A Study For A Wood Fibre Concrete Plant In The Northwest Territories

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FOR

GOVERNMENT OF THE NORTHWEST TERRITORIES
Yellowknife, N.W.T., Canada

A STUDY
FOR A
WOOD FIBRE CONCRETE PLANT
IN THE
NORTHWEST TERRITORIES

October 1975

BY

C.D. SCHULTZ & COMPANY LIMITED
Vancouver, Canada

(Registered Issue No. 1)

SCHULCO

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C. D. SCHULTZ & COMPANY LIMITED
Foresters and Consulting Engineers
Economists and Biological Scientists
325 Howe Street Vancouver, Canada V6C 2A1

October 17, 1975
Our File: T39. 3.18

Mr. Douglas Patriquin, Chief
Research and Evaluation Division
Department of Economic Development
Government of Northwest Territories
Arthur Laing Building
Yellowknife, N.W.T.

Dear Sir:

We have conducted a study involving a process of utilizing wood fibre from sawmill waste combined with cement and aggregates (admix) to manufacture building components. (We refer to a particular process developed by W.R. Friberg, P. Eng., and E. Max Huffaker, P. Eng., of Spokane and Pullman, Washington, U.S.A. An application is being processed for a patent.)

The findings of this study indicate that:

1. The Wood Fibre Concrete (W.F.C.) building components developed by Friberg and Huffaker appear to be superior and more economical than others being produced in Europe and North America.
2. W.F.C. products would be particularly useful in the Northwest Territories where the severe cold weather conditions require well insulated buildings which are constructed with fire resistant materials.
3. W.F.C. products are structurally sound, free from insect attack and will not decay.
4. Local people with limited skills can manufacture the material and erect the structures under the supervision of a trained technician.
5. The principal ingredient of Wood Fibre Concrete, unused mill residue, is available within easy reach of many N.W.T. settlements.

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October 17, 1975
Our File: T39.3.18

6. The cost of a minimum plant for experimental production of Wood Fibre Concrete building components is estimated to be $40,000.

7. The cost of providing training for the supervising technician and staff is estimated to be $13,000.

8. Three to four people would be employed in the plant and six people employed in construction work, building fifty single-family homes or other equivalent structures.

9. The plant is mainly portable and can be set up where buildings may be required.

Messrs. Friberg and Huffaker are currently setting up a corporation in the United States to finance a manufacturing company and promote sales for Wood Fibre Concrete, using the trade name (Energy Saving Material) E.S.M.

We recommend that a pilot plant be installed at Fort Resolution, Slave River Sawmill site during 1976.

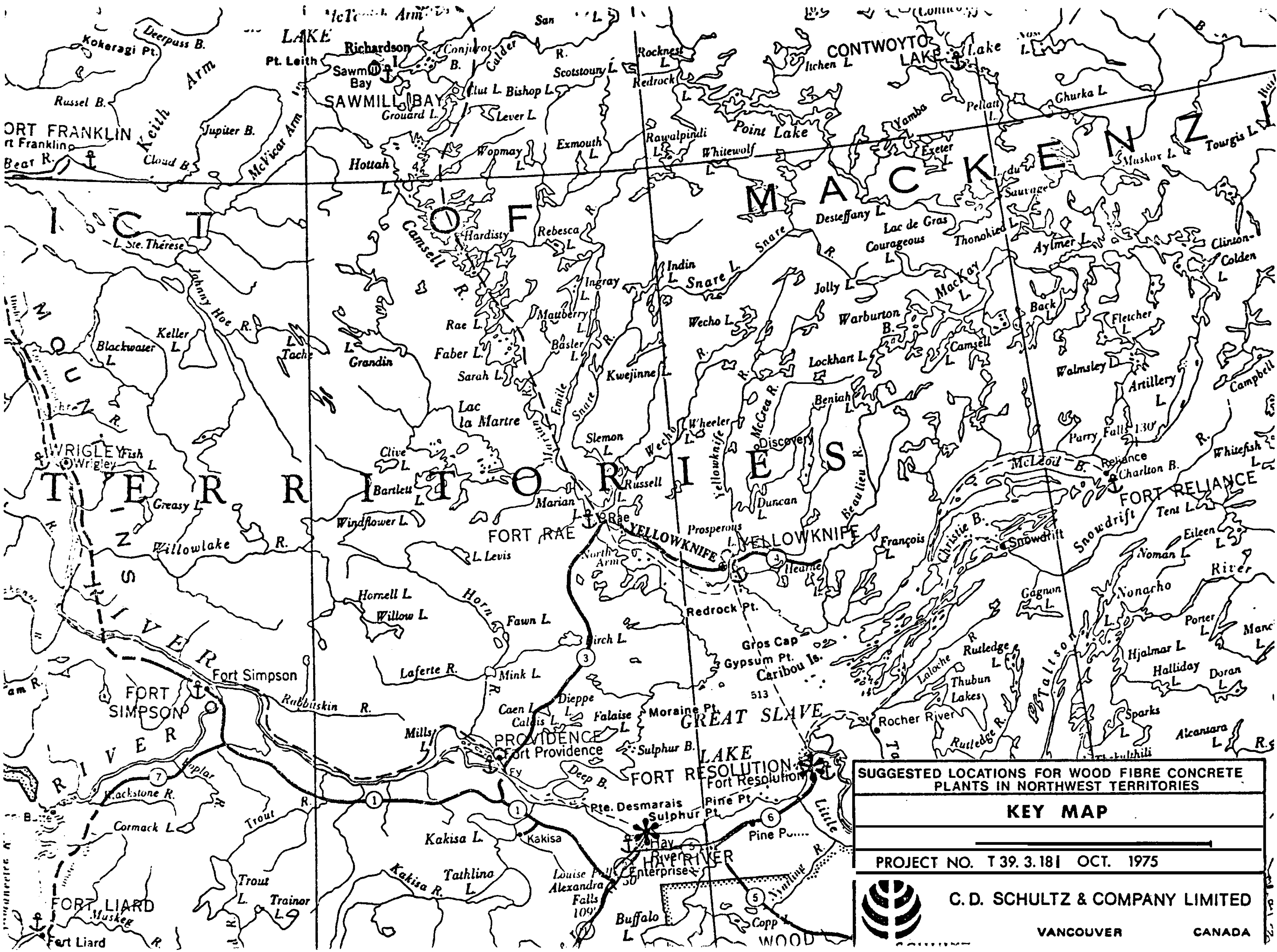
The following text contains additional data which will support our recommendation.

Yours very truly,

C.D. SCHULTZ & COMPANY LIMITED

R. Blackstock

J.R. Blackstock
Vice President



SUGGESTED LOCATIONS FOR WOOD FIBRE CONCRETE PLANTS IN NORTHWEST TERRITORIES

KEY MAP

PROJECT NO. T 39. 3. 181 OCT. 1975

C. D. SCHULTZ & COMPANY LIMITED

VANCOUVER CANADA

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APPENDICES

A STUDY
FOR A
WOOD FIBRE CONCRETE PLANT
IN THE
NORTHWEST TERRITORIES

1.0 THE REASONS FOR CONDUCTING THE STUDY

1.1 The development of the existing forest industry in the Northwest Territories has been directed to supplying the local market for lumber, piling and posts.

During 1975/76 sawmills will produce approximately six million boardfeet of lumber. An estimated 3,000 units (250,000 CU. ft.) of unused residual by-products in the form of pile peelings, sawdust, shavings and wood forms unsuitable for lumber will accrue during the sawing season.

wood Fibre Concrete (W.F.C.) is a masonry tYPe building product composed of wood and bark particles mixed with Por'tland Cement, Diatomite, clay and other substances with water added to allow pouring into forms or molds.

1.2 This study seeks-to find ways and means to:

a) Explore the practicability of utilizing unused wood fibre in a processing plant to produce building products in the forest areas of the Northwest Territories.

b) Eliminate the need to dispose of wood waste in incinerators as far as possible.

c) Provide low cost buildings which are:

- fire resistant;
- well insulated;
- structurally sound;
- free from attack by insects and decay;
- easy and economical to construct.

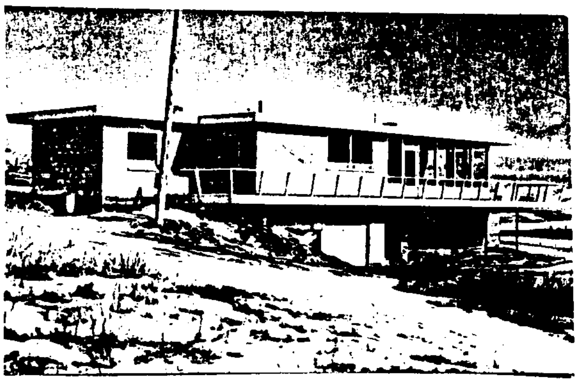
d) Provide employment for native and other people in the area.

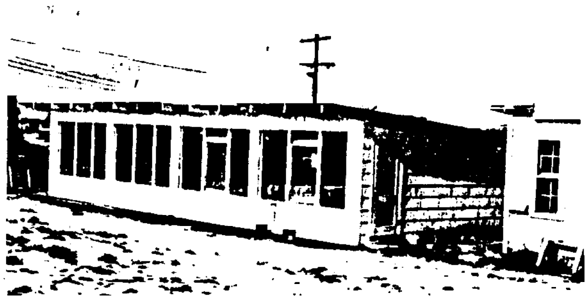
1.3 Messrs. Walter Friberg, P. Eng., and E. Max Huffaker, P. Eng., Washington, U.S.A., have developed a process which should provide the ways and means to accomplish these objectives. These gentlemen feel that this is an opportune time to introduce in North America an improved building concept similar to one which has been used successfully in Europe for many years.

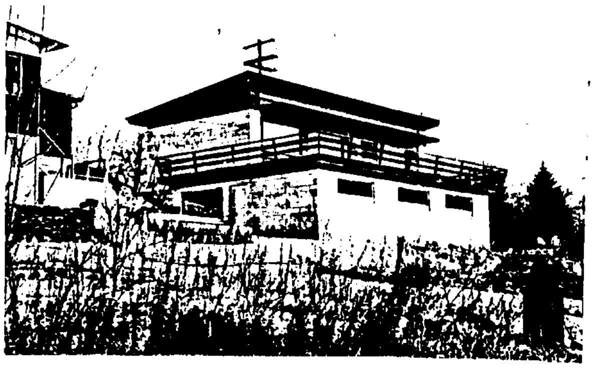
1.4 This study provides information which will indicate the feasibility of establishing this process in the Northwest Territories. The severe weather conditions in the Northwest Territories provide excellent conditions for testing the material and developing new building techniques.

'WALTER R. FRIBERG, P.ENG. IN FRONT OF HIS HOME
WHICH IS CONSTRUCTED WITH W.F.C.
SPOKANE, WASHINGTON, U.S.A.

SAMPLES OF SINGLE AND MULTI-STORY STRUCTURES USING WOOD FIBRE CONCRETE







2.0 THE DEVELOPMENT OF WOOD FIBRE CONCRETE

Crude attempts have been made to utilize sawdust mixed with Portland Cement since the early 1900's. The lack of uniformity in the sawdust from size, chemical composition, density, moisture content, and unregulated measuring methods when mixed with Portland Cement led to discouraging results.

Interest in the product seems to have been greatest during and following the first and second World Wars. The Durisol Company in Switzerland, Tretong in Sweden, and Heraclith in Germany have continued to develop, manufacture and distribute wood-concrete products with some success.

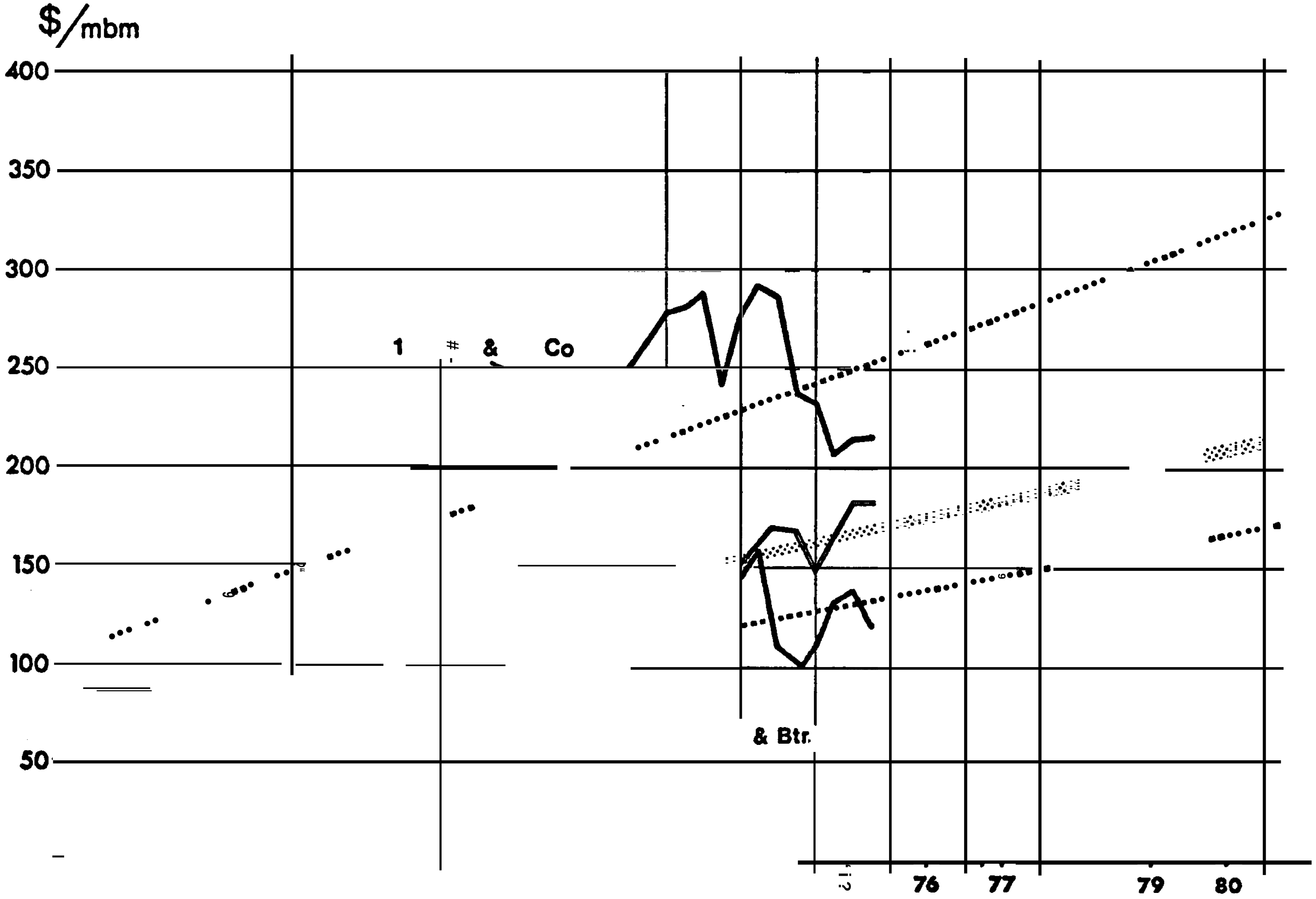
2.1 Particleboard, another product which utilizes wood fibre, and glue was first developed in Germany.

In North America, more emphasis has been placed on the development of particleboard. This is mainly used for furniture manufacture, sheathing and coverage material.

The cost of particleboard is comparable tolumberand plywood. The raw material is cheap but the process is capital intensive. Lumber, plywood and particleboard are rated as combustible materials which limits their use. (National Building Code of Canada 3.2.1 - 3.2.2.)

Until recent years North America appeared to have more than enough timber to supply its own building (lumber) requirements. This situation is rapidly changing and the cost of building material has more than doubled in the last decade. It was inevitable that the uses of other materials would"be explored.

WHOLESALE PRICE TRENDS
of
BOARDS, PLYWOOD and DIMENSION.



Based on
MADISON'S CANADIAN LUMBER DIRECTORY
1965 to 1975

Project No T 39.3.18.
Oct. 1975

.2• 2 Other Products

The use of wood fibre combined with concrete in North America has not been extensive. Locally, Du-A1 Blocks, (1967) Ltd. in Edmonton has been expanding rapidly. They have developed wood fibre cement building blocks. These are reinforced with steel and use a solid cement core for structural walls. (See Appendix IV)

Du-A1 report that they are producing an average of 2,000 units per day in their Edmonton plant. These blocks range from $1.42 for 6" x 12" x 24" to $2.59 for 12" x 12" x 24". Half blocks and corner blocks are slightly less. They also manufacture tile.

Du-A1 report that the demand for their product has increased considerably due to the rising price of lumber.

A similar product to Du-A1 was developed in Vancouver, called the Durablock, about twenty years ago. Architects at that time were reluctant to recommend it.

Several houses were built which are reported to be still standing in good condition.* A lumber dry kiln was constructed in Vancouver in 1952. The owner reported that fuel costs were greatly reduced with the superior insulating qualities of the material.

2.3 Conventional Structures

Domestic dwellings in North America are mainly built from whole wood components such as timbers, light framing, boards,

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Bridge Lumber Co. Ltd., Mitchell Island

plywood, shingles, shakes and other configurations. Wood is a renewable resource, has a low energy requirement for conversion to useful products, readily workable with simple tools and skills and has a tremendous appeal to people.

Unfortunately there are two serious problems:

a) The cost of wood products such as lumber and plywood has doubled in the past ten years.

b) In isolated sawmills such as in the Northwest Territories about 60 percent of the log is wasted in the form of sawdust, shavings, bark and unused whole wood.

The proportions of waste material are approximately (by volume) :

Sawdust	15%
Unused wood-slabs, edings etc.	25%
Bark	10%
Planer shavings	10%
Total waste	**60%**

300 DESCRIPTION OF WOOD FIBRE CONCRETE PRODUCTS

3.1 "Composite Materials*

In the proposed process the simplest mix contains six dry ingredients with five others to vary the characteristics. The possibility of error is great. Simple mixing is not sufficient due to chemical reactions desired which require the proper sequence. The result of this procedure is called an admix.

The admix and water is added to the other materials and mixed similar to concrete to form the wet W.F.C. (Wood Fibre Concrete).

The wet mass can be poured into molds for forming. This sets up and hardens similar to ordinary concrete. The hardening process can be accelerated by steam or kiln curing. In this respect it differs from other types of W.F.C. which are weakened when cured at high temperatures.

3.2 Configurations of Forms

In the mixing process the volume of water may be varied as required. This is known as a wet or dry mix. When precast building units, using hollow blocks, are made the economy of manufacture requires the mold to be stripped off immediately. A comparatively dry mix must be used to avoid deformation of the material. Tamping is required to insure that the material is in place.

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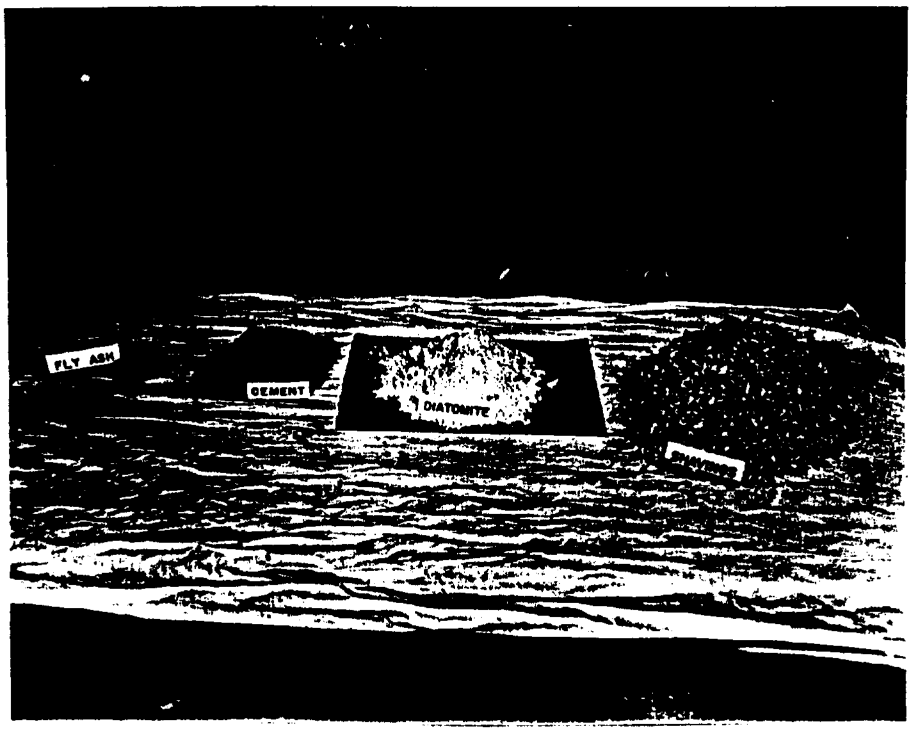
*see page 2, 1.3.



SAMPLES OF MAIN '
COMPONENTS OF WOOD
FIBRE CONCRETE

POURING GROUND FLOOR 3-1/2
INCHES THICK

If wet mixes are used the labor factor is less expensive but more molds are required to hold the material in place prior to setting. This may take up to four hours depending on the temperature.

Large molds may be used in a rectangular form in required sizes. These large blocks may be cut into panels, as required, **using** a bandsaw **with** hardened teeth.

Pallets fastened to an endless moving belt may be used to cast slabs (panels) up to three inches thick.

Floors and other horizontal components may be poured in the same manner and depth as ordinary concrete. The W.F.C. is much lighter and easier to work with. The normal thickness is three and one half inches. (In cold climates the thickness should be increased.)

Beam or suspended floors require a plastic sheet or waterproof paper laid over and attached to the joist. A wire mesh similar to fencing (2″ x 2″ or 2″ x 4″) is then laid over the sheet before the W.F.C. is poured and leveled. This provides reinforcing as it becomes imbedded in the W.F.C. A floor **takes a** minimum of one day **to set**. Suspended floors take longer.

Walls may be poured in the same manner but the cost of forms is prohibitive unless they can be reused. walls thicker than six inches take longer to dry and in cold climates a six-inch wall does not provide enough insulation. A practical economic **limit** would be **eight** inches. (See page **19).**

3.3 Recommended Construction

When components are to be transported some distance, precasting at the plant is necessary. A simple flat slab is recommended as the best configuration. A slab (1½" X 16" X 48") , weighing about 26 pounds, appears to be satisfactory.

Slabs are sufficiently fire resistant for most applications. They have bending strength, are rigid and structurally stable. Nails can readily be used for attachment to framing as required.

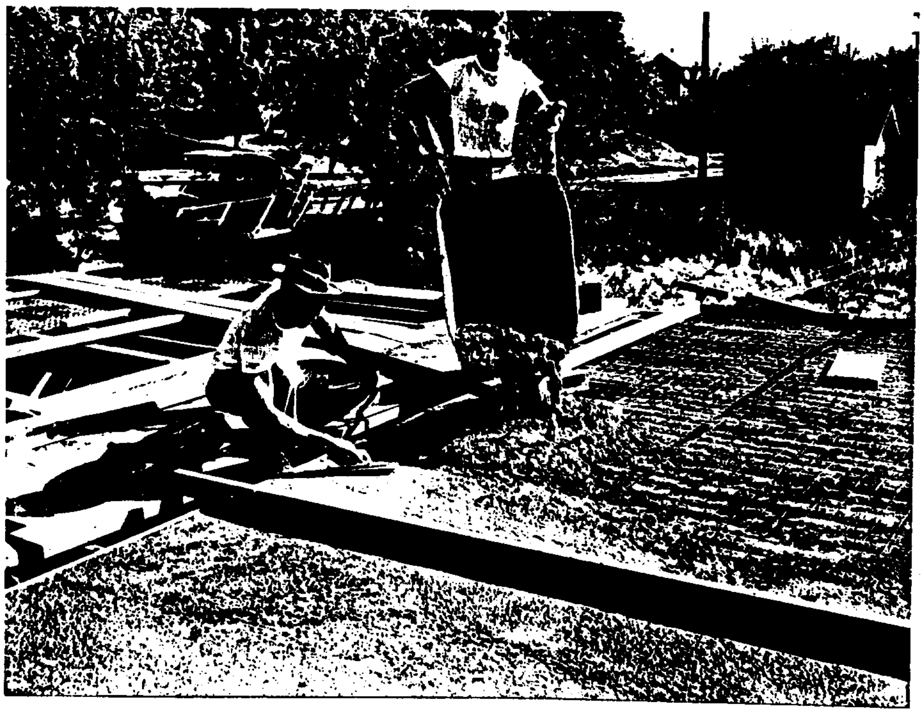
Insulation can be applied as required in the floors, walls, and ceilings in the normal way.

The advantages are (see Appendix I) :

3.3.1 Single-sized units such as 1½" x 16" x 48" can be applied to any normal wall interior and exterior, similar to plywood, lumber or other coverage material.

3.3.2 A simple and inexpensive post and beam frame will provide for automatic alignment vertical and horizontal of the units attached to it. Load-bearing capacity can be provided for single and multi-storied buildings.

3.3.3 The wall thickness is variable as determinedly the stud width thus permitting the most economical amount of insulation.



ROOF SLAB WITH STEEL REINFORCING

HEATING COILS IN PLACE READY FOR CEMENT SURFACE ON FLOOR

3.3.4 **Effective** and inexpensive vapor barrier material may be applied. (This is necessary on the warm side of the insulated wall or ceiling where the average January temperature is less than 7° C. (or 45° F.)

3.3.5 Conventional finishes can be directly applied to interior and exterior surfaces.

3.3.6 Skilled labor is not required for construction.

3.4 Floors

Floor slabs cannot be poured in exposed areas during sub-zero temperatures. It would be necessary to precast all components in a heated building during the winterseason.

Floors may be covered with wood, tile, linoleum, cork or plastics, using adhesives as a bonding agent. Wall to wall carpeting, paint or resin also can be used.. Floors in industrial buildings can be topped with concrete, 3/8 inches for foot traffic and two inches for heavy mobile equipment up to 10 tons.

3.5 Insulation

If radiant heat is required, coils may be fastened to the W.F.C. floor slab and topped with concrete. The W.F.C. insulates the heat from a downward movement and dissipates the heat upwards which has proven to be highly satisfactory.

A wet composition using bark, tree slash with twigs and needles coarse ground in a hammer hog mill, mixed with fireproofing material and the same admix as the W.F.C. may be used as a pour-in-type of insulation. This is an alternative to presently available commercial insulative materials.

The advantages of this process as an adjunct to the W.F.C. plant are:

3.s.l A fire resistant insulative material can be made from presently considered waste materials, using unskilled labor.

3.5.2 It can be sold at a good profit and still provide savings for the builder.

3.s.3 *The equipment already in the admix plant could be used with the addition of about $300 extra equipment. Slack or otherwise idle time in the plant could be used, thus increasing overall efficiency.

3.6 Other Techniques

Another technique provides a high strength waterproof material for stucco or plaster. Precast units can be laid up dry without mortar. A coating 1/8 inches thick is applied to the wall surfaces. The wall then has the strength of a mortar-built wall, with the surfaces finished.

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*Experience in using this material has been Satisfactory but limited to date.

The surface material can be mixed in the same admix plant as the W.F.C. small amounts of two additional raw materials would be required.

3.7 Alternative Materials and Forms

Durisol in Switzerland and Du-A1 in Edmonton are making hollow blocks which utilize cinders or pumice as aggregates. Both Durisol and Du-A1 find it necessary to fill the cores with concrete. Costs are increased and insulative values are decreased when compared to the product developed by Friberg and Huffaker (see Appendix IV).

Mortar forms a temperature bridge between the inside and outside of a building permitting a heat loss. The block shape is a poor insulator.

4.0 MATERIALS AND EQUIPMENT

4.1 Wood Fibre Aggregate

Any softwoods indigenous to the Pacific Northwest and most other areas may be used as a base for the wood fibre aggregate. Spruce, pine, and white fir are preferred but selection of species is not required.

The size and shape of the wood particles is important. Sawdust is suitable for compressive strength as required in floors but poor in flexture and tension.

Long-fibred fragments are more suitable for components where flexture and tension are important. Examples of the most desirable configurations are pole peelings, coarse shavings, or splinters from the reduction of an entire tree stem.
A considerable amount of bark can be tolerated which increases the insulative qualities of the mix but reduces the strength.

4.2 Bonding Agent

Regular Portland Cement is normally used. Hi-Early Cement will set more rapidly but is expensive and the additional cost is not normally justified.

4.3 The Admix

Other ingredients are part of the patent claims now being processed by a patent attorney. These ingredients are common and fairly available. The cost is within the limitations for the manufacture of W.F.C. in the areas under consideration. The location of the processing plants will probably be at or adjacent to the source of the wood fibre component.

Accurate costs of materials cannot be determined until the location of the processing plants, routes of transportation, and consumer market areas are determined.

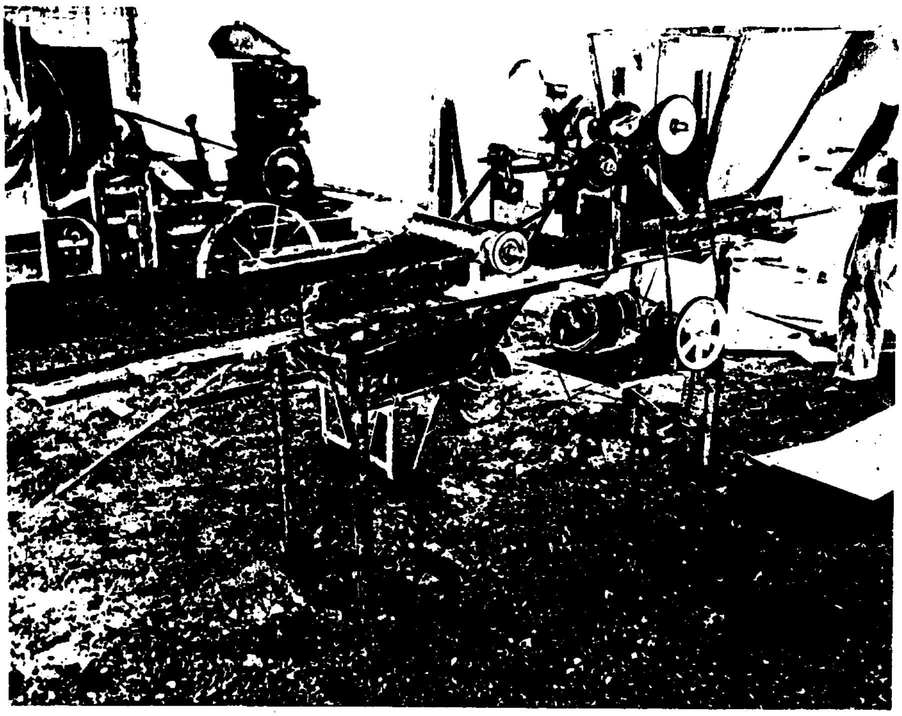
4.4 Equipment

The methods and machinery for processing the admix is another feature of the patent claim. This cannot be publicly discussed at this time. The methods will not create a manufacturing problem that will make the process technically or economically unfeasible.

The component parts of the equipment are conventional. The adaption of the components is specialized and unusual but a good mechanic can assemble them. A supervisor who can follow simple but precise instructions is required.

The equipment required for making the admix and W.F.C. is simple and inexpensive. Except for unusual circumstances the manufacture of precast units must be part of the operation.

No equipment for making large quantities of flat slabs exists at the present time. Machines for making regular concrete slabs in small sizes are available. The cost of machines for large **size** slabs is not known.



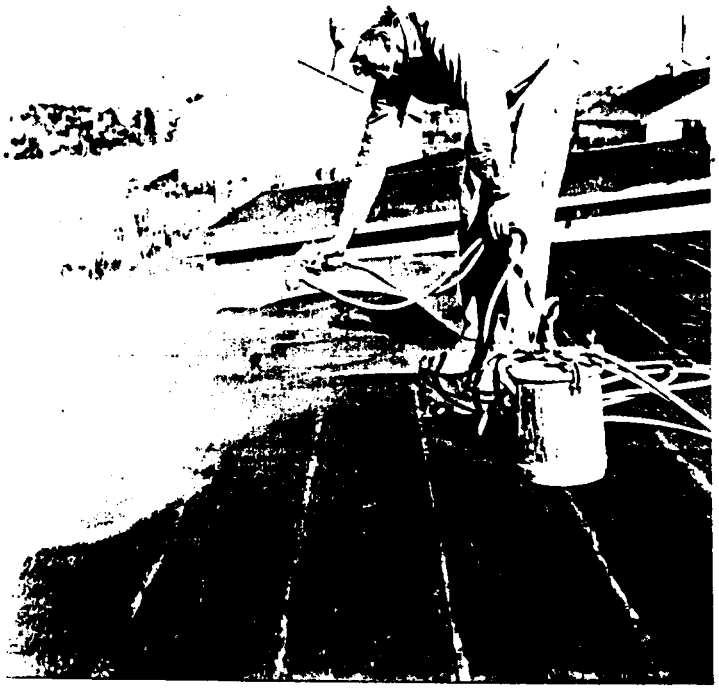
SIMPLE FLAT SLABS
BEING PRECAST

FLOOR SLABS PRECAST

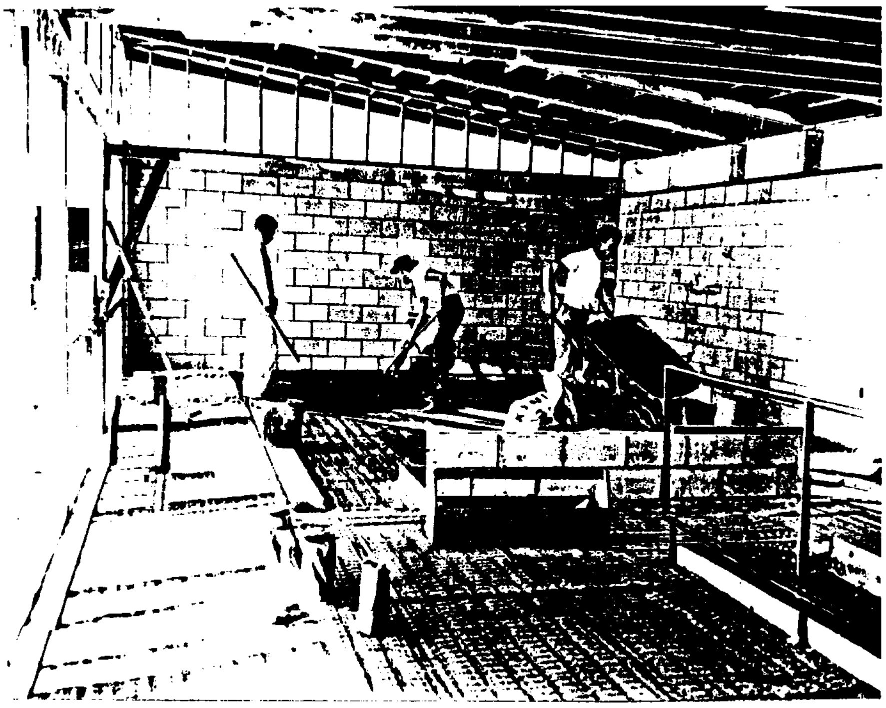
The principles of the design are indicated in an experimental machine designed and built by E. M. Huffaker, P. Eng., and W. Friberg, P. Eng. Improved design could be made in local machine shops which would be less expensive and functionally improved.

As an alternative to precast panels, large bolts or rectangular forms can be cast and reduced to required sizes with a bandsaw similar to a sawmill type. Exploratory results have been favorable to this process. These can be any size which could be sawn with a bandsaw, say 16″ thick, 4' or 8' long x 2' wide. The bandsaw would cut parallel to the length plus or minus 1½" thick x 16′ wide which would be nailed to studs or joists with standard 16″ centres.

A minor disadvantage to this system is that large bolts take longer to set after being poured.



APPLYING ROOF SEAL



POURING THE FLOOR FOR COMMERCIAL STRUCTURE

5.0 ADVANTAGES OF W.F. C. OVER CONVENTIONAL FRAME CONSTRUCTION

5.1 Fire Resistance

Tests made by the internationally recognized Pittsburgh Testing Laboratories (report attached) and others prove that W.F.C. has exceptional resistance to fire.

5.2 Ecology and Local Economy

At least 70 percent by weight of W.F.C. is industrial waste or materials that have little or no other use.

5.3 Durability

W.F.C. is immune to fungus and insect attack. Repeated extreme cycles of wetting-drying, freezing-thawing have little or no effect.

5.4 Finish

Any of the conventional (and some unconventional) finishes and materials can be applied directly to floors, roofs, interior and exterior walls. Walls may be left with no surface treatment if desired.

5.5 Solidity

A W.F.C. building has an intangible but appreciable feel of permanence and massiveness.

5.6 Insulation

Temperature insulative characteristics are better than the lumber. In combination with its companion product,' -W- fireproofed wood fiber, effective low-cost insulated buildings can be constructed of local raw materials.

5.7 Workability

W.F.C. can be molded, like concrete, into the structural and architectural shapes desired; it can also be nailed, cut, and otherwise handled like wood.

5.8 Acoustic Value

W.F.C. is a better absorbant of sound, both air-borne sound waves and those transmitted through the structure.

6.0 ECONOMICS OF BUILDING INSULATION

Heat losses through structural element depend on the following factors:

k = conductivity of the material -
in B.T.U./inch/sq.ft./hti/t_o-t_o

t = temperatures -
t_i = inside temperature; t. = outside temperature; in F^O

x - thickness of the material -
or x_1, X_2, x_3, when more than one

f = condition of surface and wind velocity -
also f_1, f_2, '3

time, in hours and area, in square feet

The heat loss through a composite wall, that is a wall (or ceiling or floor) composed of different materials of different thicknesses, can be calculated by using the following formula:

$$\text{mm} \quad U = \frac{1}{\frac{1}{f} + \frac{x_1}{k_1} + \frac{x_n}{k_n} + \frac{1}{f_o}}$$

U is in B.T.U./hr./sftfFO/F^0

B.T.U. = British Thermal Unit - the amount of heat required to raise one lb. of water by one degree Fahrenheit. In the metric system U is measured in great calories (1,000 cal.).

For example, a wall built of two slabs of W.F.C., each 1½" thick, and nailed to bearing studs, one slab forming the inside wall surface and the other the outside, would have the following U values for the given thicknesses of -W- insulation:

Fireproofed Wood Fibre	-w- insulation	1" thick - U = .129
		2" thick - u = .095
		4" thick - U = .062
		8" thick - u = .037

In comparison, an 8″ cinder or pumice block wall, plastered inside, has a U value of .41. That is, the heat loss through an 8″ cinder block wall is more than 11 times the heat loss through the W.F.C. wall of the same thickness, and under the same conditions.

To translate the above somewhat abstract values into dollars worth of fuel saved for a given building in a specific location, the following formula is used:

$$F_s = \frac{24(u - U_i)\,AD}{CE}$$

Where F_s is the amount of fuel saved in one heating season.
u is the coefficient of conductivity without insulation.
U_i is the coefficient of conductivity, insulated wall.
A is the area of the wall (or ceiling).
D is the degree days for the buildings location.
c is the calorific value of the fuel used.
E is the efficiency of the burner, or furnace.

Using this formula for the following examples, it is assumed that fuel oil is the fuel, with a calorific value of 141,000 B.T.U./gal. and a burner efficiency of 60%. (These values and others used in this discussion, are taken from the handbook published by the American Society of Heating and Ventilating Engineers, an internationally recognized authority, and are for average conditions) . The wa″ll area is assumed as 1,000 sq. ft., that of a small house. The degree days values are official data from the U.S. Weather Bureau computed from meteorological data taken by weather stations at the sites; these data are mathematically expressed as the aggregate of the differences between outdoor temperatures and 65° F. for one year, and averaged over the years weather records were kept.

As examples these are:

For Seattle	D = 4815
Edmonton	10320
Yellowknife	15910

Examples:

Fireproofed Wood Fibre

For Seattle	-w- insulation 1" thick will save	99.7	gal.oil/yr.
	2"	146.2	
	4"	191.2	
	8"	225.4	
For Edmonton	1"	213.7	
	2*	313.3	
	4"	409.9	
	8"	483.1	
For Yellowknife	1"	329.5	
	2"	483.0	
	4"	632.0	
	8"	744.8	

Increasing the thickness of insulation increases the amount of fuel saved, but at a diminishing rate, while the cost of additional insulation increases nearly in proportion to its thickness. There is therefore some thickness beyond which it is not economical to go. This optimum thickness can be determined from the formula:

$$\text{Optimum thickness (T)} = \sqrt{\frac{JN(t_i - t_o)k}{PZ\ (10^3)}} - \frac{k}{U}$$

Wherein T = optimum thickness in inches
J = cost of useful heat, in dollars/million B.T.U.
N = hours per year that heat is required
Z = cost of insulation, in cents/sq.ft./1" thick
P = annual cost for depreciation, interest on invest.
Other symbols= same as in preceding examples

Examples: **Using** the above formula, the optimum thickness of -W- insulation for the conditions stated are tabulated below:

For Seattle	oil @ 504/gal.	T = 3.5"
	55 "	3.73
	60	4.00
	65	4.23
	70	4.47
For Edmonton	50	5.96
	55	6.33
	60	6.69
	65	7.04
	70	7.37
For Yellowknife	50	7.83
	55	8.30
	60	8.72
	65	9*17
	70	9.58

For buildings that are air-conditioned during the summer, the optimum thickness of insulation would be considerably greater, because the cost of removing heat from a room is much higher than adding heat. It should be noted that the values given above and on the preceding page are for 1,000 sq. ft. of wall only. Floors should usually be insulated also, and ceiling insulation is usually more important and effective than wall insulation. So, for all-around insulation of an average dwelling, the economy of insulation is more important than the above figures might tend to indicate.

7.0 MINIMUM PLANT AND OPERATING COSTS

7.1 Determination of Minimum Size Plant

The size of a Wood Fibre Concrete plant must be related to the market for the products and location of the market, access to raw materials, the availability of services and supplies and the availability of manpower.

The Northwest Territories market is limited by volume but with the increasing cost of fuel, the extremely cold weather in winter and the lack of effective fire protection, the market has a distinct need for qualities in the buildings which Wood Fibre Concrete offers.

Assuming that the first plant was established at Fort Resolution the main raw material requirement, wood fibre, would be plentiful. Cement, clay, diatomite and the minor quantities of other materials can be imported from Alberta. Diatomite may be available in the Northwest Territories soon in the future if a consistent demand is required.

The plant is not capital intensive. Services and supplies are available though more expensive than in Alberta. Labor is plentiful for the eight to ten people who will be required.

A minimum plant would produce components for one single-story dwelling, 1,300 sq. ft. floor area, per day.

Assuming that this would be used as a pilot plant for training and experimental purposes the production schedule would be:

May to October, 5 months, say, 100. days.

Production in the first year during the training and ' break-in period - 50% of capacity, components for 50 houses.

The plant machinery is easily transportable and can be moved on very short notice.

It would be practical to alternate the use of the plant from Fort Resolution, Fort Smith, Hay River and Fort Simpson for training purposes.

When the people are trained and market acceptance is assured, more permanent arrangements could be made.

7.2 Operating Statistics

7.2.1 Material Requirements - 100 days

Description	%	(100 units) Minimum Plant	(50 units) Pilot Plant
		Tons	Tons
Admix Diatomite Ceramic Clay Lime Others	12.5	400	200
Cement	37.5	1,200	600
Wood Fibre	40.0	1,280	640
Water	10	320	160
Total	100	3,200	1,600

Time Schedule - 100 davs

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
				10	20	20	20	20	10	-,	-

7.2.2 Estimated Capital Cost of Plant

Building 600 sq. ft. @ $25	$15,000
Admix equipment	4,500
Mixer - 2 yards capacity	3,000
Materials handling equipment	5,000
Dump-truck (borrow from sawmill)	
Contingencies, engineering & installation	12,500
	$40,000

7.2.3 Estimated Cost of Material - Fort Resolution
(Slave River Sawmill)

	per cu.yd.	per ton
Edmonton Admix Cement	$27.00	$50.00
Freight from Edmonton	21.60	40.00
Wood **Fibre** (shavings, sawdust) at Fort Resolution	2.50	8.10
Total	$61.10	$98.10

Estimated **Daily Cost** for Pilot Plant
(22.63 cu. yds.) W.F. C.

Annual cost of investment - 10% $40,000 x 10% ÷ 100 days	$ 40.00
Depreciation - 10% $40,000 x 10% ÷ 100 days	40.00
Labor - **3 men @** 8 hours x $6	144.00
Utilities, fuel, supplies, water	50.00
Materials (22.63 cu.yds.)	1,382.69
Total Daily **Costs**	$1,656.69

Cost per cu. yd.	- $ 73.20
Cost per unit	- $ 3,313.38
Annual cost - 100 days	- $165,669.00

8.0 HOUSING PRODUCTION AND COSTS

8.1 Assuming a production of 22.63 cubic yards of wood fibre concrete components per day for 100 days, approximately 50 dwellings would be constructed in the first year.

The cost of a dwelling 1,000 square feet has been estimated for: a frame house using lumber and plywood, and a wood fibre concrete house using wood frame construction.

A comparison of costs indicate a 25 percent saving by using Wood Fibre Concrete.

The costs were calculated on a unit basis by estimating the quantities of materials, i.e., framing and coverage, in detail. A flat roof would be used on the W.F.C. building.

Non-structural components were estimated using the Boeckh Building Cost Modifier for Edmonton with some freight added.

The delivered cost of lumber and plywood was taken at the retail level with freight added. (The lumber would be obtained from the sawmill at Fort Resolution) .

8.2 A comparison of the cost of a 1,000 square foot dwelling (25' x 40') is estimated as follows:

SUMMARY OF COST OF CONSTRUCTION
(See Appendix V)

No Basement Dwelling 25' X 40'	Lumber & Plywood	Wood Fibre Concrete with wood frame
Structure Cost	$17,426.00	$11,948.00
Non-Structural Components	11,442.00	11,078.00
TOTAL ESTIMATED COST per Dwelling	$28,868.00	$23,026.00

(Not including licenses, insurance, planning, administration, financing and contractor's profit).

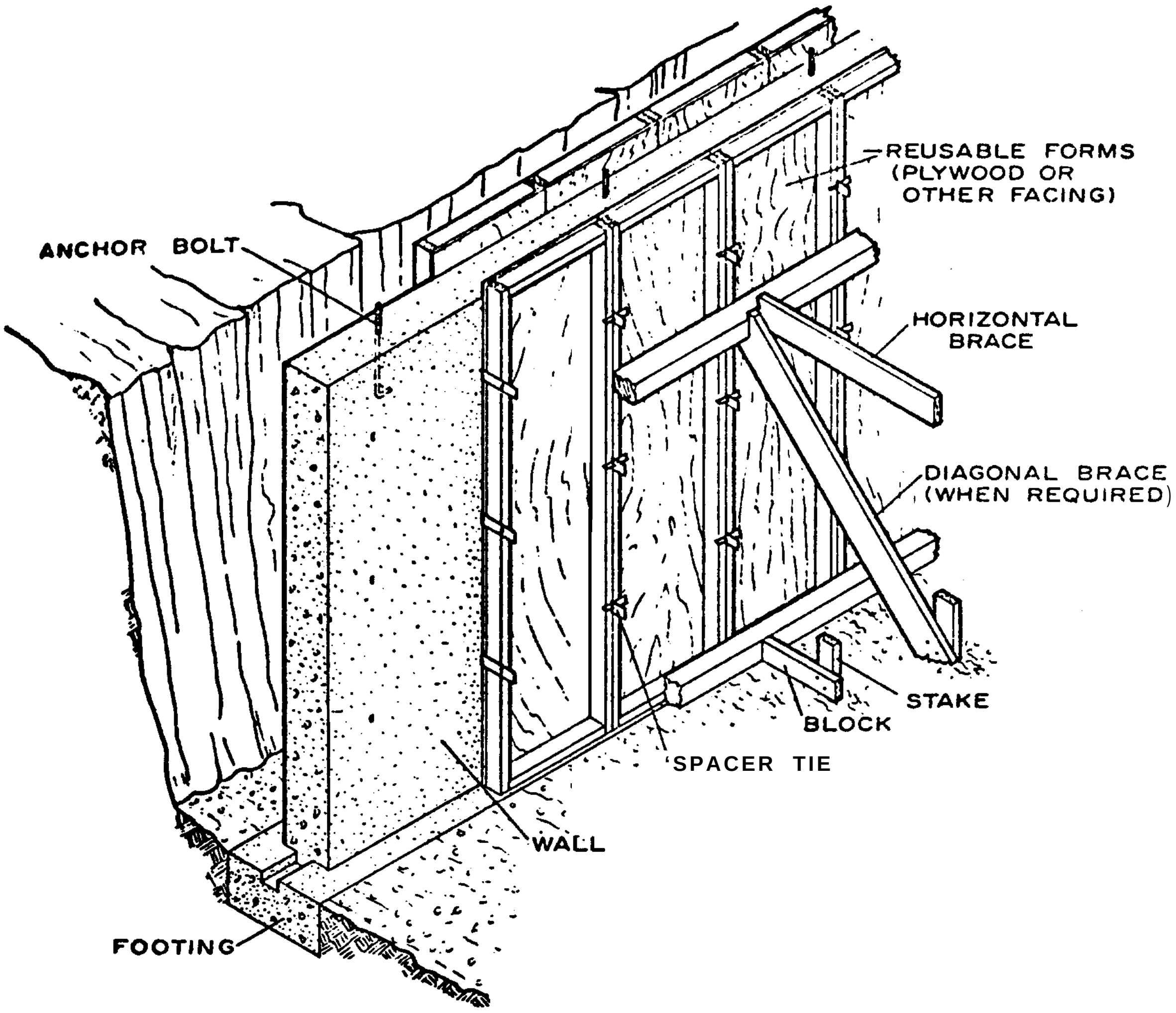
The unit cost of a Wood Fibre Concrete type home would be reduced by approximately $1,500 if the pilot plant operated at full production.

The Wood Fibre Concrete structure offers savings in building materials and manpower. (See Appendix V).

APPENDICES

APPENDIX I

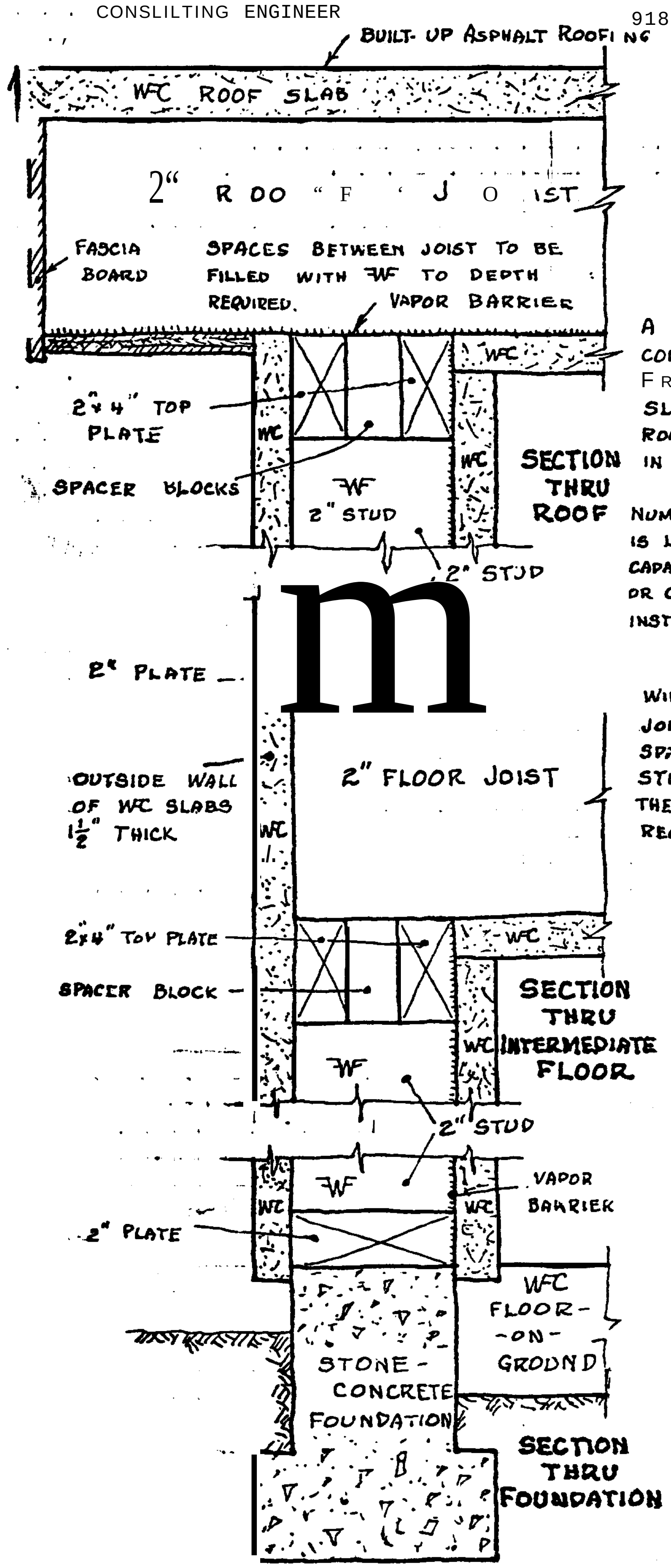
BUILDING FRAMES USING W.F.C.



EXAMPLE OF FOUNDATION WHERE REGULAR CONCRETE OR WOOD FIBRE CONCRETE COULD BE USED

Note: Reusable forms

W. R. Friberg, P. E.
CONSLILTING ENGINEER
TELEPHONE 624-7015
918 AZALEA DRIVE. SPOKANE, WASHINGTON 99204



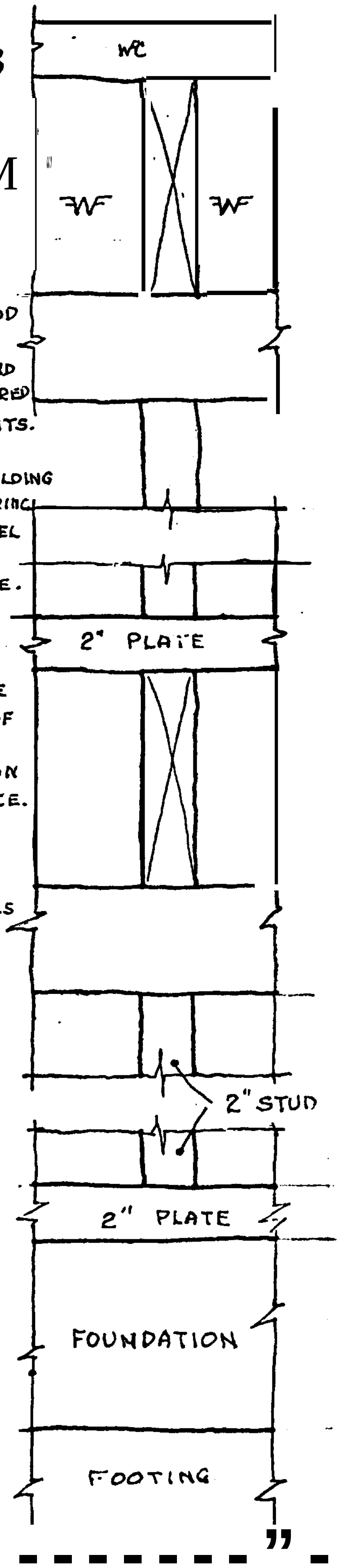
WC SLAB oaf POST & BEAM FRAME

A METHOD OF BUILDING CONSTRUCTION USING A WOOD FRAME COVERED WITH WFC SLAB UNITS. THE FLOORS AND ROOF MAY BE EITHER WFC POURED IN PLACE OR OF PRECAST UNITS.

NUMBER OF STORIES IN THE BUILDING IS LIMITED ONLY BY LOAD BEARING CAPACITY OF THE FRAME. STEEL OR CONCRETE MAY BE USED INSTEAD OF THE WOOD FRAME.

WIDTH OF FLOOR & ROOF JOIST IS DETERMINED BY THE SPAN AND LOADING. WIDTH OF STUDS IS DETERMINED BY THE THICKNESS OF INSULATION REQUIRED IN THE STUD SPACE.

CEILING AND INSIDE WALLS OF WFC 1½" THICK



20 Sept 76

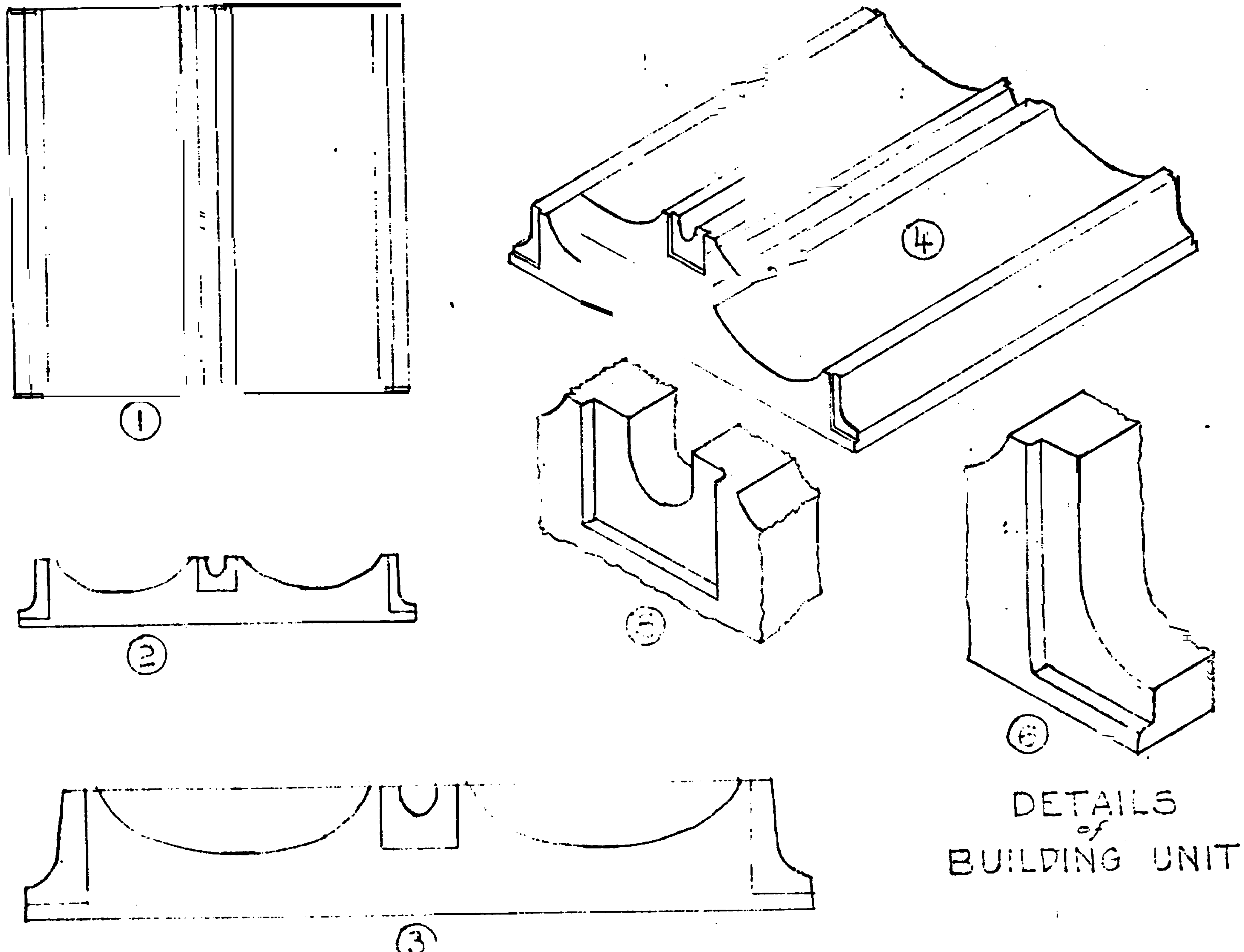
APPENDIX II

USES OF PRECAST W.F.C.

APPENDIX II

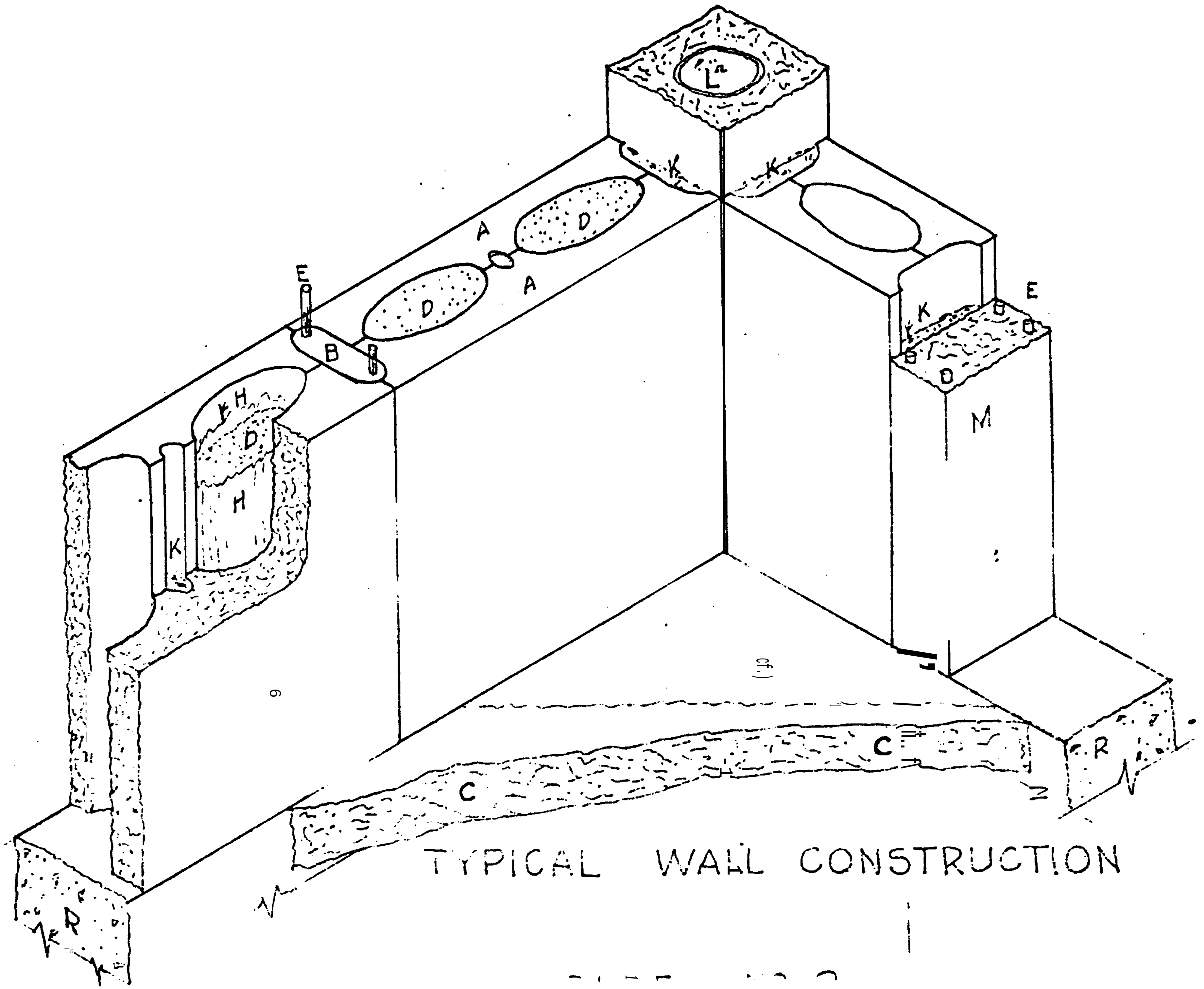
Attached drawings show possible ways of using precast W.F.C. units.

A manually operated mold was constructed. A number of these units was cast and used in the construction of Mr. Friberg's home in Spokane. The special shape is unnecessary. The flat slab mounted on a wood frame would be satisfactory, and be much less expensive to make and use.

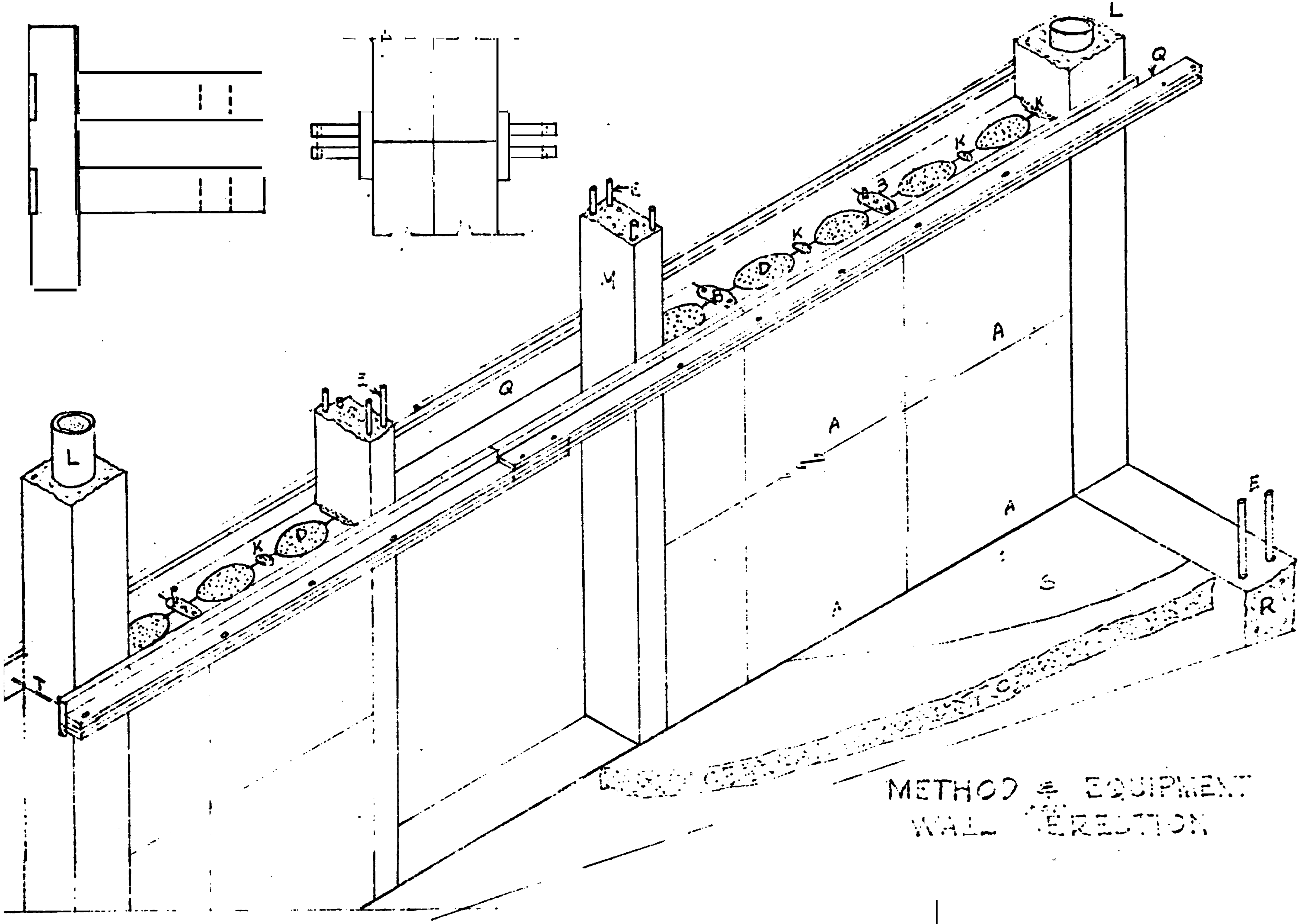


DETAILS
of
BUILDING UNIT

SHEET NO. 1

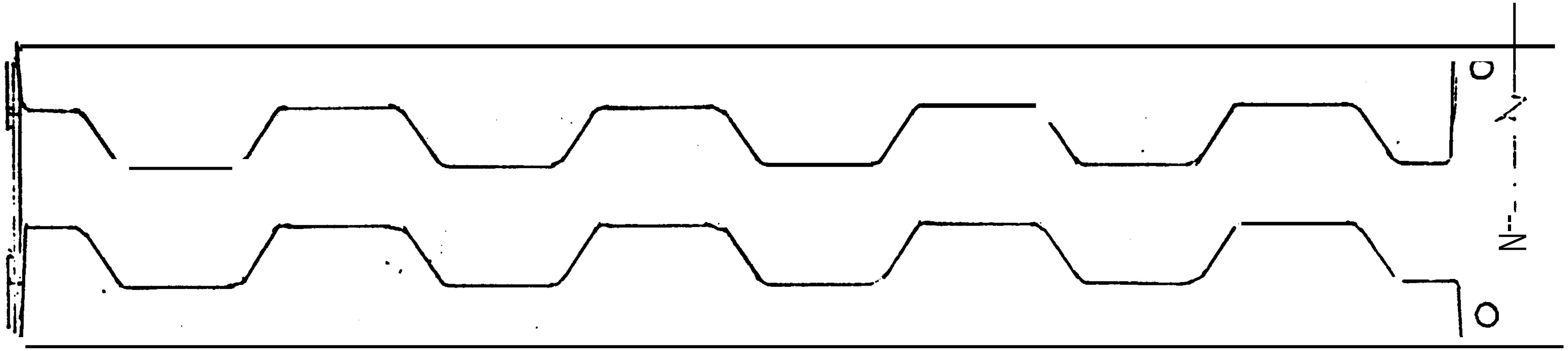


TYPICAL WALL CONSTRUCTION

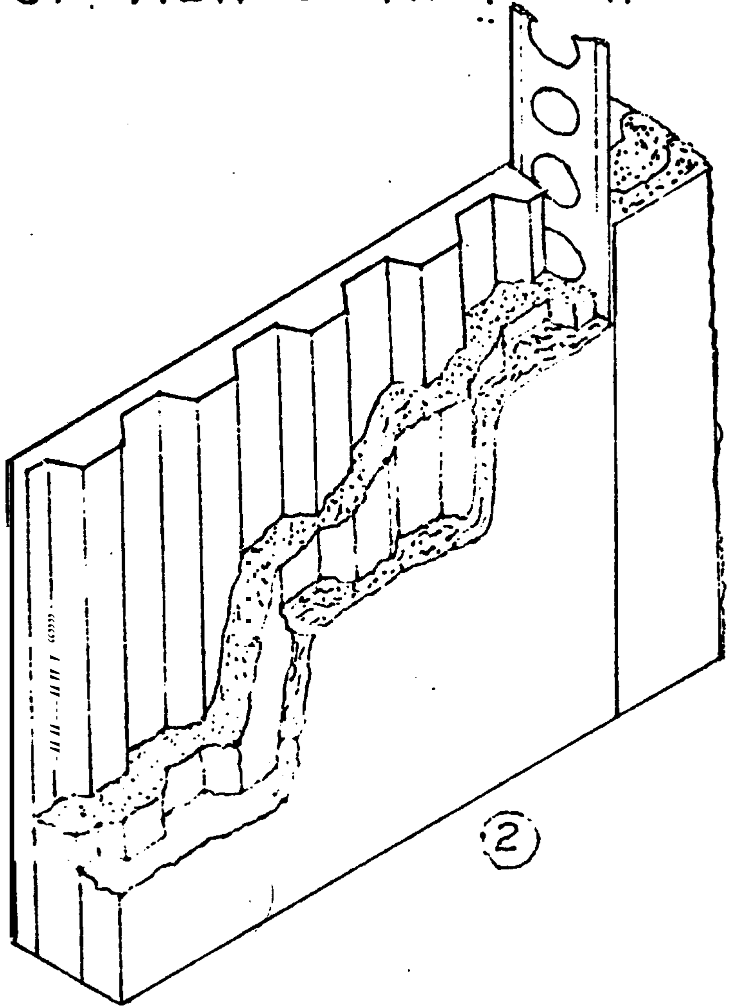


METHOD & EQUIPMENT
WALL ERECTION

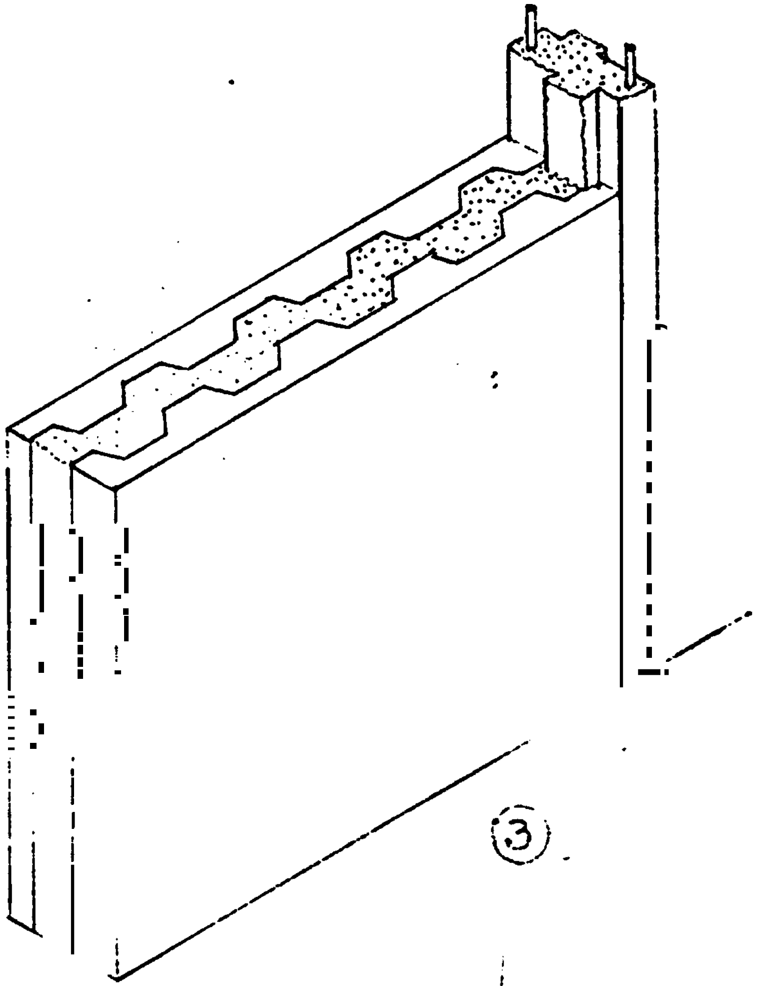
SHEET NO. 3



① TOP. VIEW of PARTITION or LITE-WALL UNITS IN PLACE



②



③

SHEET Nº 5

APPENDIX III

RESULTS OF TESTS ON WOOD FIBRE CONCRETE

FORM 407 REV.

PITTSBURGH TESTING LABORATORY

ESTABLISHED 1881

LABORATORY No. 76013

ORDER No. SP-4202

CLIENT'S No.

REPORT #1

Date: 7-29-75

Report to:

W.R. Friberg, P.E.
918 Azalea Drive
Spokane, WA 99204

Description: Tests on Specimens of a Special Wood-Fiber Concrete

* * *

Seven beam specimens were submitted for flexural loading; two cylinders for compression; and one slab for fire testing. It is our understanding that you need all the readings taken during the tests, so these are reported as recorded at the time of test. The deflections were measured by a dial instrument; on the beams, it was mounted at the mid-point, which was also the point of load.

COMPRESSION TESTS

The two cylinders were 12" X 6" diameter and were designated by the markings "M" and "N". The capped length of "M" was 12.13" and 12.09" for "N". In the table below P = load in pounds and d = deformation in inches.

	M	N		M	N		M	N
P	d		P	d		P	d	
100	.012		2600	.050		5100	.0811	
200	.016		2700	.051		5200	.083	
300	.017		2800	.052		5300	.0846	
400	.019		2900	.053		5400	.0864	
500	.0195	.010	3000	.054	.045	5500	.088	.074
600	.0205		3100	.055		5600	.0898	
700	.022		3200	.056		5700	.0916	
800	.023		3300	.057		5800	.933	
900	.024		3400	.0581		5900	.0951	
1000	.025	.0145	3500	.0591	.0461	6000	.097	.083
1100	.026		3600	.0605		6500	.107	.092
1200	.027		3700	.062		7000	.119	.104
1300	.028		3800	.063		7500	.1315	.127
1400	.029		3900	.0642		8000	.143	.13[illegible]
1500	.0301	.0192	4000	.0653	.0522	8500	.163	.148
1600	.0321		4100	.067		9000	.1827	.167
1700	.0325		4200	.0683		9500	.205	.190
1800	.034		4300	.070		10000	.203	.214
1900	.0345		4400	.0711		10500	.2615	.239
2000	.0365	.024	4500	.0724	.059	11000	.299	.278
2100	.039		4600	.074	.0	11500	.341	.320
2200	.0405		4700	.0751		12000	.393	.373
2300	.042		4800	.0771		12500	.459	.437
2400	.0445		4900	.0785		13000	.625	.594
2500	.0491	.0352	5000	.080	.065	13500	.625	.634
						14000	.749	.702

Failure in each cylinder was by crushing along planes roughly perpendicular to the cylinder axis. There was little evidence of failure in shear, and there was only slight increase of cylinder diameter when under the maximum load. See photos attached.

FLEXURAL TESTS

The beam specimens submitted were all 18" long and about 6" wide, and of various thicknesses, as given below. Three of these were marked "G", "H", and "I" (these designations are continued in this report), and were reinforced with 2" X 2" X 16 ga. welded wire mesh cast into the material about 1/8" from the lower face. One (marked "F" had one thickness of fiberglass woven cloth secured to the lower face with polyester resin. The other three ("B", "C", and "J") were not reinforced in any way. All were tested by imposing a concentrated load at mid-span, the supports being 16" on centers. The deflection was measured at mid-span; loading was continued past the point of failure to disclose more clearly the characteristics of the break. In the tables below P = imposed load in pounds; d = deflection in inches; b = width of beam in inches; t = thickness of beam in inches. l = span in inches = 16" for all.

	"B" b = 6.06" t = 4.343"	"C" b = 6.0" t = 4.25"	"J" b = 6.06" t = 3.11"
P	d	d	d
100	.006	.006	.023
200	.015	.022	.034
300	.022	.035	.047
400	.028	.046	.056
500	.035	,055	.075
600	.041	.063	
700	.0475	.072	
800	.0545	.081	
900	.061	.0s9	
1000	.068	.103	
1500	.112		

	"G" b = 6.0" t = 2.92"	"H" b = 5.875" t = 3.83"	"I" b = 5.94" t = 2.44"	"J" b = 5.88" t = 1.97"
P	d	d	d	d
100	.002	.005	.040	.015
200	.0145	.0135	.055	.042
300	.0285	.020	.067	.074
400	.040	.0258	.076	.113
500	.054	.033	.092	.162
600	.0725	.0395	.114	.213
700	.0935	.0465	.136	.275
800	.130 (750)	.054	.165 (750)	.356
900		.0625		
1000		.0705		
1300		.115		
1400		.160		

The primary failure in all the beams was in tension. The reinforcing wire snapped slightly before there was noticable tension cracks in the beams, and there was no evidence of crushing failure along the cross wires of the welded mesh, and indications were that a greater cross-sectional area of tension steel would increase the load bearing capacity of all beams, but especially "G" and "H". The fiberglass coating failed in shear (adhesion) near the ends of the beam, simultaneous with rupture in tension across one-half of the lower face directly under the point of load.

FIRE TEST

Specimen submitted was 18" X 18" X 3 1/8" and of the same material as that of the beams and cylinders tested.

An oven was built of brick and fireclay, with the specimen as one wall, 18" X 18", and an aperture in the wall opposite the specimen for the torch. Thermocouples were mounted on the inside and outside surfaces at the center of the slab, and the leads connected to a potentiometer, and the temperatures were read at 15 minute intervals during the test. The flames of a propane gas torch under pressure were directed against the inside surface of the specimen, and the temperature of the inside was maintained as closely as possible to 2000° F. A circular area in the center of the slab became incandescent in less than [illegible] minutes and remained so thru-out the test; the diameter was about 14" and the color from white in the center to red at the edges. Ambient air temperature was 87° F at the beginning and 65°F at the end of the test.

TEMPERATURES DURING TEST

T = time elapsed, in hours and minutes
I = temperature on inside face of slab, °F.
O = temperature on outside surface, °F

T	I	O
0	87	87
:15	2084	91
:30	2026	91
:45	1973	96.5
1:00	2046	104.5
1:15	1982	111
1:30	2115	120
1:45	2065	
2:00	1995	131
2:15	2048	132
2:30	2100	135
2:45	1980	137
3:00	1950	141
3:15	1966	143
3:30	1953	142
3:45	2034	145
4:00	2070	145

A stream of water at hose pressure was thrown on the hot face immediately upon the conclusion of the above test, and was continued until no more steam was given off.

About 30 minutes after the test began the hot face began to checker, or alligator, and this continued to increase slightly during the test. After completion of the test the slab was sawed into segments and this revealed that under the hottest part of the flame a layer of 3/4" thickness had formed; this was a brittle and frangible material of a light tan color, and the checkering was confined to this layer. Under this was a layer of charred material about 3/4" thick. The remainder of the slab thickness was apparently unchanged. There was no discernible gases or smoke given off by the material during the test, nor was there any measurable dimensional change. The water pressure dislodged some of the light colored layer, but none of the black layer.

Respectfully submitted

PITTSBURGH TESTING LABORATORY

J.H. Thomas
Spokane District Manager

jsb

4-Client
3-PTL

NOTES ON ESM TESTS MADE JUNE-JULY 1975

The tests included in this report were made on ESM specimens all cast at the same time from the same mixing batch. Compression tests were made on 2 cylinders each 12"x 6" dia; flexural tests were made on 7 beams, all by concentrated load at midpoint of a 16" span. Three of these beams were non-reinforced, they are designated B,C, and J. Four of the beams were reinforced, 3 by placing welded wire mesh 2"x 2"x 16 ga. in the bottom of the mold box and pouring ESM over it, thus simulating the use of ESM in a suspended floor pored over joists 16" o.c. These are designated G,H,and I. The fourth specimen was cast without reinforcement, then, when dry, a layer of fiberglass was stuck to the under side with polyester laminating resin. This simulated actual construction using precast units over joist, and the fiberglass-resin provides some reinforcement, a vapor barrier and a ceiling finish. The dimensionsoof these beams and their behavior under load are show shown on the accompanying charts.

The compression-deformation is shown on a separate chart. This is of secondary interest because ESM is not intended as a bearing material

The stress-strain diagrams were obtained by plotting the deformation at the loading point (as read from a deflection measuring dial during the testing operation) against the stress as calculated from the flexure formula S = Mc/I

To provide a perhaps more meaningful presentation of the ESM as a suspended flooring material, the following data is tabulated showing the carrying capacity in pounds per square foot at uniform loading. These values were calculated by averaging the stress-stain curves and finding their intersections at span/360 and span/240, the usually acceped maximum deflection allowable. As a safty factor the values were arbitrarily reduced to 73% of the reinforced beam value and 81% for the non-reinforced.

Uniform Loadding on Non-reinforced ESM

Joist 16" o.c.		Joist 24" o.c.	
Floor thickness	lbs./sq.ft.	Floor thickness	lbs./sq.ft.
2"	56	2.5"	39.07
2.5	98.2	3	56.25
3	127	3.5	76.56
3.5	172.8	4	99.99

Uniform Loading on Reinforced ESM Beams

Joist 16" o.c.		Joist 24" o.c.	
Floor Thickness	lbs./sq. Ft.	Floor Thickness	lbs./sq. Ft.
2"	84.4	2.5	58.59
2.5	131.85	3	[illegible].37
3	139.86	3.5	114.84
3.5	258.42	4	149.99

8 July 75

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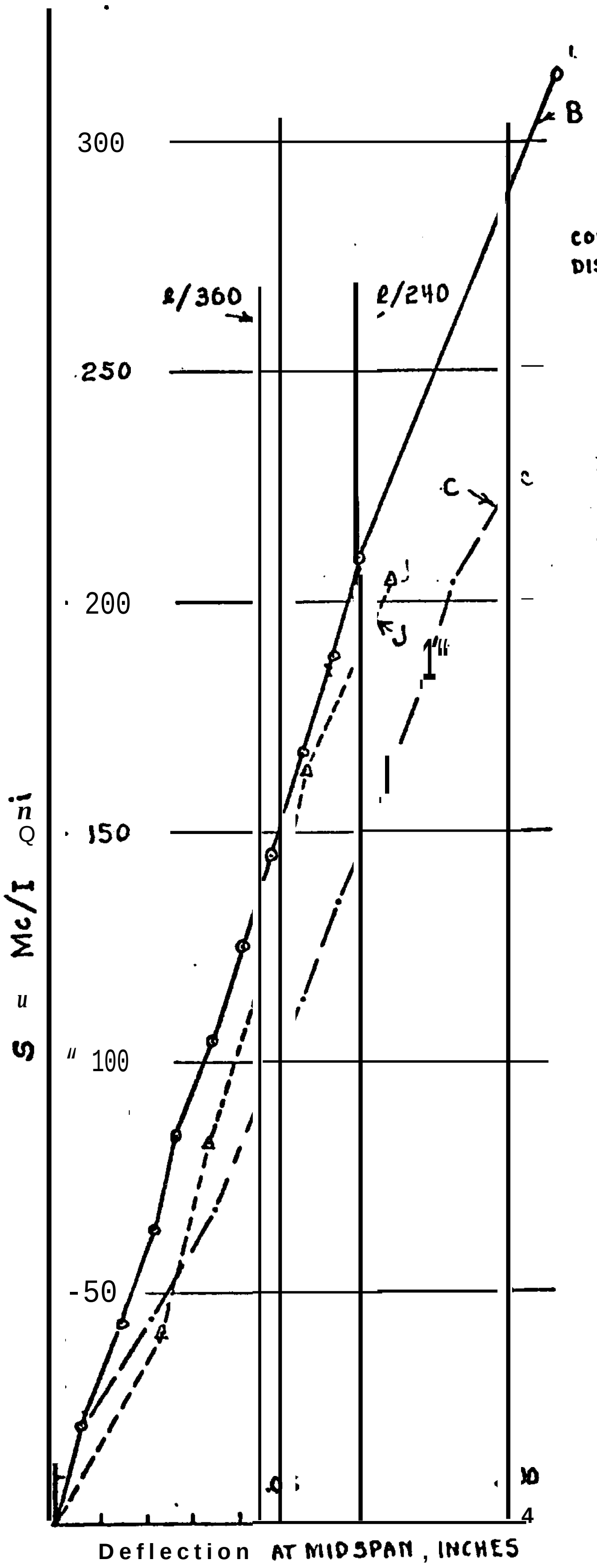
STRESS - STRAIN DIAGRAMS FOR NON-REINFORCED ESM BEAMS



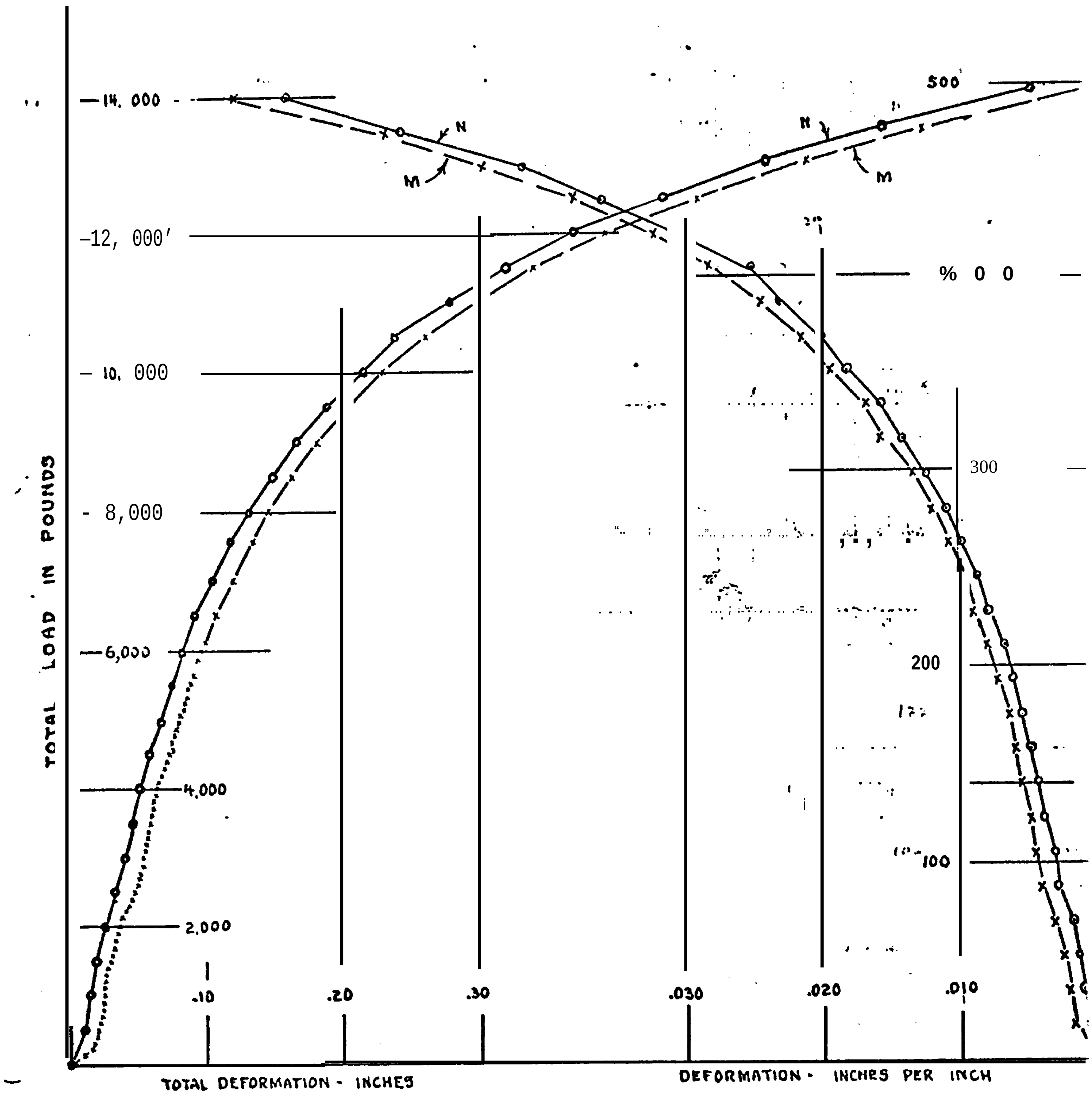
CONCENTRATED LOAD AT MID SPAN
DISTANCE BETWEEN SUPPORTS = 16"

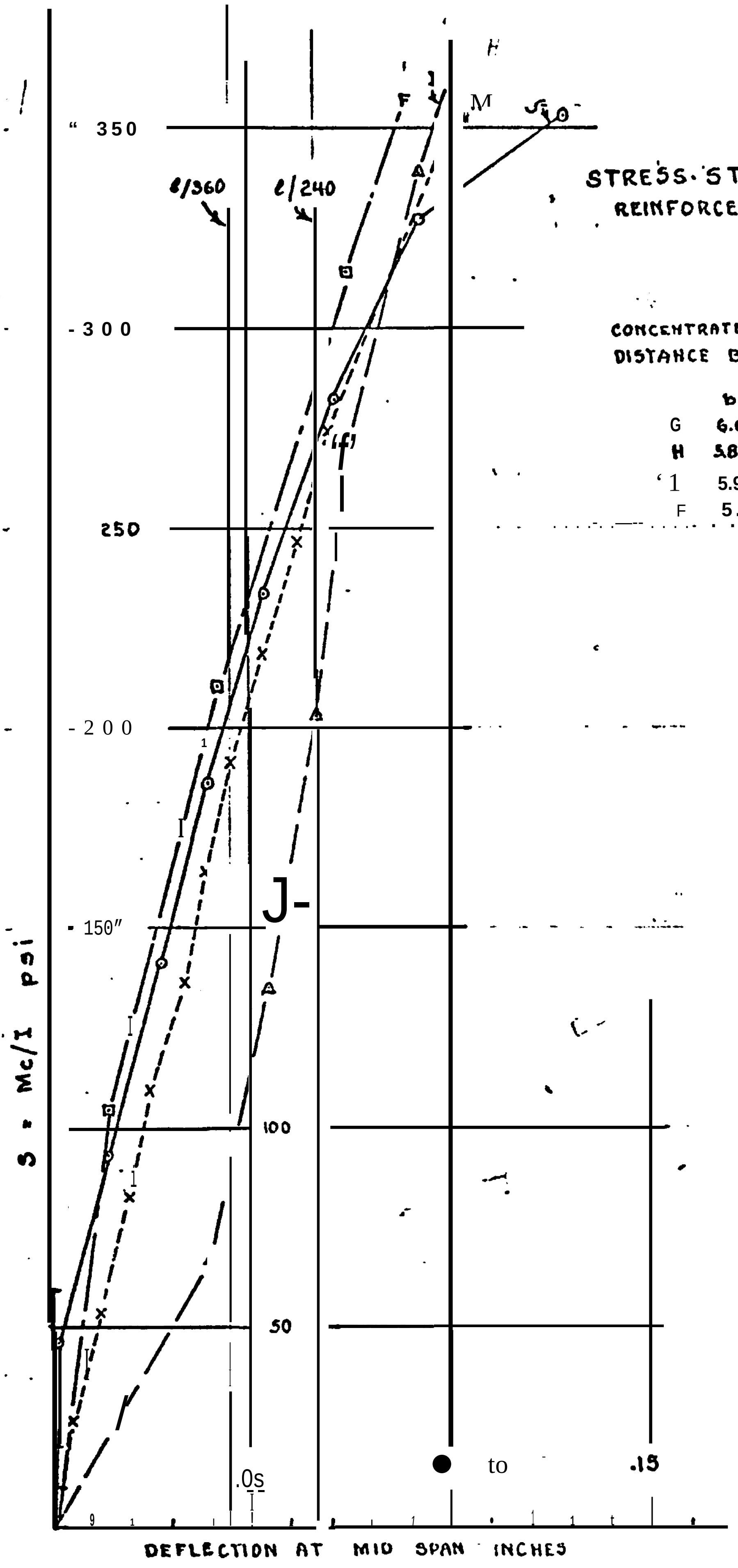
	b	d	I
B	6.06"	4.343	41.368 "
C	6.0	4.25	38.385
J	6.06	3.11	15.197

CHKD BY........ DATE ....

JOB NO.....

LOAD- DEFORMATION CURVES
6"x12" ESM CYLINDERS





STRESS-STRAIN DIAGRAMS
REINFORCED ESM BEAMS

CONCENTRATED LOAD AT MID SPAN
DISTANCE BETWEEN SUPPORTS = 16"

	b	d	I
G	6.0"	4.92	12.45
H	5.875	3.83	27.87
I	5.96	2.44	2.169
F	5.88	1.97	3.745

APPENDIX IV

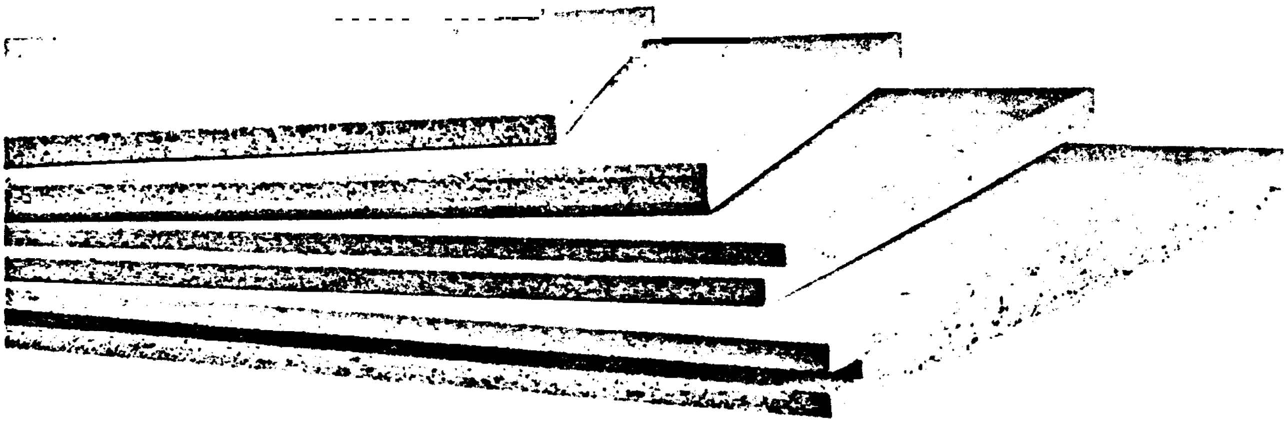
OTHER WOOD FIBRE COMPOSITION MATERIALS

A. PRODUCTS - DURISOL (SWISS)

B. PRODUCTS AND PRICES - DU-AL **(CANADIAN)**

Information

Duripanel



Building with Duripanel

Bauen mit Duripanel®

Construire avec Duripanel®

Eigenschaften qualities

unbrennber* incombustible
feuerwiderstendsfahig ** fire resistant
witterungsbestandig weather resisting
bruch- und schlagzah resistant of Crashes
termitensicher termite resistant
pilzresistent fungus resistant

lässt sich wie Zementprodukte verputzen und streichen, abar auch wie Holzwerkstoffe beschichten und mit gewohntem Schreinerwerkzeug (Hartmetall) bearbeiten.

Anwendungsgebiete

Fassaden Facade
Trennwände Separating Wall
Böden floor
Decken ceiling
Nasszellen wet cell
Stützenverkleidungen Supporting beam cover
techn. Anwendungen für Industrie und Gewerbe
Technical use for Industry + Trade

***Schweiz/suisse:** VI q

Caracteristiques

incombustible*
résistant au feu**
r6sistant aux **intempéries**
rs$sistant a la rupture et aux chocs
r6sistant aux termites
résistant aux attaques cryptogamiques
peut **être crépi** et peint comme les produits en ciment ainsi **qu'être revêtu** comme le bois et **façonné** avec l'outillage de menuisier usuel (metal dur).

Domaine d'application

Feqades
Perois de separation
Sols
Plafonds
Cellules humides
Revilements de piliers
Applications techniques clans l'industrie et l'artisenat

● *EMPA-Attest/Certificat LFEM: 18 mm = F30, 28 mm = F60

Durisol AG fur Leichtbaustoffe
Durisol Materiaux de construction **légers** SA
Bademwstresse 21
8963 Dietikon ZH
Tel 01 / 88 69 81(ab IQ 1175. 740 69 81)

Durisol

Durisol AG für Leichtbaustoffe
Durisol Matériaux de construction légers S. A.
Badenerstrasse 21
CH-8953 Dietikon

Durisol

Telefon 01 666981
(ab 19. Nov. 75:01 74069 81)
Postcheck 80-12896
Telegramm Durisol Dietikon
Telex 58724 durol ch

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SEP 03 1975
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copy

C. D. Schultz & Company Ltd.
Foresters and Consulting
Engineers
Att. Mr. J. R. Blackstock'
325 Howe Street
Vancouver, V6C 2A1
Canada

Ihr Zeichen	Unser Zeichen	Dietikon
JRB/ed	JS/ik	September 4, 1975

Duripanel

Dear Mr. Blackstock,

We kindly thank you for your letter dated August 29, 1975 and the interest in our new product Duripanel, the cement-bonded particle wood panel.

Your attention brought to the new building board is fully justified. Duripanel is in fact an entirely new type of building board on the construction market and is not comparable with other boards regarding its properties and its wide range of applications.

The enclosed documents give you all interesting information. In particular we would like to draw your attention to the fact that this new board is absolutely frost-resistant.

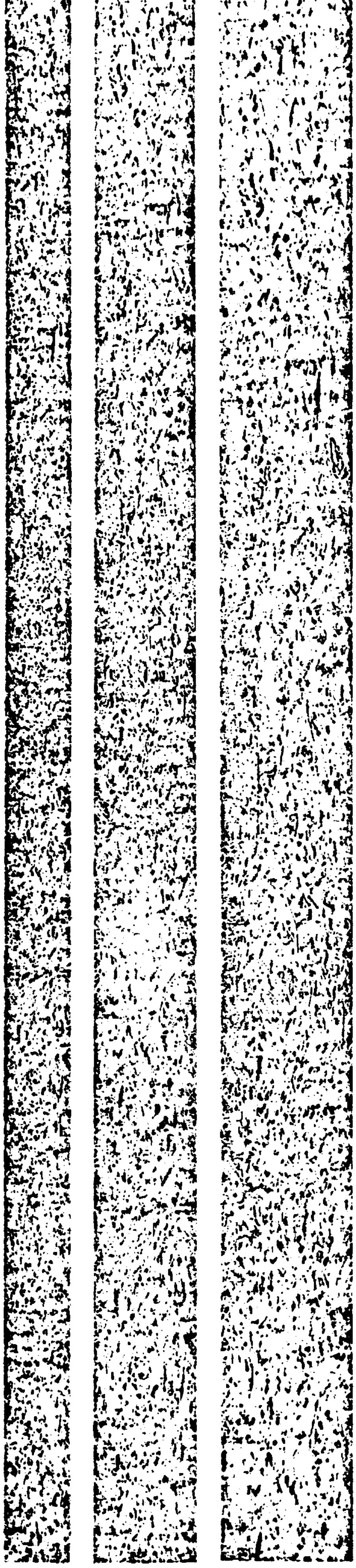
The heat-insulation in a double-skin Duripanel-element is secured by a supplementary mineral fibre board whose thickness can be chosen.

If you should require further information, we shall be pleased to supply you with them. Hoping to have been of good service to you, we remain,

Yours sincerely,

DURISOL
AG fur Leichtbaustoffe

Encl.



Duripanel®

Technical data and production program

Physical properties

Density–according to expected properties: **(at an ambient humidity of 10% by weight)**	1100–1350 kg/ins
Thermal conductivity	λ = 0.220 kcal/mh°C
Thermal coefficient of expansion	β = 0.01‰ °C
Specific heat	c = 0.35 kcal/kg°C
Water vapor resistance factor	μ = 4 5

Mechanical properties

Bending strength (at rupture) (according to density)	σ_B = 90–140 kp/cm^2
Tensile strength (perpendicular to surface)	00 = 4–6 kp/cm^2
Tensile strength (parallel to surface)	σ_Z = 50 kp/cm^2
Compressive strength (parallel to surface)	σ_D = 150 kp/cm^2
Modulus of elasticity	E = 35,000–50,000 kp/cm

Other properties

Expansion and shrinkage parallel to surface (at variation of the humidity of the board by about 1% by weight)	0.02%
Expansion in thickness (after 24 hours water immersion)	1.2-1.8%
Fire properties of the construction material Duripanel®	
According to Swiss classification	practically incombustible
USA flammability tests	incombustible
FR Germany (DIN 4102)	A2 requested
Behaviour of construction units under fire (according to execution)	f30, f60, f90
Smoke evolution	low
Toxicity	negligible
Freeze-thaw test (with water-immersion) 150 cycles –20"C1+20'C	weather and frost-resistant
Resistant against fungi, rotting, termites, sound insulating	

The following institutes have ***tested Duripanel®***

Federal Testing Institute for materials (EMPA), Dubendorf, Switzerland ● Institute for building physics, Berne, Switzerland ● Research laboratory of Duripanel, Dietikon, Switzerland ● Material Testing Institute, University Karlsruhe, FR Germany ● Institute for building physics, Stuttgart, FR Germany e Federal Testing Institute for materials, Berlin, FR Germany ● Technical University, Aachen, FR Germany ● Technical University, Munich, FR Germany ●

Production program, sizes

Ex factory

Width: 125 cm
Length: 250,260,300,310 cm
Thickness: 10,12,14,16,18,20,22, 24 mm
Edges: trimmed
Surface: non treated

Upon request

Special sizes cut upon request
Edges: with groove, tongue, or shiplaped
Surface: untreated or laminated, colour and texture as desired.
Laminated with plastic sheet, wood or felt

Durisol

01 /886981

Durisol AG fur Leichtbaustoffe CH-8953 Dietikon/Schwei

Duripanel®

The new building material for light-weight construction

Wood and cement were always recognized natural products for the building industry. Wood is light and its **tensile** strength is good, cement does not burn and is weather-resistant.

The characteristics of these two building materials would uniquely complement one another if it were possible to combine wood with cement in a chemically and physically fused compound, thereby creating a completely new building material. About 35 years ago the **Durisol AG** developed the necessary process and ever since produces Durisol. It is now being manufactured in more than a dozen countries around the world using the Know-how of Durisol of Switzerland.

In the late sixties, Durisol successfully developed a manufacturing process to fuse cement-bonded wood fibres into highdensity building panels with good tensile strength and uniform quality. During the following five years, several institutes and specialists in Switzerland and Germany collaborated to research, develop and test the new product. Today, the new construction panel, which we call Duripanel is ready for the market. In the well-known firm of Bison Werke, Springe (FRG), Durisol found a suitable partner for the design and construction of a plant where Duripanel ® can be industrially produced.

Operation of the first industrial Duripanel production plant started in autumn of 1974 at Dietikon (Switzerland).

Duripanel® is the light-weight building board of the future,-combining the advantages of wood and cement: incombustible, weatherproof, termite and fungus resistant, it can be plastered like cement products, coated and processed like wood.

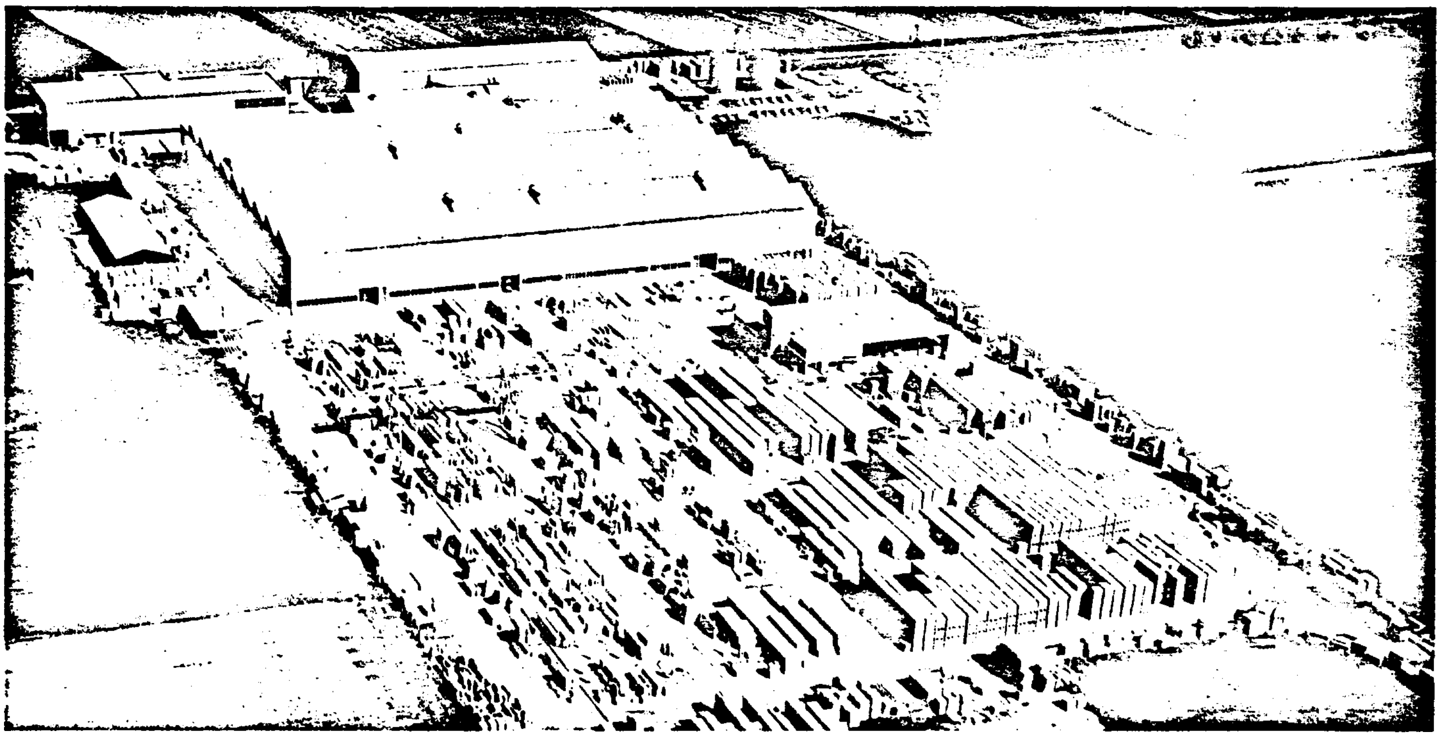
Duripanel® rationalizes and reduces building costs.

Call for our technical assistance.

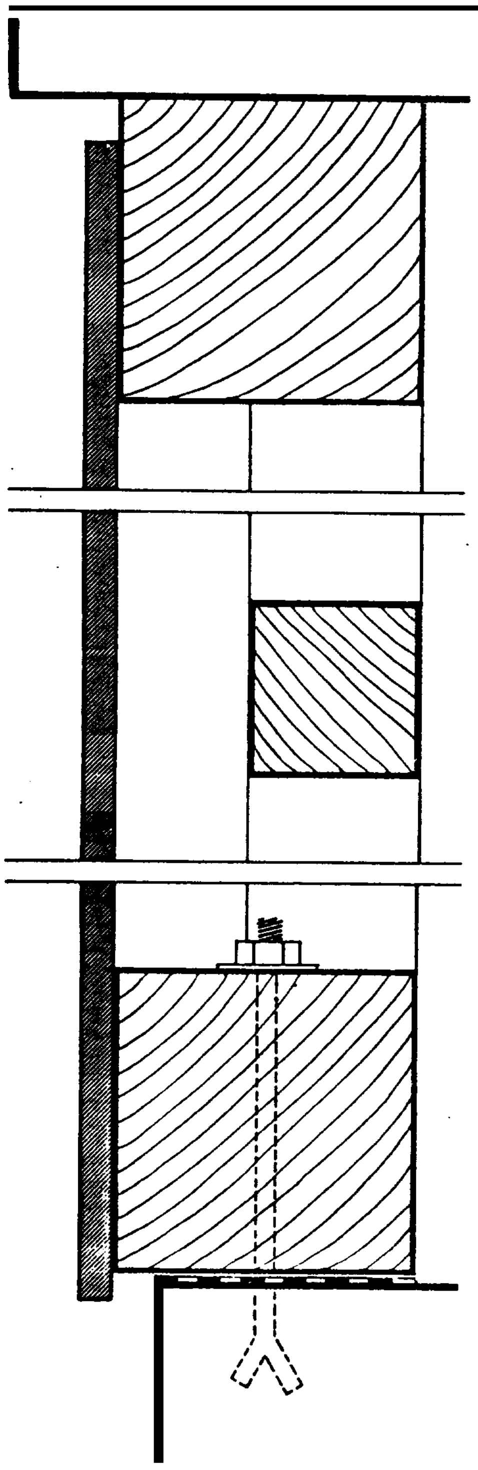
Durisol AG fur Leichtbaustoffe
Badenerstrasse 21
CH-8953 Dietikon (Switzerland)
Telex 58724 durol ch

01 /886981

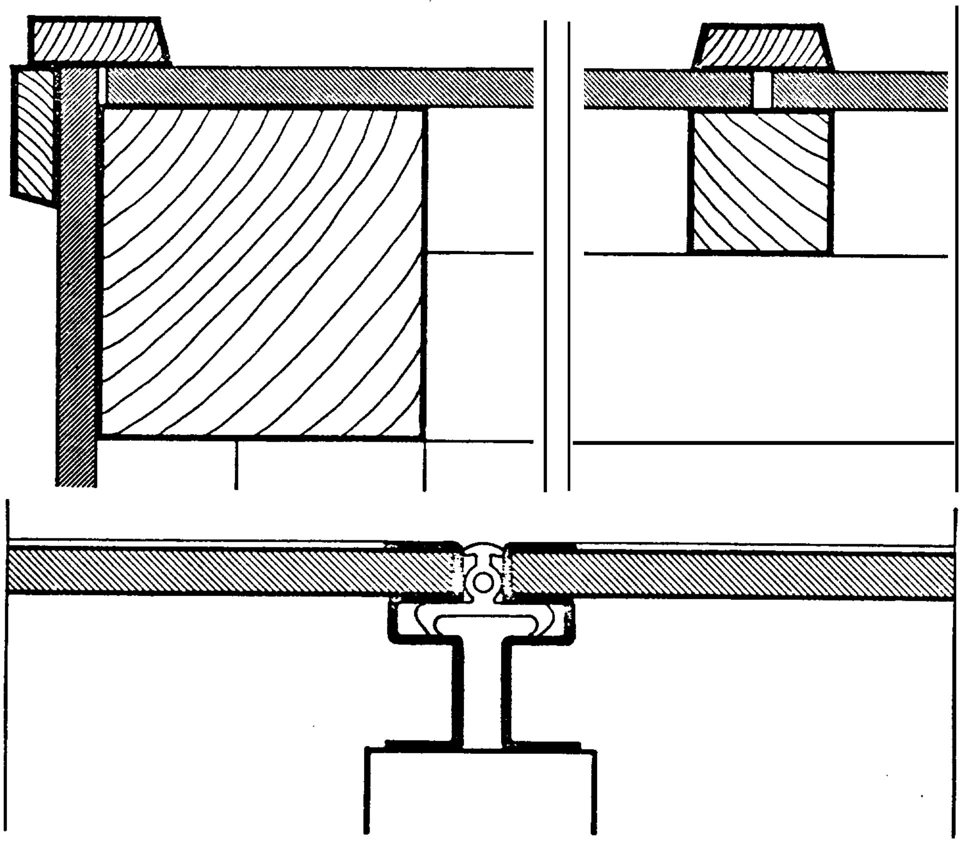
(from 19th Nov. 75: 01/ 74069 81)



5. Exterior wall, single-facing for non-heated warehouses.



Heat transmission (without considering frame)	"U" value: 0,68 BTU/sq.ft.hr.°F
Sound protection	----
Fire protection	f 30



Even for simple structures, the choice of materials will often be influenced by the looks of the finished building. The direct application of one layer onto the wooden framework is possible, eventually with an interior and exterior protection against moisture absorption. (View A).

If Duripanel® has to be installed without protective or colour coating or directly to metal profiles, a gliding connection with clamps or tongue and **groove** profiles is recommended. (View BI an B2).

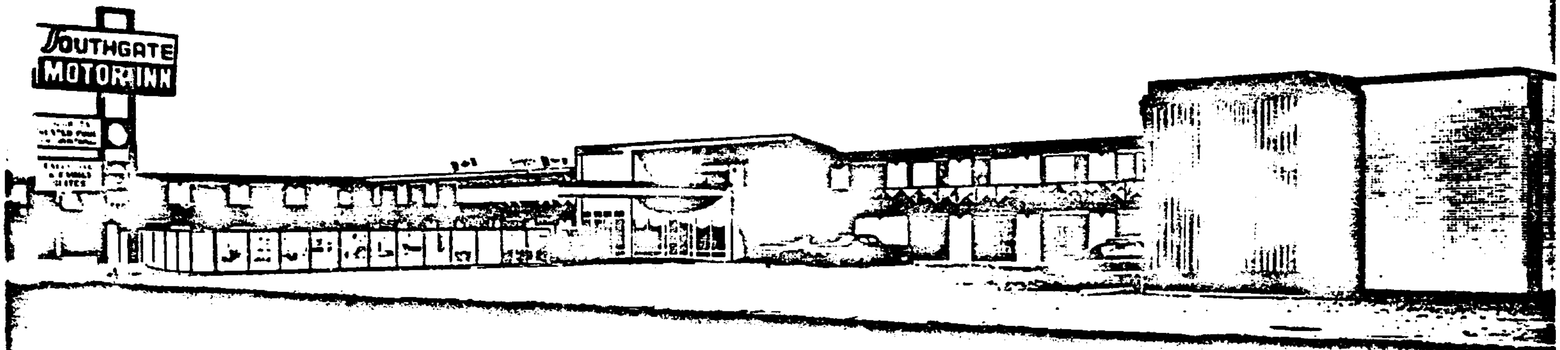
In function of board thickness and fastener distance, one has to expect with built-ups like B1 and B2 slight deformations when using non-treated boards.

Duripanel®

Durisol **AG für Leichtbaustoffe**
Badenerstrasse 21
CH-8953 Dietikon (Switzerland)
01 / 88 69 81

The DU-AL System for better living

MOTELS APARTMENTS HOUSES TOWN HOUSES RESORTS DU-AL Insulated Basements



DU-AL BLOCKS (1967) LTD.
(Manufacturers & Distributors)
P.O. Box 2267
Edmonton, Alberta, Canada


s pioneer De

North's Metis, needy to get rental housing ai

By ART SORENSEN
Of The Journal

YELLOWKNIFE, N.W.T. — Details h

idations designed
using shortage

THE EDMONTON JOURNAL, Friday, March 15, 1968

Housing Crisis

Assembly Line Pr

D. B. MENZIES

Meet the FIAT 124
TION WAGON

All Give Han
To Solve N.S.
Housing Crisis

Ottawa, Province
Stepping Up Assistance

One of a series
By DUART FARQUHARSON
Southam News Services

HALIFAX—Everyone is trying to do something to solve the housing crisis in Nova Scotia.

olics take first ste
o provide low-cost housi

ilder plans quick-built suites

he urgent tone of news headlines tell he story, but what's the solution?

e housing shortage has become so
tical that all levels of government
e becoming involved.

sk forces have been appointed—
dy groups and crown corporations
e being established in an
empt to deal with this
ntinent-wide dilemma.

e cost of housing is spiraling rapidly;
h no let-up in sight,
d unfortunately, high costs no
ger guarantee high quality.
dies clearly show that Canadians
e becoming urbanites at an
reasingly faster rate. It is estimated that by 1980 three out of every five Canadians will live in large metropolises surrounding Montreal, Toronto and Vancouver. Other major cities are already following this trend.

We have no alternative-we must solve the problem of how to house many thousands of families each year. We have to explore new methods and utilize the latest technological advancements to transform the house-building trade from a fragmented customer's service to a modular system dwelling industry,

APPENDIX V

ESTIMATED COST OF CONSTRUCTION

No Basement Dwelling 25' x 40'

Lumber and Plywood Structure (Structural Components)

			Unit Cost	Sub Total	Total
Dimension					
Ceiling & Flr.	Joists	4,000 B.M.			
Walls	Studs	2,000			
Roof	Rafters	1,200			
Roof	Bracing	500			
Porch & steps		300			
	Beams	1,000			
Plates, Caps	Stringers	500			
		9,500	@ $ 300.00	$ 2,850.00	
	Nails	300 lbs.	@ .60	180.00	$ 3,030.00
Boards					
Sub-floor	Shiplap	1,200			
Ceiling	Shiplap	1,200			
O.S. Walls	Shiplap	3,000			
Gables	Shiplap	200			
Roof overhang	**C.M.**	500			
Porch (2)	**C.M.**	500			
Falsework	**Boards**	1,000			
		7,600	@ 350.00	$ 2,660.00	
	Nails	210 lbs.	@ .60	126.00	$ 2,786.00
Plywood					
I.S. Walls	9/16" G.I.S.	2,400 sq.ft.			
Valances & trim incl. closets	9/16" G.I.S.	1,000 Sq.ft.			
		3,400 Sq.ft.	@ .50	$ 1,700.00	
Floor	3/4" G.I.S.	1,200 Sq.ft.	@ .75	900.00	
O.S. Walls	3/4" Siding	2,000 B.M.	@ 500.00	1,000.00	
Roof	**9/16"** Sheath.	1,500 sq.ft.	@ .30	450.00	
	Nails"	400 lbs.	@ .60	240.00	$ 4,290.00
Labor					
25.2 B.M. x 35 hrs. = 882 **hrs.**					
Carpenter		382 hrs.	@ 10.00	3,820.00	
Laborer		500 hrs.	@ 6.00	3,500.00	$ **7,320.00**
TOTAL *COST* STRUCTURE - Lumber & Plywood					**$17,426.00**

Estimated Cost of Construction - continued

NO **Basement Dwelling 25′ x 40′**			**Wood Fibre Concrete with Wood Frame (Structural Components)**		
			Unit Cost	**Sub Total**	**Total**
Dimension					
Ceiling 61 Fir.	Joists	5,000 B.M.			
Walls	Studs	2,000 B.M.			
	Bracing	500 B.M.			
Porch & Steps		300 B.M.			
	Beams	1,000 B.M.			
Plates, Caps	Stringers	500 B.M.			
		8,300	@ $ 300.00	$ 2,400.00	
	Nails	240 lbs.	@ .60”	144.00	$ 2,544.00
W.I?.C. Slabs					
Sub-floor	3½"	1,000 Sq.ft.			
Roof	3½"	1,500 Sq.ft.	@ .79	1,976.00	
O.S. Walls	1½"	2,000 Sq.ft.			
Ceiling	1½"	1,500 Sq.ft.			
Porch	1½"	500 Sq.ft.			
1.S. Walls	1½"	2,400 sq.ft.			
		6,400 sq.ft.	@ .35	$ 2,240.00	
	Nails	270 lbs.	@ .60	162.00	$ 4,378.00
Plywood					
Valances & 1.S. closets	9/16" G.I.S.	1,000 sq.ft.	@ .50	$ 500.00	
	Nails	20 lbs.	@ .60	12.00	$, 512.00
Labor					
17.7 B.M. X 35 hrs. = 619 hrs.					
Carpenter		200 hrs.	@ 10.00	2,000.00	
Laborer		419 hrs.	@ 6.00	2,514.00	$ 4,514.00
TOTAL COST STRUCTURE - Wood I?ibre Concrete with Wood Frame					$11,948.00

Estimated Cost of Construction - continued

Non-Structural Components Installed Costs
(Reference Boeckh Building Cost Modifier Aug. 1975)

No Basement Dwelling 25' x 40'	Unit cost	Frame Lumber & Plywood Sub total	Wood Fibre Concrete with Wood Frame Sub total
Excavation depth - 2'	.117	117.00	117.00
Piling 20 pcs. 30' installed	100.00	600.00	600.00
Windows	.47	470.00	470.00
Storm (Wood storm, sash, and screens)	.34	340.00	340.00
Doors and trim	.50	500.00	500.00
Floor - Vinyl	.72	720.00	720.00
Paint per sq.ft.	.80	800.00	*1,000.00
Roof - Asphalt	.72	720.00	
Roof - Cement	.40		400.00
Electric Service	.84	840.00	840.00
Plumbing (bath & 3 fixtures)		1,792.00	1,792.00
Sewerage - Septic		756,00	756.00
Cupboards		1,117.00	1,117.00
Chimney - outside		1,223.00	1,223.00
Fireplace		437.00	437.00
Gutter, (aluminum, inst.)		350.00	350.00
Insulation (Rockwool)		660.00	
**Fireproofed Wood Fibre (52 cu.yds.)	8.00		416.00
TOTAL Non-Structural Components		$11,442.00	$11,078.00

***Paint for W.F.C. building 25% higher than lumber and plywood.**

**Cost estimated to be $8.00 per cubic yard. (Treated wood fibre and Portland Cement sometimes referred to as wood wool) .