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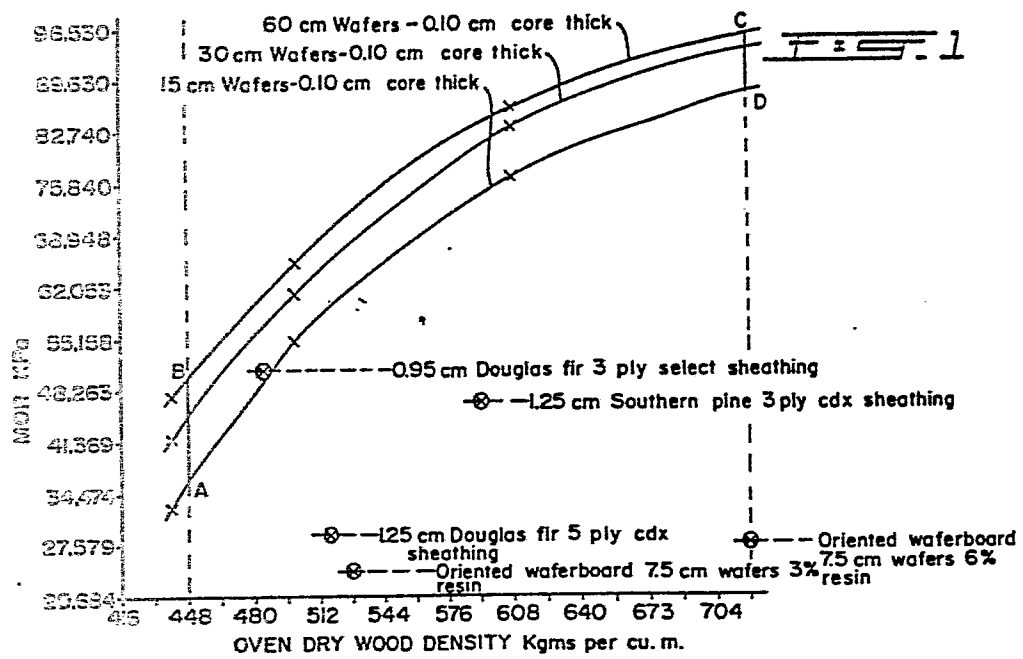
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(54) **Long wafer waferboard panels.**

(57) A waferboard panel is made from long wafers to have the same strength properties as plywood. The panel comprises at least three layers of wood wafers having an initial aggregate specific gravity, less than about 0.6 oven dry weight with volume at 12% moisture content, the panel having face layers on outside surfaces and at least one core layer. The wafers in the face layers have a mean orientation not greater than about 10 degrees, and lengths of at least about 15 cm, preferably 30 cm. Average widths of the wafers in the face layers are in the range of about 0.75 to 5.0 cm and the panel has an oven dry wood density in the range of about 430 to 720 Kgms. per cu metre with an MOR to density ratio of at least about 50 and an MOE (M) to density ratio of at least about 17.



LONG WAFER WAFERBOARD PANELS

The present invention relates to waferboard panels made with long wafers to produce a structural panel board having strength and stiffness properties equivalent to plywood.

5 If waferboard panels can be used in place of plywood, there are substantial advantages.

Plywood is made from veneer sheets which are sliced or peeled from logs and this requires a reasonably high grade of logs. Wafers are cut on a waferizer from lower grade logs and have a higher wood yield than in the preparation of veneer. Capital costs are less for waferboard plants than for plywood plants, and waferboard manufacturing costs are less than the manufacturing costs of making plywood. However, waferboards have a major disadvantage relative to plywoods, namely they have a low strength to density ratio. Comparing strength to density ratios, both modulus of rupture to density ratio and modulus of elasticity to density ratio is far lower for waferboard than for plywood.

20 Construction grade Southern pine plywood (CDX) has an average modulus of rupture (MOR) of about 41,370 KPa and a modulus of elasticity (MOE) of about 13,790 (M) KPa at a density of 592 Kgms per cu metre to give an MOR/Density ratio of 70 and an MOE(M)/Density of 23. Douglas fir 5-ply CDX sheathing has an MOR/Density ratio of 54 and an MOE(M)/Density ratio of 19.

25 Non-oriented waferboard made from 38 mm long wafers and a resin content of 2.3% has an MOR of about 18,615 KPa and an MOE of about 3450 (M) KPa at a density of 664 Kgms per cu metre to give an MOR/Density ratio of 28 and an MOE(M)/Density ratio of 5. As can be seen the MOR/Density ratio of waferboard is under one half that of plywood.

30 A machine oriented strandboard made with 75 mm

long wafers and higher resin contents can increase the strength/density ratios, but they are still only about half that of plywood.

The strength properties of waferboard can be increased by increasing density, or increasing resin content, however, increased density raises wood cost and transportation cost, makes the product heavier to handle, causes greater thickness swell when wet and reduces productivity when plant is wood processing limited. If the resin content is increased say from 3% to 6%, the manufacturing costs increase by about 15%.

In the past, panel boards such as particle board, fiberboard, waferboard, flakeboard, oriented strand board (O.S.B.) have generally been made with wafers or flakes having lengths not more than 100 mm. H. Dale Turner, in an article entitled "EFFECT OF PARTICLE SIZE AND SHAPE ON STRENGTH AND DIMENSIONAL STABILITY OF RESIN BONDED WOOD PARTICLE PANELS", published October 1954 in the Journal of F.R.P.S., describes tests carried out on wafers having lengths up to 7.5 cm and concluded that 4 cm was the most economic length of wood wafers for the production of waferboard or strand board. In an article entitled "THE EFFECT OF FLAKE GEOMETRY ON MECHANICAL PROPERTIES OF EASTERN SPRUCE FLAKE-TYPE PARTICLE BOARD", by Craig A. Schuler and Robert A. Kelly, published in Forest Products Journal of June 1976, tests were carried out on flake lengths of 2.5 and 7.5 cms and the article concludes that flake length is a significant factor for modulus of elasticity, (MOE) modulus of rigidity (MOR) and internal bond (IB). The article does not suggest flake lengths higher than 7.5 cm.

T.M. Maloney in "MODERN PARTICLE BOARD AND DRY PROCESS FIBERBOARD MANUFACTURING", published in 1977 by Miller Freeman Publications, concludes that 10 cm is the

maximum flake length that should be used in the preparation of flakeboards (pg. 194).

Long wood strands of up to 60 cm and longer are well suited for use in structural lumber products. One example of a structural lumber product is Barnes, U.S. Patent No. 4,061,819, published December 6, 1977 which was re-issued as Re 30,636 on June 2, 1981. This patent clearly shows that long wood strands having lengths of at least 30 cm may be used to produce a discrete dimensional structural lumber product. Waferboard panels, however, are generally, made in layers having wafers in different orientations and do not generally have the strength requirements of a structural lumber product. Furthermore, wafers or flakes are generally made of a thinner material than strands used in structural lumber products in order to have layers of flakes or wafers to form a panel.

In the past, it has not been considered feasible to use the structural lumber technology for the manufacture of waferboards. For example, even though the use of strands over 30 cm long has been known since at least as early as 1977, relating to the manufacture of structural lumber products, an article published by K. Walter , J. Kieser and T. White, entitled "EFFECT OF CHIP SIZE ON SOME STRENGTH PROPERTIES OF ORIENTED STRAND BOARD (OSB),(pages 183 to 188) published in 1979 in Holz Als Roh-Und Werkstoff, discloses that chip lengths greatly effect the strength properties, however, the lengths disclosed relate to 30, 50 and 80 mm, and no suggestion is made for lengths greater than these.

In a paper by Tomohisa Ikeda and Tomio Takemura, entitled "EFFECT OF CHIP LENGTH ON CREEP PROPERTIES OF PARTICLEBOARD", (pages 332 to 337) published on May 25, 1979 in Mokuzai Gakkaishi, tests were carried out on

wafer lengths up to 80 mm long, but it was concluded that there was no benefit to be gained for wafer lengths beyond 40 mm in length.

5 In the proceedings of the 14th Washington State University International Symposium on Particleboard, which were published in April 1980, the consensus in the published papers was that there were no advantages in increasing wafer length. P. Vajda, in his paper entitled "WAFERBOARD vs ORIENTED STRUCTURAL BOARD", (April 1980),
10 on page 25 states "Increasing flake or wafer size to 7.5 cm or possibly 10 cm as proposed by some, will also improve MOR and MOE, but also to a limited degree. Moreover, increasing length and width results in increased difficulties in the flaking, conveying, binning, blending and forming operations, and also
15 constitutes a considerable departure from what may be assumed as proven technology.

J.A. Fyie, D.J. Henckel and T.E. Peters, in their paper entitled, "ELECTRO-STATIC ORIENTATION FOR
20 EFFICIENCY AND ENGINEERING COMPOSITION PANEL PROPERTIES", (April 1980), talks about shorter flake lengths on page 277. "We have made single layer flakeboards from both 40 mm and 70 mm flakes and found only a thirteen percent decrease in MOE for the shorter flake geometry. The decrease is tolerable and the shorter flake may lead to
25 fewer handling, blending and conveying problems..." .

R.T. Leitner and his paper entitled, "STRUCTURAL BOARD: A 3-LAYER ALTERNATIVE TO WAFERBOARD AND OSB" (April 1980), states on page 34 that "Long wafers are
30 costly and difficult to produce". He concludes on the next page that "little improvement could be expected by increasing flake length much above 2.5 cm".

From these reports, it is clear that those skilled in the art of producing waferboards, oriented strand

boards and other types of panel boards, have never applied the long strand technology concerned with structural lumber products to the production of waferboards.

5 As can be seen from these articles described above relating to waferboard, it has always been considered that there was no advantage in increasing wafer lengths over about 100 mm. No one has previously considered that a waferboard product could be made with long wafers or
10 that such a product attained the full strength properties of the wood at or approaching normal wood density.

Furthermore, while it is considered by those skilled in the art of waferboard technology, that the problems arising with handling, storing, blending and
15 resin coating long wafers would be too difficult or costly to resolve. This has been found incorrect. It has now been found that by increasing wafer lengths to over 15 cm, and preferably over 30 cm, the wafers having an initial aggregate specific gravity of less than 0.6 oven dry weight with volume at 12% moisture content, and
20 using such wafers in the face layers of a multiple layer waferboard together with core wafers of sufficient thickness, and/or sufficient resin content to prevent horizontal shear failure in the core layer, a wood panel can be prepared having substantially the same
25 strength/density ratios as an equivalent plywood.

Long wafers can be properly coated with resin in either powder or liquid form. One example of an apparatus to blend long wood wafers with a liquid resin is disclosed in our co-pending application, U.S. Serial
30 Number 441,925 filed November 15, 1982. It has also been found that long wafers can be laid in a mat of substantially uniform thickness. One such device for forming such a mat is shown in our co-pending application U.S. Serial Number 420,084 filed September 20, 1982. The

apparatus spreads the wood wafers in a uniform manner to provide a mat having substantially even thickness. The wafers may be laid in an oriented pattern or in a random pattern.

5 The present invention provides a waferboard panel with increased strength properties, comprising at least three layers of wood wafers having an initial aggregate specific gravity less than about 0.6 oven dry weight, with volume at 12% moisture content, the panel having
10 face layers on outside surfaces and at least one core layer, the wafers in the face layers having a mean orientation in the range of about 2 to 10 degrees, the wafers in the face layers having lengths of at least about 15 cm, and preferably at least about 30 cm, average widths in the range of about 0.75 to 5.0 cm and average
15 thickness in the range of about 0.025 to 0.125 cm with a preferred range of about 0.05 to 0.075 cm for wafers in the face layers and about 0.075 to 0.125 cm for wafers in the core layers, the panel having an oven dry wood density in the range of about 430 to 720 Kgms per cu m.
20 with an MOR to density ratio of at least about 50 and an MOE (M) to density ratio of at least about 17. In other embodiments, phenol-formaldehyde resin content is in the range of about 1 1/2 to 8%, preferably 2 to 3%, based on the oven dry weight of the wood wafers for the face
25 layers and core layers.

 In another embodiment, the panel having an MOR parallel to the orientation of the wafers in the face layers for an oven dry wood density in the range of about 430 to 720 Kgms per cu m. within the boundary of A, B, C
30 and D in FIG. 1, and an MOE parallel to the orientation of the wafers in the face layers within the boundary of E, F, G and H in FIG. 2.

 In further embodiments of the invention, the panel

has face layers representing a range of about 30-60% of total thickness of the panel. Dry MOR and dry MOE of the panel in the direction perpendicular to the orientation of the wafers, is not less than about 20% of the dry MOR and dry MOE of the panel parallel to the orientation of the wafers. In still further embodiments, the core layer has a random orientation of wafers or a cross orientation of wafers.

In a preferred embodiment, each layer of wood wafers has a thickness greater than three wafers.

In drawings which illustrate embodiments of the invention:

FIG. 1 is a graph comparing MOR against density for waferboard panels made from long wafers varying from 15 cm to 60 cm in length;

FIG. 2 is a graph comparing MOE against density for waferboard panels made from long wafers varying from 15 cm to 60 cm in length;

FIG. 3 is a graph comparing MOR against wafer length for long waferboard panels of the present invention at a density of 561 kgms per cu m. ;

FIG. 4 is a graph comparing MOE against wafer length for long waferboard panels of the present invention at a density of 561 Kgms per cu m. ;

FIG. 5 is a graph comparing mean wafer lengths against MOE/Density ratio for long waferboard panels of the present invention.

The term "wafers" used throughout the specification includes flakes, strands, plates and other terms sometimes used in different countries. Wafers may be made on conventional waferizers which cuts wafers to the desired shape, or wafers may be cut or slit from veneer. In the present invention the wafers are made having a length greater than 15 cm, preferably greater

than 30 cm, up to 60 cm or more. Greater lengths may be used but there appears to be little improvement in strength properties over this figure. Thicknesses of the wafers may vary from about 0.025 to 0.125 cm and width should be in the range from about 0.75 to 5.00 cm. It is preferred that the average wafer thickness in the face layers is in the range of about 0.05 to 0.075 cm and in the core layers in the range of about 0.075 to 0.125 cm.

The type of wood used in North America, particularly in the West Coast is generally a mixture of different types of hardwoods and softwoods having an initial aggregate specific gravity, oven dry weight with volume at 12% moisture content, of less than about 0.6. There are many types of wood used for wafers, both hardwood and softwood. Aspen, for instance, is a hardwood having a specific gravity in the range of about .35 - .39. An example of a softwood is a Balsam fir.

Once the wafers are prepared, they are generally dried to reduce moisture content and then blended with wax and resin prior to being formed into a mat of wafers. Slack wax is a prepared wax generally blended with the wafers to improve water proof properties of the end product, and preferably powdered phenol-formaldehyde resin is generally used for both face and core layers. Although reference is made to using powdered resin, it is also feasible to spray liquid resin onto the wafers. An example of such a blending system is shown in co-pending application U.S. Serial Number 441,925 which describes a multiple stage blending of wood wafers with a liquid resin. The phenol-formaldehyde resin content is preferably in the range of about 1 1/2 to 8% based on the oven dry weight of the wood wafers for both face layers and core layers.

In the preparation of a waferboard panel, wafers

are generally laid in at least three separate mats one on top of another before proceeding to a press where the layers of wafers are compressed and simultaneously heated to cure the resin. In a preferred embodiment, the face layers of a waferboard panel generally represent about 30 - 60% of the total thickness of the panel. The core layer, or core layers, represent the remaining panel thickness. As the wafers are laid in the first layer, the long wafers are laid in a oriented fashion such that the mean orientation of the wafers laid in the mat are at an angle greater than zero degrees, but not more than about 10 degrees from the direction of orientation. If the orientation angle increases much beyond about 10 degrees, then the strength in the direction of orientation of the panel is reduced. Alternatively, if the mean orientation of the wafers results in too small an angle, that is to say below about 2 degrees, then the strength of the panel in the direction perpendicular to the direction of orientation is reduced. It has been found that an angle of orientation around 10 degrees proves satisfactory, and it is preferred that the product have a strength and stiffness in the perpendicular direction to the direction of orientation of about 20% of the direction parallel to the orientation.

The core layer or core layers may be random oriented or cross oriented. The term "cross oriented" means that the wafers in the core layers are laid in a direction which is approximately 90 degrees to the direction of orientation of the wafers in the face layers. In some embodiments a mixture of both random and cross oriented core layers are provided depending on the requirements of the waferboard panel. In the case or core layers, it is not imperative that the wafers be the same thickness or as long as those in the face layers.

After the layers have been laid in mats one on top of another, the multi-layered mat advances to a press where in a preferred embodiment, each panel is compressed at a temperature of slightly above 200 degrees Celsius for at least four minutes. The press is a standard unit well known in the manufacture of waferboard panels.

It has generally been found that the resin content is at least about 1.5% based on the oven dry weight of the wood wafers. In a preferred embodiment, the resin content for both face and core layers is in the range of about 2 to 3% based on the oven dry weight of the wood wafers. In one embodiment, 4% phenol-formaldehyde resin was used in the face layers with 3% only in the core layer. The wax content was 2% based on the oven dry weight of the wood wafers.

TABLE I

<u>PRODUCT</u>	<u>WAFER LENGTH cm.</u>	<u>DENSITY kgms per cu. m.</u>	<u>MOR Kpa</u>	<u>MOE (M) Kpa</u>	<u>MOR/ DENSITY</u>	<u>MOE(M) / DENSITY</u>
<u>PLYWOOD</u>						
0.95 cm Douglas Fir 3 Ply Select Sheathing	-	493	50,056	14,769	101.5	30.0
1.25 cm Southern Pine 3 Ply CDX Sheathing	-	593	46,402	13,907	78.2	23.5
0.63 cm Douglas Fir 5 Ply CDX Sheathing	-	517	28,062	10,066	54.3	19.5
<u>WAFERBOARD</u>						
Homogenous	3.75	665	18,616	3,447	28.0	5.2
Oriented 3% Resin	7.5	529	23,442	7,005	44.3	13.2
Oriented 6% Resin	7.5	721	27,579	7,584	38.3	10.5
<u>LONG WAFER WAFERBOARD</u>						
Core Wafer Thickness 0.10 cm	7.5	561	46,195	9,653	82.3	17.2
0.10 cm	15	561	55,158	11,032	98.3	19.7
0.10 cm	30	561	62,053	11,721	110.6	20.9
0.10 cm	60	561	66,879	11,997	119.2	21.4

Comparisons of strength to density ratios are illustrated in TABLE I. As can be seen, the MOR to density ratio and MOE to density ratio is far lower for normal waferboard than for plywood. Oriented strand board has improved properties, but is still not comparable with plywood. Oriented strand board has improved properties, but is still not comparable with plywood.

FIGS. 1 and 2 illustrate the strength properties for long wafer waferboard for varying densities made according to the present invention for different lengths of wafers. Oven dry wood densities from 430 to 720 Kgms per cu m. cover the range of densities for the long wafer waferboard product made from wafers having an initial aggregate specific gravity oven dry weight with volume at 12% moisture content of below 0.6. The ratios of MOR to density within the boundary lines A, B, C and D of FIG. 1 are at least 75. The ratios of MOE (M) to density within the boundary lines E, F, G and H of FIG. 2 are at least 17.

EXAMPLE I:

Waferboard samples were made by slitting wafers from veneer strips cut from Aspen with an initial aggregate specific gravity oven dry weight with volume at 12% moisture content of approximately 0.38. The wafers in the face layers were 0.05 cm thick and were cut to 7.5, 15, 30 and 60 cm lengths. The core wafers were 0.10 cm thick. The face layers were oriented with a mean orientation not greater than 10 degrees and the core layer was cross oriented. 5% phenol-formaldehyde resin was used in the panels whose overall thickness was 1.25 cm. The panels comprise three plies. FIGS. 3 and 4 illustrate the effect of strand length on MOR and on MOE. As can be seen in the FIGS. above a 30 cm wafer

length, the curve commences to level out. There is believed to be no real improvement in strength properties beyond 60 cm long wafers.

EXAMPLE II:

Waferboard samples were made from wafers cut on a commercial waferizer for nominal wafer lengths of 3, 7.5, 11.4, 15 and 30 cm. Actual wafer lengths varied substantially below the nominal length, but had a mean value of up to about 20% below the nominal. The wood was Aspen, similar to the type of wood used in EXAMPLE I. The thickness of the core wafers was 0.05 cm, the same thickness as the wafers in the face layers.

TABLE II

<u>PRODUCT</u>	<u>WAFER LENGTH cm.</u>	<u>DENSITY kgms per cu. m.</u>	<u>MOR KPa</u>	<u>MOE (M) KPa</u>	<u>MOR/ DENSITY</u>	<u>MOE(M)/ DENSITY</u>
	Mean Nominal					
Wafers cut on a waferizer	6 7.5	529	17,926	4,964	33.9	9.4
0.05 cm. wafer core thickness	9.1 11.4	529	28,613	6,550	54.1	12.4
	12.2 15	529	37,232	7,722	70.4	14.6
	24.4 30	529	57,227	10,066	108.2	19.0

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As can be seen in TABLE II, the waferboard made from nominal 11.4 cm long wafers had an MOR/Density ratio above 50 and an MOE(M)/Density ratio of about 12. The waferboard made from nominal 30 cm long wafers had an MOR/Density ratio of 108, and an MOE/Density ratio of 19.

FIG. 5 illustrates the comparison between the mean wafer lengths against MOR/Density ratio for a waferboard having a wafer thickness of about 0.05 cm in both core layer and face layers. As can be seen, a mean wafer length of 16.5 cm was required to attain a ratio of 17 in this test.

Various changes may be made to the waferboard panel according to the present invention without departing from the scope of the present invention which is limited only by the following claims.

Claims

1. A waferboard panel with increased strength properties comprising at least three layers of wood wafers, having an initial aggregate specific gravity less than about 0.6 oven dry weight with volume at 12% moisture content, the panel having face layers on outside surfaces and at least one core layer, the wafers in the face layers having a mean orientation in the range of about 2 to 10 degrees, the wafers in the face layers having lengths of at least about 15 cm, average widths in the range of about 0.75 to 5.0 cm, and average thickness in the range of about 0.025 to 0.125 cm, the panel having an oven dry wood density in the range of about 430 to 720 Kgms. per cu m. with an MOR to density ratio of at least about 50 and an MOE (M) to density ratio of at least about 17.
2. The waferboard panel according to Claim 1 having a phenol-formaldehyde resin content in the range of about 1 1/2 to 8% based on the oven dry weight of the wood wafers for the face layers and core layers.
3. The waferboard panel according to Claim 2 having a phenol-formaldehyde resin content in the range of about 2 to 3% based on the oven dry weight of the wood wafers for the face layers and core layers.
- 4) The waferboard panel according to Claim 1 wherein the average thickness of the wafers in the face layers is in the range of about 0.05 to 0.075 cm, and the average thickness of the wafers in the core layers is in the range of about 0.075 to 0.125.
5. The waferboard panel according to Claim 1 wherein the wafers in the face layers have lengths of at least about 30 cms.

6. The waferboard panel according to Claim 1 wherein each layer of wood wafers has a thickness greater than three wafers.

5 7. A waferboard panel with increased strength properties comprising at least three layers of wood wafers having an initial aggregate specific gravity less than about 0.6, oven dry weight with volume at 12% moisture content, the panel having face layers on outside surfaces and at least one core layer, the wafers in the
10 face layers having a mean orientation in the range of about 2 to 10 degrees, the face layers having wafers with lengths of at least about 15 cm, average widths in the range of about 0.75 to 5.0 cm and average thickness in the range of about 0.025 to 0.125 cm, the panel having an
15 MOR parallel to the orientation of the wafers in the face layers for an oven dry wood density in the range of about 430 to 720 Kgms. per cu m. within the boundary of A, B, C and D in FIG. 1, and an MOE parallel to the orientation of the wafers in the face layers within the boundary of E, F, G and H in FIG.2.

20 8. The waferboard panel according to Claim 7 having a phenol-formaldehyde resin content in the range of about 1 1/2 to 8% based on the oven dry weight of the wood wafers for the face layers and core layers.

25 9. The waferboard panel according to Claim 8 having a phenol-formaldehyde resin content in the range of about 2 to 3% based on the oven dry weight of the wood wafers for the face layers and core layers.

30 10. The waferboard panel according to Claim 7 wherein the average thickness of the wafers in the face layers is in the range of about 0.05 to 0.075 cm, and the average thickness of the wafers in the core layer is in the range of about 0.075 to 0.125 cm.

11. The panel according to Claim 7 wherein the face

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layers are about 30 - 60% of total thickness of the panel.

12. The panel according to Claim 7 wherein dry MOR and dry MOE of the panel in the direction perpendicular to the orientation of the wafers, is not less than about 20% of the dry MOR and dry MOE of the panel parallel to the orientation of the wafers.

13. The panel according to Claim 7 wherein a core layer has a random orientation of wafers.

14. The panel according to Claim 7 wherein a core layer has a cross orientation of wafers.

15. The panel according to Claim 7 wherein the wafers in the face layers have lengths of at least about 30 cm.

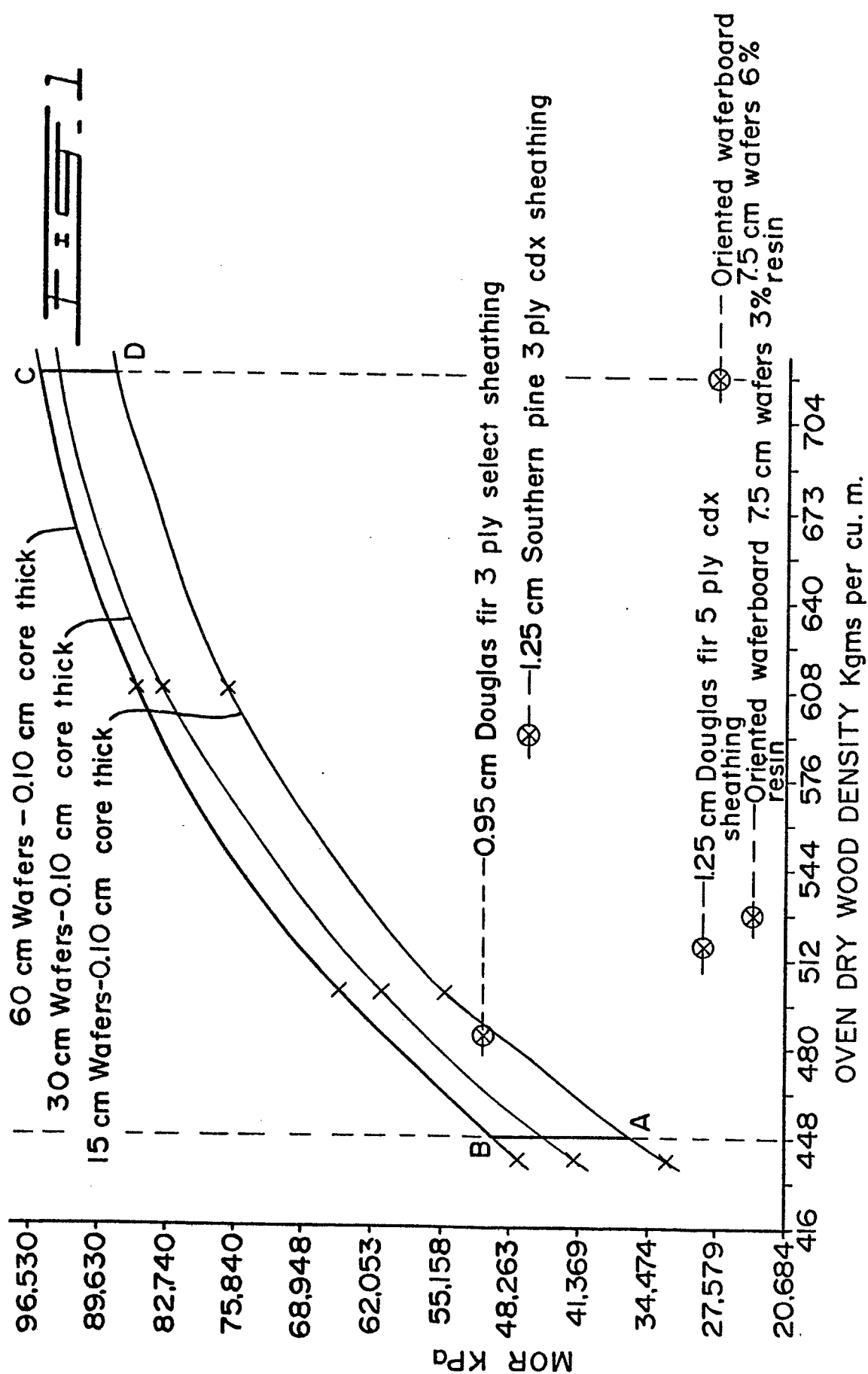
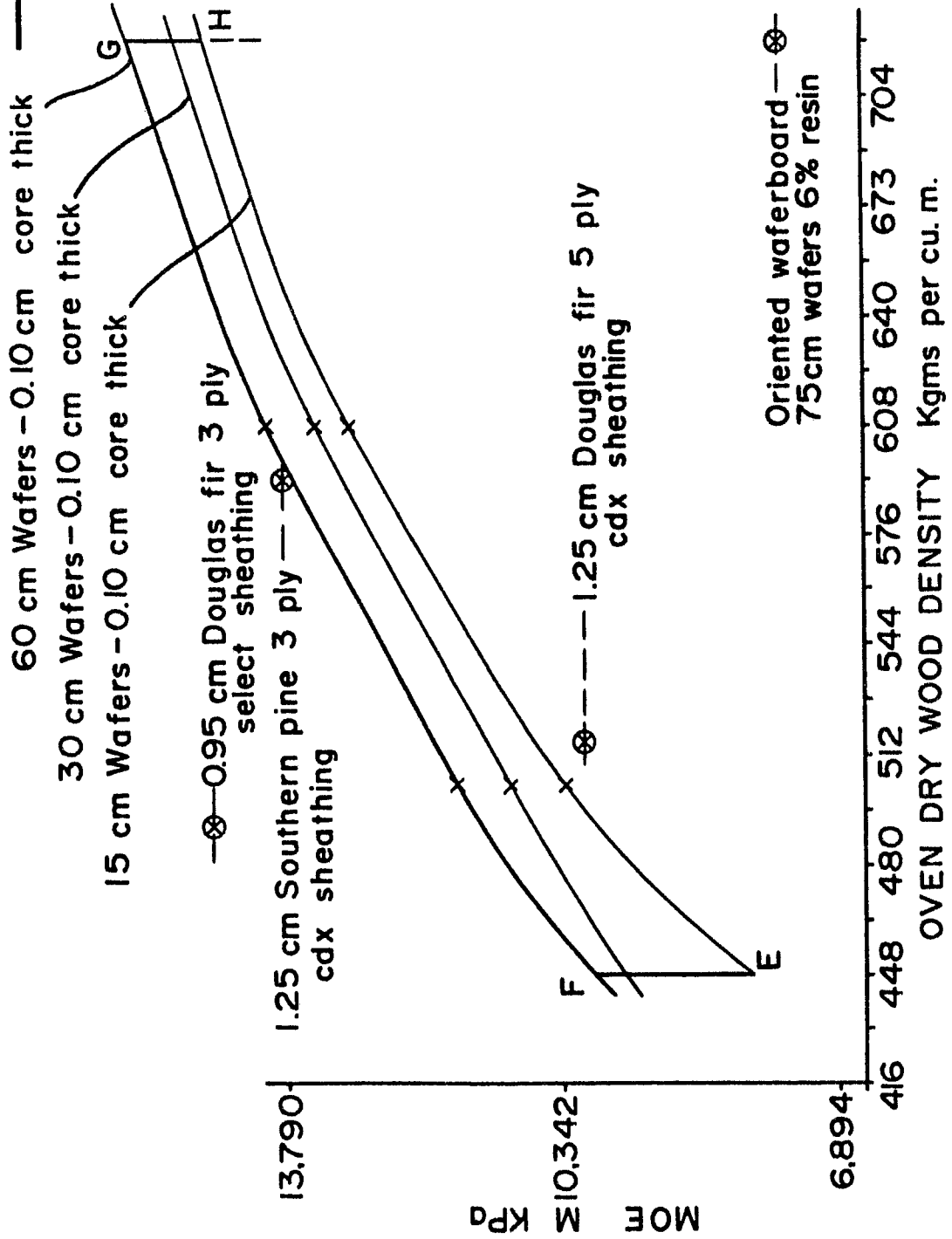


Fig. 2



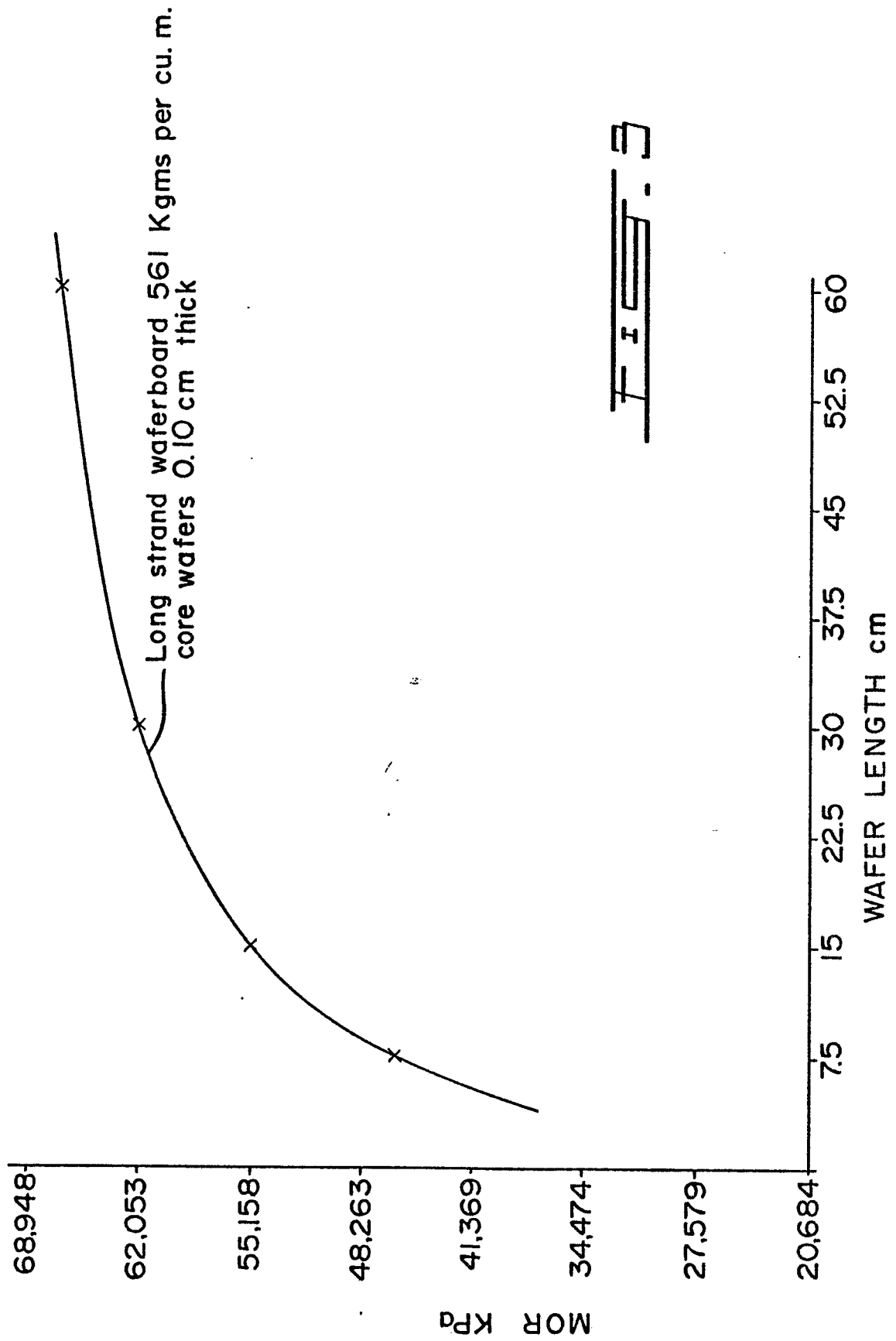


Fig. 3

