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Report
to

CANADIAN FORESTRY SERVICE
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MARCH 1985

ENGINEERING PROPERTIES OF
CANADIAN WAFERBOARD

CONTRACT NO. 02-50-10-020

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by

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March, 1985

prepared for

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SUMMARY

As a result of unexpected professional manpower shortage in the Wood Engineering Department of Forintek Canada Corp., the scope and objectives of the proposed study were considerably reduced during the current fiscal year.

The major conclusions from the present modified study were that:

1. short-term product development and acceptance may be based on performance criteria, but medium- to long-term efforts should be based on the newly emerging "systems-based" or "baseline" design approach;

2. the Technical Committee of The Waferboard Association should provide the basic guidance in short, medium, and long term research planning; and

3. the Wood Engineering, Building Construction Technology, and Composites Departments of Forintek Canada Corp. should be concerned solely with the technical aspects of the research work.

The next fiscal year should primarily be devoted to obtaining specific problem statements from The Waferboard Association for future research into waferboard strength properties.

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OBJECTIVES

The objectives proposed for the 1984/85 fiscal year were:

1. To develop, through a literature review, a comprehensive understanding of the structural end-use conditions for which engineering design properties of Canadian waferboard are required.

2. To develop a research plan to identify the research needs and properties for studies of the engineering properties of Canadian waferboard and to coordinate the research with the Canadian waferboard industry.

3. As time permits, to initiate sampling and structural evaluations of Canadian waferboard.

BACKGROUND

In North American markets, the majority of waferboard is used in applications where acceptance is dependent upon passing stipulated performance tests. Under the current conditions, the competitiveness of waferboard as wall sheathing, roofing and flooring material does not seem to be threatened in the near future.

There are situations, however, where marketing of waferboard depends on the availability of engineering data which cannot be readily derived from the standard quality control and performance tests. For example, engineering design data would be helpful in overseas markets, such as the United Kingdom, where light wood-frame structures are designed individually. The same data would also be needed for the approval of novel building systems by the new "systems-based design" or "baseline" approach emerging in the United States. These considerations led the Wood Engineering Research Program Committee to assign a high priority to the initiation of a study on engineering properties of Canadian waferboard.

STAFF

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METHODS

The original proposal was based on the assumption that a new research scientist would be hired within the Wood Engineering Department, who would devote most of his time to reviewing the problems associated with determining design properties of Canadian waferboards and to suggesting an appropriate research plan. That new research scientist's position has remained vacant to date. Thus, a different strategy was needed and devised.

After initial discussions between Dr. J.D. Barrett and Mr. J.C. Havard, the writer was asked to identify the basic legal requirements and technical alternatives for a "design code" or "performance test" approach to increased marketability of Canadian waferboard. These alternatives were presented in an internal Forintek discussion paper entitled "Engineering Properties of Waferboard: Discussion of Alternatives". This paper is attached to the present report as Appendix I. The paper was reviewed in detail by Forintek staff members. Some of the questions pertaining to engineering properties of waferboards were also discussed with two members of the technical committee of The Waferboard Association. The document stands as Forintek's analysis of alternate plans of action for research on the engineering properties of waferboard.

APPENDIX I

ENGINEERING PROPERTIES OF WAFERBOARD: DISCUSSION OF ALTERNATIVES

A discussion paper prepared for the
Internal Task Force on Waferboard

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July 27, 1984

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1.0 OBJECTIVES

The ultimate goal of determining the engineering properties of waferboard panels is to ensure a wide market acceptance for the product, as reliably performing structural elements, building components or complete building systems, both in Canada and abroad. In technical terms, this necessitates compliance with local, national and international building codes, which usually reference various commodity and/or performance standards and engineering design codes. Only a general survey of possible research needs, covering the most likely code, economic and technical problems is attempted here.

2.0 BACKGROUND

In principle, any new building material or system that would perform as satisfactorily as the existing alternatives--but at a lower cost--would have a readily available domestic and export market. Indeed, because of their relatively low cost, waferboard panels have gained acceptance as wall, floor, and roof sheathing both in Canada and the United States (Dickerhoof, Youngquist and Carll, 1982).

3.0 LEGAL REQUIREMENTS

For simplifying discussion, let us assume that all municipal building by-laws and regulations are closely modelled on the requirements of the National Building Code of Canada (NBCC). Then, there are two basic approaches to the building of wood frame structures for residential or small industrial occupancy. Namely, structures may be designed by qualified engineers or architects in accordance with Part 4: "Design", or constructed directly in accordance with the rules of Part 9: "Housing and Small Buildings" of the NBCC.

Wood frame structures designed in accordance with Part 4 of the NBCC would be expected to resist dead loads, live loads, wind, snow and earthquake loads, following design methods specified by the Canadian Standards Association CAN3-086-M80: "Code for Engineering Design in Wood" or CAN3-086.1-M84 (Draft): "Code for Engineering Design in Wood - Limit States Design". This approach assumes that the building materials are produced to widely accepted commodity product standards and their strength properties are well established. Materials complying with these requirements would have no restrictions concerning their end-use other than conformance to design methods specified in the code(s).

Traditionally built houses are rarely designed in this manner, although some differences in the spacing of joists and studs are recognized in Part 9 of the NBCC as a function of expected loads, based on past experience. Any new material or component that can be shown as equivalent or better than their conventional counterparts, may be introduced into light frame structures under this approach. Indeed, this has been one of the reasons for the development of performance standards for new panel products and structural components, such as "APA Rated Sheathing" and "APA Rated Sturd-I-Floor" of the American Plywood Association (Carll, Dickerhoof and Youngquist, 1982). The limitations of this approach are that the product qualifies only for a special segment of the potential market; and that product standardization is not explicity encouraged. Furthermore, performance requirements might change substantially--or may be manipulated easily and defensively by potential customers or agencies--in offshore markets.

Both of the above alternatives have some technical and economic--thus, marketing--advantages and disadvantages. A decision is needed to identify the best of these alternatives, or their most effective combination, for the most rapid penetration of the potential national and international markets for waferboard and/or oriented strandboard. These decisions are usually made on an ad hoc market opportunity basis by the producers.

4.0 TECHNICAL ALTERNATIVES

4.1 Design Code Approach

This approach allows the most complete market penetration by any (panel) product, but requires the collection and publication of the most extensive and expensive set of technical information, and the maintenance of rigorous quality control during production. Only one Canadian panel product reached this mature level of acceptance and marketability: sheathing grade Douglas-fir plywood.

To put waferboard into the same competitive position as Douglas-fir plywood, a single (North American) commodity or product standard would have to be developed and a standard quality control procedure would have to be initiated in all participating mills. Next, the strength properties and adjustment factors required by the design code(s) would have to be determined for all grades, thicknesses, densities, and species mixtures of waferboards specified in the commodity standards. This approach would require close co-operation between waferboard producers and a large research effort to determine the necessary strength properties and adjustment factors.

For the sake of simplicity, let us assume that the current commodity standards for waferboard in Canada [CAN3-0437-1985: Waferboard (draft) or CSA 0188-1975:

Mat-formed wood particleboard] and in the United States (ANSI A208.1: Mat-formed particleboards) are similar and acceptable, without major modifications, for the foreseeable future. Similarly, assume that current mill practices and testing agencies, such as TECO and APA, can ensure adequate quality control in production. Thus, product standards and quality control procedures would <u>not</u> have to be newly developed for producing uniform waferboard panels.

The technical information needed to develop the design code approach to waferboard marketing is outlined in Table 1 together with estimated manpower requirements. Most of the suggested data would have to be newly collected or generated, since little relevant strength information has been published in the past (The Waferboard Association, 1983). In performing the needed tasks, care should be taken to follow procedures developed for or comparable to those used in determining plywood behavior specified in ISO or ASTM stanards (e.g., ASTM: D35001-76, D3043-76, D2718-76, D3600-76, D2712-76). All of the items listed in Table 2 could be considered as separate studies. Indeed, a baseline study on "load duration effects in waferboards" has already been introduced into our 1984/1985 program of work as part of a co-operative project between Forintek Canada Corp. and the Madison Forest Products Laboratory of the U.S. Department of Agriculture.

4.2 Performance Requirements Approach

This approach allows the <u>fastest penetration of a specific market segment</u> by any (panel) product, with a minimum of expenditures, when widely accepted performance standards are available. Otherwise, development of performance standards also would have to be considered.

For the sake of simplicity, let us assume that the current performance requirements specified by the American Plywood Association, such as "APA Rated Sheathing" and "APA Rated Sturd-I-Floor", are adequate for identifying panel products for selected market requirements. Similarly, let us assume that current mill practices and testing agencies, such as TECO and APA, can ensure compliance with these requirements.

A comprehensive test program would only serve to establish a national or continental benchmark of mean performance level and its variability. The technical information to be collected in such a survey is outlined in Table 2, together with estimated manpower requirements. As indicated, the proposed work may be considered as five fairly independent and large studies. Some information is already available within each of the five fields (The Waferboard Association,

1982) based on research and quality-control work performed in the past.

What could be the most useful contribution of Forintek Canada Corp. to the increased acceptance and sale of waferboard panels through improved performance criteria for new applications? The fabrication and testing of specific structural elements, under various environmental and load conditions, for an evaluation of their performance is slow and expensive, even in the simplified forms proposed by the appropriate ASTM and APA methods. For example, fabricating and testing ten 12 ft. x 15 ft. floor segments, collecting and analyzing the data and report writing may cost about $50,000.00. Note that the same procedure would have to be repeated for each different floor construction.

Analytical prediction of structural performance would be more efficient and flexible. Forintek Canada Corp. has already developed and calibrated models for simulating the behavior of floors, flat roofs and wall systems of conventional wood-frame construction. The estimated cost of predicting or simulating the behavior of not 10 but 100 12 ft. x 15 ft. floor segments would be less than $300.00. This assumes that all the necessary material properties are known or can be estimated with acceptable accuracy. Determination of missing panel and joint properties would add to the above cost. Nevertheless, the total cost of estimating the performance of a given floor system might remain below $5,000.00.

5.0 SUMMARY

Both approaches outlined above have some advantages and disadvantages. Selecting an appropriate plan of action depends on either knowing or second-guessing policy decisions that will be made by the waferboard producers. For example, would producers be willing to standardize the size of wafers, species mixtures, glue types, glue spreading techniques, curing temperatures, and curing pressures more closely than in the past? Would producers like to diversify their markets or are they happy with current sales patterns? Is the long-term trend towards national or continental production of commodity products or towards more specialization by individual mills or regions? Answers to these general questions of policy, or identification of general trends, are essential in determining the most effective short-term, medium-term and long-term research efforts of Forintek Canada Corp. Indeed, selection of appropriate research goals appears to be the most difficult problem facing us now.

Technical problems facing the waferboard industry may be relatively simple. Indeed, solutions to the specific technical problems may already exist in the literature, or could be readily developed by (Forintek) engineers in the near future.

REFERENCES

American National Standards Institute (ANSI): A208.1:
Mat-Formed Particleboard.

American Plywood Association (APA):
APA Rated Sheathing.
APA Rated Sturd-I-Floor.

American Society for Testing and Materials (ASTM):
D 1037-72
D 2718-76
D 2719-76
D 3043-76
D 3500-76
D 3501-76
E 72-74
E 661-80

Canadian Standards Association (CSA):
0188-1975: Mat-Formed Wood Particleboard.
CAN3-0188.2-M78: Waferboard
CAN3-0437-M85: Waferboard (draft)
CAN3-086-M80: Code for Engineering Design in Wood

Carll, C.G., H.E. Dickerhoof and J.A. Youngquist. 1982. U.S. wood-based panel industry: Standards for panel products. Forest Prod. J. 32(7):12-15.

Dickerhoof, H.E., J.A. Youngquist and C.G. Carll. 1982. U.S. wood-based panel industry: Production trends and changing markets. Forest Prod. J. 32(6):14-23.

National Research Council of Canada. 1975. National Building Code of Canada. Ottawa, Ont.

The Waferboard Association. 1983. Waferboard: The Structural Panel. Atlanta, Georgia.

Table I

Studies Needed to Develop Design Code Approach to Waferboard Marketing

Items/Objectives	Manpower* Prof.	Manpower* Tech.	Equipment	Materials, Supplies	Reports
(1) Code strength properties for each grade, thickness and composition:					
Sampling plan	20				X
Sample collection	10	30			
Bending strength Bending stiffness	2	10		X	X
Tensile strength Tensile stiffness	3	15		X	X
Compressive strength Compressive stiffness	2	10	X	X	X
Shear-through strength Shear-through rigidity	4	20	X	X	X
Shear-plane strength Shear-plane rigidity	4	25	X	X	X
Report writing	20	5			X
Sub-total	65	115			
(2) Effect of factors on each strength property:					
Grade and size	4	20		X	X
Moisture content	4	20	X	X	X
Relative density	3	15		X	X
Composition (species, glue)	4	20		X	X
Grain orientation	3	15		X	X
Layering	3	15		X	X
Thickness	4	20		X	X
Load duration	6	30	X	X	X
Report writing	20	5			X
Sub-total	47	140			

*Man-days

Table I (Continued)

Studies Needed to Develop Design Code Approach to Waferboard Marketing

Items/Objectives	Manpower* Prof.	Manpower* Tech.	Equipment	Materials, Supplies	Reports
((3) Jointing properties:					
Scarf joints	4	20	X	X	X
Butt joints	2	10	X	X	X
Gusset joints	4	20	X	X	X
Nail withdrawal	2	10		X	X
Nail pull through	2	10		X	X
Nail tear out	2	10		X	X
Nail spacing	4	20		X	X
Screw withdrawal	2	10		X	X
Screw pull through	2	10		X	X
Screw tear out	2	10		X	X
Screw spacing	4	20		X	X
Truss-plate joints	4	20	X	X	X
Splice-plate joints	4	20	X	X	X
Summary report	20	5			X
Sub-total	58	195			
(4) Structural properties:					
Flange-web shear modification factors	4	20	X	X	X
Lateral stability of waferboard-wet beams	4	20	X	X	X
Shear section coefficients	4	20	X	X	X
Stressed skin panel compression buckling coefficients	4	20	X	X	X
Summary report	20	5			X
Sub-total	36	85			

*Man-days

Table 2

Studies Needed to Develop Performance Criteria
Approach to Waferboard Marketing

Items/Objectives	Manpower* Prof.	Manpower* Tech.	Equipment	Materials, Supplies	Reports
(1) Performance of single layer floors:					
Span rating: 16, 24, 32					
Exposure : dry, wet/redry					
Loading : concentrated (static, impact)	6	30	X	X	X
distributed (uniform, variable)	3	15	X	X	X
Report writing	20	5			X
Sub-total	29	50			
(2) Performance of roof sheathing and sub-flooring:					
Span rating: 16, 24, 32, 64?					
Exposure : dry, wet/redry					
Loading : concentrated (static, impact)	6	30	X	X	X
distributed (uniform, variable)	3	15	X	X	X
Report writing	20	5			X
Sub-total	29	50			

*Man-days

Table 2 (Continued)

Studies Needed to Develop Performance Criteria
Approach to Waferboard Marketing

Items/Objectives	Manpower* Prof.	Tech.	Equipment	Materials, Supplies	Reports
(3) Performance of wall sheathing:					
Span rating:					
Exposure : dry, wet/redry					
Loading : concentrated (static, impact)	3	15	X	X	X
racking	6	30	X	X	X
Report writing	20	5			X
Sub-total	29	50			
(4) Fastener performance:					
Nail withdrawal	1	5			X
Nail-head pull through	1	5			X
Lateral nail resistance	1	5			X
Screw withdrawal	1	5			X
Screw-head pull through	1	5			X
Lateral screw resistance	1	5			X
Truss-plate joint resistance	2	10			X
Report writing	20	5			X
Sub-total	28	45			

*Man-days

Table 2 (Continued)

Studies Needed to Develop Performance Criteria
Approach to Waferboard Marketing

Items/Objectives	Manpower* Prof.	Manpower* Tech.	Equipment	Materials, Supplies	Reports
(5) Simulation or modelling:					
Single layer floors	15	-			X
Roof-sheathing and subflooring	15	-			X
Wall sheathing	15	-			X
Nail behavior	10	-			X
Screw behavior	10	-			X
Truss-plate behavior	10	-			X
Report writing	20	5			X
Sub-total	95	45			

*Man-days