable sealants like chlorinated rubber paint, for longer life of the board.

E-4 DRYING OF PANELS

The plywood for concrete shuttering work may be used repeatedly. However, if it has to be stored for a long time after one use, the panels should be dried by stacking in free circulation of air and on suitable spacers before storage.

E-5 DESIGN DATA

E-5.1 The following data are generally applicable to plywood for concrete shuttering work. However, as the species of timber used vary from manufacturer to manufacturer and with that the density and strength, the instructions of the manufacturers would be helpful for individual cases.

E-5.1.1 *Mass*

Generally, density of plywood for concrete shuttering work may be taken as 650 kg/m^3.

The mass per square metre in various thickness is given below:

Sl No.	*Thickness* mm	*Mass* kg/m^2
(1)	(2)	(3)
i)	6	3.90
ii)	9	5.85
iii)	12	7.80
iv)	19	12.35
v)	25	16.25

NOTE — When in wet condition, the mass may increase by 30 percent or more. The accuracy of the above mass can be taken only within a tolerance of ± 10 percent because of varying species and also variation in the moisture content.

E-5.2 Loading and Deflection

Taking the maximum permitted deflection as 1 : 270 (that is 1/270th of the span between the bearers), the following load per square meter, in kg/m^2, are arrived at; the maximum load permitted is given provided that the face grain of the plywood is perpendicular to the length of bearers:

Sl No.	*Centre Distance of Bearers* (*Span*) mm	9 mm *Thickness* kg/m^2	12 mm *Thickness* kg/m^2
(1)	(2)	(3)	(4)
i)	300	1 270	1 950
ii)	400	540	850
iii)	450	320	640
iv)	600	170	360

E-5.2.1 When the face grain of plywood is parallel to the bearers, the permissible load may be as follows:

Sl No.	*Centre Distance of Bearers* (*Span*) mm	9 mm *Thickness* kg/m^2	12 mm *Thickness* kg/m^2
(1)	(2)	(3)	(4)
i)	300	760	1 220
ii)	400	320	540
iii)	450	195	390
iv)	600	110	170

NOTES

1 The above loads apply when the concrete is laid on concrete shuttering plywood as in slabs and beams. The same thickness of concrete in a wall can be held without excess deflection by thinner boards.

2 The maximum loads should be reduced to 75 percent, if wet boards are used.

E-5.3 Bending Radii

The following are approximately the minimum bending radii for plywood for concrete shuttering work, when dry:

Sl No.	*Thickness* mm	*Across the Group of the Outer Plies* m	*Parallel with the Group of the Outer Plies* m
(1)	(2)	(3)	(4)
i)	6	0.90	1.25
ii)	9	1.65	2.15
iii)	12	2.55	3.30

E-5.3.1 Plywood without any polymer coating or suitable overlay may be bent to still smaller radii by soaking in cold or hot water (temperature up to 70 °C) before fixing.

E-5.4 Fixing

It is advised that, wherever possible, screws or nuts and bolts are used for fixing. While handling, scratching by screws, nuts and bolts or other metal fixtures should be avoided. This is particularly so in case of plywood with polymer coating or with suitable overlay.

E-6 CONSTRUCTION

E-6.1 Concrete shuttering formers for columns, piers, walls and other vertical surfaces are usually made from the plywood by fixing the same on to a backing framework of timber or iron. The timber frame members can be joined end to end by butt joint or lap joint or mitred joint. The shuttering plywood should be screwed or nailed to the framework. When designing the formers, these shall be made in the form of shooks to be joined side to side by suitable nuts and bolts spaced at suitable distances. This would permit easy assembly and dismantling of the former and reassembling for second use. Steel frameworks may be of angled iron or channel section suitably fabricated and braced to which shuttering plywood can be fixed either by nuts and bolts or by screws, the latter driven from the steel frame side. As an illustration, a concrete former box for a column is made in the form of four shooks or frames one for each side. The plywood is so fixed on to the timber or steel framework that it gives a flush surface on the inside. The four-side frames are assembled into box form by use of nuts and bolts at appropriate distances, where holes have been drilled earlier. After the concrete is poured and kept for the prescribed time, the former can be disassembled by opening the nuts and bolts fixed on the sides and reassembled or refixed for the second use with the same nuts and bolts.

E-6.2 Concrete formers for concrete walls or other broad vertical surface works may be similarly made in the form of wood or iron frames fixed with shuttering plywood panels. The two wide side surfaces on the two sides of a wall can be further secured to avoid a sag at intermediate places by use of nut and bolts through the concrete. This would keep the former frames from spreading out. Such intermediate nuts and bolts may be removed after 48 h of concrete pouring and the hole in the wall later on plugged with concrete. The bolts may also be left in and later on cut out at the protruding portions. An alternative method would be the provision of well-designed additional supports and props outside. Formers, if required on one side only of a wall as in underground tanks and sewers, should be similarly made and suitably supported.

E-6.3 In case of concrete slabs, the concrete shuttering plywood may be laid without any framework on suitable bearers and be assembled side by side with suitable fixing cleats to avoid any ridge formation in the concrete work at the joint. Dismantling may be done by carefully removing the props and beams from one side. Some users prefer use of backing frame work even for horizontal slabs and beams. Backing framework may be made of wood or steel.

E-6.4 For concrete beams, box formers are made as in E-6.1 and then suitably supported by props.

E-6.5 Some users use steel framework into which plywood may be slid just in the same way as pressed steel shuttering sheets. The plywood for use as shuttering in such cases should be cut to the size of the recess or to the required shape and rested into the position like shuttering steel sheets.

E-6.6 The supporting structure for the plywood shuttering should be adequately strong. The design data given under E-5.2 provides some guidance to design these supports.

E-6.7 Many users use thin sheets of plywood for concrete shuttering as linings over conventional timber shuttering. The advantage gained by this is, primarily, a uniform, smooth surface on the concrete work. Care should be taken in such cases that the level of timber battens is reasonably correct to take the maximum advantage of getting a uniform and smooth surface finish of concrete work.

E-6.8 When used for architectural concrete and curved forms, the data given in E-5.3 should be used to design the curved surfaces of the formers.

E-6.9 When removing concrete formers or sheets, care should be taken to carry out the parting, sliding and lowering carefully to avoid damage.

E-6.10 Plywood supplied with suitable overlay requires handling with special care to avoid scratching of the surface as scratches on the surface take away the advantage of surface overlay. The sheets after each use shall be cleaned off of any sticking sand or aggregate.

E-7 PRECAUTIONS

E-7.1 After work at one site is over, the plywood used should be dried and sent to stores, or taken for re-use elsewhere. If a builder has finished work and does not want to store the plywood for long, the same could be disposed off to another builder for shuttering work or may be used as plywood of non-decorative type for general purpose.

E-7.2 There is a tendency in builders to cut plywood to shorter sizes for convenient handling. This should be discouraged as the greatest advantage of plywood for concrete shuttering is in its availability in large sizes leading to smooth ridge-free concrete work, thus saving in the expenses of elaborate plastering.

ANNEX F

(*Foreword*)

COMMITTEE COMPOSITION

Wood and Other Lignocellulosic Products Sectional Committee, CED 20

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