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# THE USE OF FIBRE BUILDING BOARDS IN THE JOINERY INDUSTRY [1/]

by

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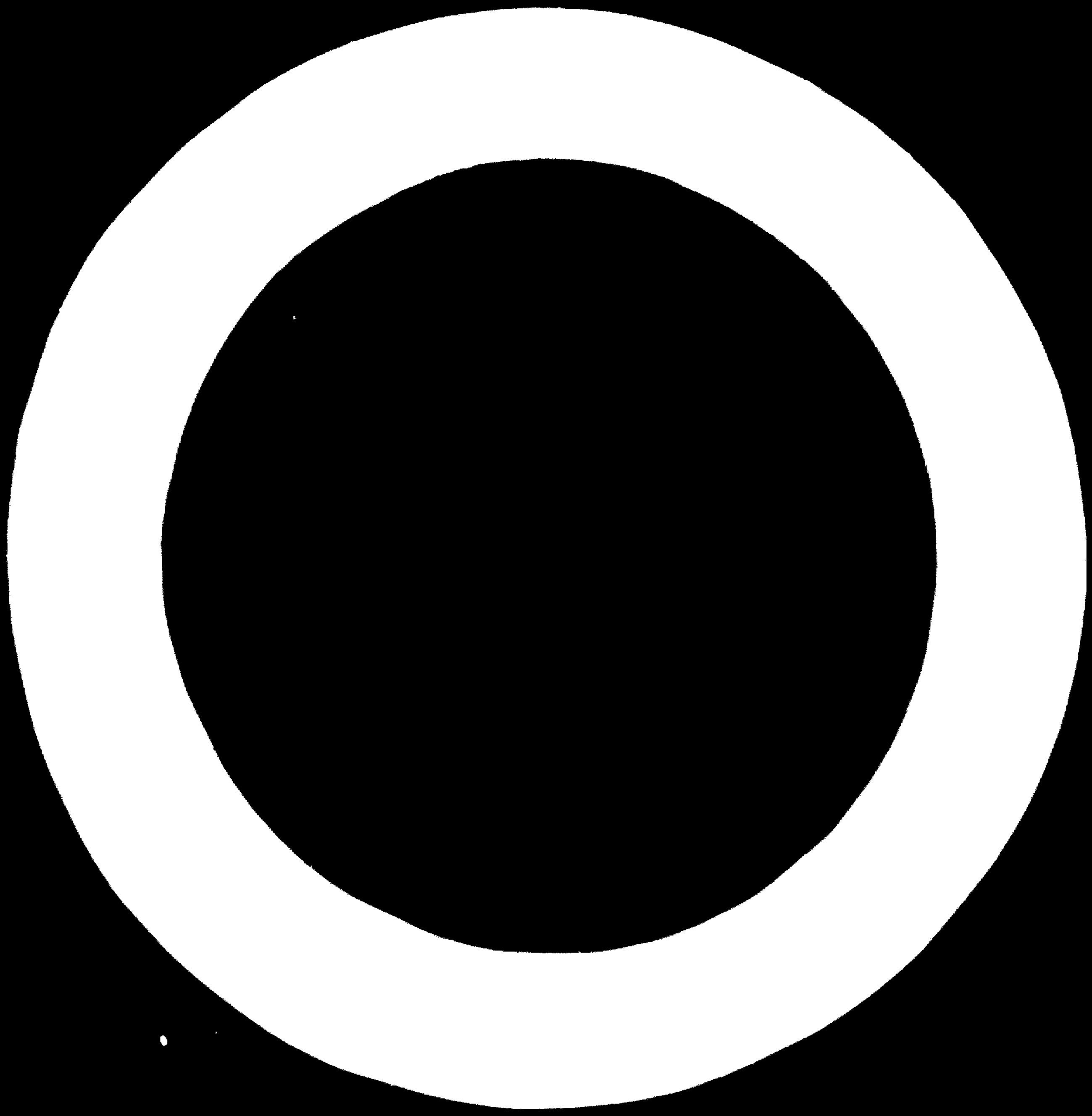

# THE USE OF FIBRE BUILDING BOARD IN THE JOINERY INDUSTRY

by

Anjal Kaila

## Building and joinery industry

Housing and housing policy are one of mankind's most essential problems. In every country, new dwellings are needed and old dwellings must be kept in good condition and be brought up to date. Stipulating the level of requirements on buildings and furniture is a matter of standardization that ranges beyond national borders. This standardization refers to buildings, dimensions, choice of material and correct use of material. The joinery and furniture industry are an important part of this whole, that nowadays, because of the expense, is a well automated branch of production.

## Board products

Among vegetable raw material, wood and wooden boards are products that mankind will never run out of. Different board qualities have individual properties, which appropriately used will produce the best results. The present extensive knowledge of board properties makes this possible.

Besides plywood, blockboard and chipboard, fibre building board is a raw material widely used by the joinery industry. Its use is even increasing owing to the versatile collaboration with plastics. It is a fact that wood often serves as a model for the properties of plastics, primarily because the properties of wood are excellent. Development seems to bring us more and more to collaboration between wood and plastics.

## Different types of fibre building board

The classification of fibre building boards into different types is based upon:

- the method of manufacture
- the mode and circumstances of use
- the density in $kg/m^3$

Density forms the basis of the existing international classification of fibre building board. The ISO classification is as follows:

| | | | Thickness |
|---|---|---|---|
| - hardboard | density $kg/m^3$ | $> 800$ | 2 - 8 mm |
| - medium board | " | $> 350 \quad < 800$ | 6 - 30 mm |
| - soft board | " | $\leq 350$ | 9 - 32 mm |

So wide a density scale guarantees a wide range of use for fibre building board with the possibility of choosing the right type of board according to each object. In the joinery industry, principally hardboard and medium board are used, i.e. density range from 0.65 - 1.20. Soft board is used in the building industry as decorating and insulating board, particularly impregnated with bitumen for use in moist places.

## Strength and mechanical properties of fibre building boards

Forest Products Laboratory, Madison USA, has published in 1967 a summary of wallboards' strength and mechanical properties, that is given in table 1.

## World fibre building board industry

Fibre building board mills were built to utilize residues from sawmills and paper mills or to utilize inferior raw material. This new industry first secured a foothold in U.S.A. and in the Nordic Countries. The production of soft board grew rapidly in U.S.A. but for a long time Mason's hardboard patent restricted the production of hardboard elsewhere. In Europe the manufacture of hardboard and medium board went ahead after Asplund's (Sweden) new production method and the output of these boards has risen continuously throughout the world. Latest development for production of hard and medium board is the dry process, which is particularly popular in places where water pollution due to waste water from fibre board p oduction is a serious problem.

In 1967 the proportion of hardboard production of total fibre building board was as follows:

| | | |
|---|---|---|
| Europe | 85 % | of total = 2.142.000 tons hard and medium board |
| North America | 49 % | 1.072.000 " |
| South and Central America | 72 % | 98.000 " |
| Africa | 74 % | 72.000 " |
| Asia | 73 % | 394.000 " |
| Pacific Area | 91 % | 174.000 " |
| World total | 72 % | 4.384.000 tons hard and medium board |

Hardboard represented 77 % of the total fibre building board production in Finland in 1967. The good properties of medium board, the variety of thicknesses and densities, and its ability to compete with particle and joinery board for indoor and outdoor use have caused production of this type of board to increase.

World productive capacity

In 1971 world capacity was approximately 9.000.000 tons and world forecast for the growth in production for 1970-1980 is 5.2 % per annum. The productive capacity in various countries is shown in figure 4.1 and the regional development of capacity of the fibre board industry between 1929 and 1969 is shown in figure 4.2.

At present, there is unused production capacity both in Europe and in U.S.A. resulting in stagnation in the growth of new industry due to lack of cheap raw material. In developing countries the fibre building board industry is not sufficiently developed and it seems probable that where there is consumption, availability of raw material and industrial potential, the fibre building board industry should be able to make growth. The need of foreign currency is one of the main problems concerning the building up of forest based industries, both for their own demand and export, in developing countries. In regions where there is overproduction the industry will have to concentrate on special products and processing.

The total progress of forest based industries in developing countries has not completely met the demands made on it. In 1966 FAO presented a research "Wood: World Trends and Prospects" concerning the world wide need of investments in forestry and forest based industries in 1961-1975. In that research 39 billion dollars were subscribed to the expansion of forest based industries. The share of wood board making industry is 3.3 billion dollars, of which the share of developing countries is 22 %, that is 0.75 billion dollars.

Many different factors have an influence on the forest based industries' capability of competing in the developing countries. Up till now the developing countries have not been able to any considerable degree to export the products of their forest based industries to the industrialized countries, where equivalent raw materials have been available. But the situation is changing as suitable raw materials are decreasing in the industrialized countries. However, irrespective of the raw material used, the utilization and developing of forest resources in these countries is hampered by many difficulties, such as

- greater need for investment funds (25-50% more)
- planning and engineering work
- building, installation and maintenance difficulties
- heavier freight charges
- the efficiency of production, auxiliary substances
- power and energy problems
- the efficiency of marketing
- the inadequacy of home market and distribution system
- high rate of interest etc.

The share of developing countries in the world production of fibre board was in 1967 about 5 % (see table 4.3). In all probability the importance of fibre board is much greater in those developing countries where the resources of saw and plywood logs are scarce. The developing of the market for fibre and particle board to achieve the advantages of mass production has been the bottle neck of production almost in all developing countries. However, the bottle neck of development is probably still farther away, in other words information about resources and well organized projects are still missing. As for the products of forest industry the developing countries will probably reach selfsufficiency as soon as in 1980's, and will export them considerably to industrialized countries.

| | Production, million tons | | |
|---|---|---|---|
| | 1957 | 1967 | Growth % 1957-1967 |
| Whole world | 3.42 | 6.18 | 6.1 |
| Scandinavia | 0.74 | 1.02 | 3.2 |
| Developing countries | 0.10 | 0.29 | 10.9 |
| % of whole world | 3.0 | 4.7 | |
| | Export | | |
| | 1957 | 1967 | Growth % 1957-1967 |
| Whole world | 0.62 | 1.15 | 6.3 |
| Scandinavia | 0.44 | 0.58 | 2.9 |
| Developing countries | 0.00 | 0.03 | 20.0 |
| % of whole world | 0.8 | 2.7 | |
| | Import | | |
| | 1957 | 1967 | Growth % 1957-1967 |
| Whole world | 0.53 | 1.16 | 8.1 |
| Scandinavia | 0.00 | 0.00 | - |
| Developing countries | 0.07 | 0.12 | 5.5 |
| % of whole world | 13.2 | 10.3 | |

**Table 4.3 Production, export and import of fibre board**

Per capita consumption of fibreboard

Consumption depends primarily on local conditions, climate, level of income, technical production, competing products, customer service, market conditions and research activities. The Nordic Countries lead in the consumption of fibre building board, but have already been surfeited with the material for some time past. This is due to the high consumption and to new competing products. In 1970 consumption per capita was 41.2 kg in Sweden, 31.4 kg in Norway, 18.0 kg in Finland and in United Kingdom 5.8 kg. World average was 1.90 kg/capita in 1967. Figure 4.3 shows production, exports, imports and consumption of hardboard and insulation board in certain countries and figure 4.4 estimated future requirements of fibreboard for 1970 - 1975.

The ECE Timber Committee estimates that Europe's trade in fibreboard may reach a turning point in 1971 with imports exceeding exports for the first time ever.

The housing industry is a major fibreboard consumer in the Nordic Countries and it seems likely that a similar correlation exists in the other countries between housing construction and board consumption. The following table indicates the consumption of fibreboard by some Swedish woodworking industries 1967:

| | | |
|---|---|---|
| Sawmills and planing mills | 5.200 tons | |
| Wooden box and box material factories | 180 " | |
| Veneer and plywood mills | 2.400 " | |
| Furniture factories | 6.200 " | 90 % |
| Joinery factories | 86.200 " | |
| Basket making | 300 " | |
| | 100.480 tons per year | |

In United Kingdom the consumption of medium and hardboard by density - 1970 was as follows:

| | Medium board | Standard Hardboard | Tempered Hardboard | Total |
|---|---|---|---|---|
| Construction | 9.3 | 34.0 | 13.4 | 56.7 |
| Furniture | 0.3 | 17.0 | 0.9 | 18.2 |
| Transport | 0.9 | 6.4 | 1.5 | 8.8 |
| Packaging | 0.3 | 4.0 | 1.0 | 5.3 |
| Miscellaneous | 1.4 | 8.8 | 0.8 | 11.0 |
| Total | 12.2 | 70.2 | 17.6 | 100.0 |

In United Kingdom the consumption of hardboard by thickness - 1970 was as follows:

| | 3.2 mm | 4.8 mm | Others | Total |
|---|---|---|---|---|
| Construction | 43.7 | 8.8 | 4.2 | 56.7 |
| Furniture | 16.5 | 1.3 | 0.4 | 18.2 |
| Transport | 6.3 | 1.5 | 1.0 | 8.8 |
| Packaging | 4.0 | 1.0 | 0.4 | 5.4 |
| Miscellaneous | 8.0 | 1.8 | 1.1 | 10.9 |
| Total | 78.5 | 14.4 | 7.1 | 100.0 |

In Finland the consumption of fibre building board in 1968 was as follows:

| | medium + hardboard | soft board |
|---|---|---|
| Building and element industry | 60 % | 93 % |
| Joinery industry | 35 % | 2 % |
| Caravan etc. | 5 % | 5 % |

Raw material of fibre building board

As a general rule, the raw material problem of the fibre building board industry is quantitative and economic rather than technical. Research can lead to a technical process that will utilize almost any kind of raw material from wood and plant fibre to tree bark. Resins can be used to increase the strength and various sizing agents are available to make the boards water resistant. In the case of wood in particular, the raw material costs in Europe represent 20 - 40 % of the total costs, fig. 4.5, depending upon the size of the mill and the manufacturing process. The factors that most frequently determine the siting of mill are labor cost procurement, transport, handling and storage of raw material together with marketing of the end product.

As for raw materials the possibilities to plant fast growing forests are good. For example eucalyptus trees, which are very good raw material for hard and semihard fibreboard, can be grown with 6 - 15 year cycles. The annual growth is 10 - 60 $m^3$/ hectare. The same growth is also reached by poplar, willow and many tropical hardwoods and pine species with suitable fibre qualities. These can be grown for fibrewood with 12 - 20 years' cycles with the annual growth of 10 - 40 $km^3$/hectare. With concentrated fields of raw material the advantage of pulp and board qualities' uniformity is achieved. These facts support very strongly the possibilities of forest industry in developing countries.

Methods of production

The following methods are used when manufacturing fibreboard:

| | | | |
|---|---|---|---|
| A | Compressed boards | - wet process<br>- wet-dry process | fibre transport by water |
| | | - semi-dry process<br>- dry process | fibre transport by air |
| B | Non-compressed boards | - wet process | fibre transport by water |

In the wet process the wet lap is gathered by means of water. However, water is not available everywhere or the mill waste water may pollute the surroundings in which case the so-called dry process has to be used. By these processes hardboard and medium board in thickness 2.0 - 30 mm are manufactured, density range 600 - 1200 $kg/m^3$.

Non-compressed boards are manufactured by the wet process and the wet lap is dried in a drying device. The product is soft board, thickness 9 - 32 mm, density range 250 - 350 $kg/m^3$. This board is primarily used as insulation board.

The choice of process depends on the desired product. It may be a board smooth on one side only, or on both sides, thin or thick, light or heavy. Thick ($>$ 8 mm) and light board is most economically manufactured by the dry process, whereas it is better to manufacture thin ($<$ 8 mm) and heavy board by the wet process. Both boards already have a long-established usage in the joinery industry.

A hard or medium board with good dimensional stability is glued by different types of resin and paraffin according to the quality desired, before it is compressed and dried. For use in exceptionally high humidity the board is saturated with drying oil to which fungi and termite protectives can be added.

Properties of fibreboard

Hardboard should be regarded more as a surface material for indoor use, whereas medium board is a joinery board and surface material that can be successfully used also in moist places as well as outdoors.

The manufacture of fibreboard is changing over to strictly standardized qualities classified according to use:

- board for general use
- board for special uses

The international ISO standardization has advanced so far that it is more and more based on the properties demanded of boards in various fields of application.

| | | |
|---|---|---|
| ISO-recommendation | R 766, | Determination of Dimensions of test pieces |
| " | R 767, | Determination of moisture content |
| " | R 768, | Determination of bending strength |
| " | R 769, | Determination of water absorption and ... |
| " | R 818, | Definition - Classification |

The manufacture of special boards is becoming dominant, such as:

- special quality (strength, surface, workability, dimensional stability of the board, fire-resistance, constructional grade of hard and medium board)
- ready covered with paints and plastics
- constructional grade suitable for various constructions and elements
- standardized dimensions, module 3M=300mm and millimetre dimensions (thickness, width and length).

## The use of hard and medium board in the joinery industry

The joinery industry is far rationalized in general but still an industry that requires much labour. Its level of efficiency is determined by the size of the series, and long series imply uniform raw material and even quality.

Hard and medium board are well suited for the joinery industry owing to their homogeneity and special properties. Some of these properties are common to both types but some are specific. Common properties are:

- smooth surfaces - easy to paint
- workability
- small tolerances
- sufficient strength properties
- good dimensional and form stability
- sufficient impact resistance.

Besides, medium board has specific properties, such as:

- metallic or plastic jointing possibilities
- heat and sound insulation
- resistance to moisture.

Surface and paintability

In general, the fibreboard surface is made of finely-ground overlay fibre which is usually also well glued. This makes the surface compact and fit for sanding and it sticks well to the base fibres. The following demands are made on a good surface:

- the surface should be smooth and the fibres homogeneous,
- the consumption of paint should be small and the paint adhesion good,
  - alkyd paint - by the spraying technique - gives a glossy surface with 22 g paint/$m^2$ (fig. 4.6)
  - 2-component acid catalysed paint - by the curtain flow technique - gives a glossy surface with 60-80 g paint/$m^2$,
- with a view to sanding, the surface layer should be 0.4 - 0.5 mm thick,
- the surface should pass a moisture resistance test 30 % → 65 % ⇆ 90 % r.h. without the fibres rising, or the bottom showing through,
- the surface fibre should not generate tensions in the board.

Board with glue or drying oil impregnated surface, is a special quality that can be finally sanded already at the mill. Its consumption of paint is small and it is popular particularly for the manufacture of doors owing to its even surface and quality.

## Workability

To begin with, let us look at "the joinery properties" that represent the most important ones as regards fibreboard. This property can hardly be expressed in figures but it can easily be determined emotionally, so to speak. First of all, the board should have fine edges and a good surface and it should be slightly brittle but yet tough. In brief, it should be easy to work by ordinary tools. Attempts have been made to determine this numerically, but so far no one has succeeded in finding the right characteristics. Now our opinion is that these properties are not directly proportional to the volume per weight but that they refer more to the variations in quality that occur in connection with changes in the properties of the raw material in pulp refining, gluing and heat tempering. On the other hand, the volume per weight being low, the board gets better dimensional stability, i.e. it does not warp so easily.

Both hard and medium board can easily be worked. They can be sawn, planed, bored, perforated, milled and cut. A good board does not crack, split or become fluffy when being worked by hard metal cutters in normal conditions. A thing that makes these boards particularly suited for the joinery industry is the fact that the surface layer is smooth and that the edges are even after being worked.

## Tolerance

Nowadays all medium boards are calibrated, and at buyer's request also hardboard is calibrated to +/- 0.2 mm accuracy. Length and width tolerances, edge straightness and squareness have been standardized. Boards can also be manufactured to an accuracy desired by the buyer.

Strength properties

The common strength properties of hardboard and medium board are, in general, satisfactory for the joinery industry. The rigidity of the board increases to the 3rd degree of the thickness. It is, however, to be noted that fibreboard is a visco-elastic product (fig. 4.7) stretching when exposed to lengthy load (fig. 4.8). The FPRL report (England) shows that the basic bending stress for 4.8 mm hardboard was generally comparable with that for plywood (fig. 4.9), but that the modulus of elasticity was only one third or one half of that for plywood.

When covering boards with hard, shrinking overlays, the tensile strength perpendicular to the surface must be observed, because it can become critical if the board is covered with plastic that shrinks on one side. Therefore, a balance film is necessary. The tensile strength against the surface in hardboard should be at least 0.8 N (=Newton)/$mm^2$ in this step (fig. 4.10).

Working and dimensional stability

All wooden boards work (live) according to the relative humidity in air. Fibreboard works to a small extent lengthwise and crosswise, but more perceptibly in direction of thickness where there are tensions due to pressing compression that strive to be liberated.

Working is permanent or varying according to the humidity in the place where the board is being used and permanent or constant (fig. 4.11). The smaller the equilibrium moisture content of the board, the less the board works.

Form stability opposes changes that strive to buckle the board when the humidity is extremely high, i.e. 90% r.h. If the board is fastened or supported at long edges, high humidity will result in swelling that is not in relation to the density of the board, but by the batten spacing and the thickness of the board as special points. On the other hand, low humidity will lead to cracking due to shrinkage.

Fibreboard that is correctly heat treated and moistened works, however, to such a small extent that it will not handicap the joinery industry, but in the building industry where fibreboard is used outdoors working is prevented by constructive means (see Figure 4.23).

Impact resistance

In certain constructions, such as honey-combed sandwich doors, the impact resistance of fibreboard is significant. The surface of fibreboard should stand dynamic strain as long as the product is used. In the hard body impact test, the panels were supported horizontally by 15 mm wide strips along both 900 mm edges and along the bottom 600 mm edge. The end edge was not supported. A 50 mm diameter steel ball weighing 520 gr was dropped from a point 735 mm above the panel surface such that its energy at the moment of impact was 3.75 joules as required by the draft standard. Immediately after impact, the imprint depth was measured using a dial gauge instrument. Suggested strain tests for doors are shown in figures 4.12, 4.13, 4.14 and 4.15.

Screw holding characteristics

Driving in screws in the side of even thick medium board is not the right solution but when hinging, holds that stick to the surface of the board or to the side framings are generally used (see Figure 4.23).

Heat and sound insulation

Medium board can already be used in constructions where a moderate heat and sound insulation is necessary. In this respect, soft board comes up to the maximum requirements.

Resistance to moisture

Fibreboard does not contain water soluble additives, and when manufactured in temperatures above 200°C, the separate fibres as well as the whole board is more or less "killed" against moisture movements. Chemical additives are used in the fibre building board industry to counterbalance differences in the raw material and methods of manufacture and also to give the product certain specific properties.

The moisture content of board sheets will adjust themselves to the conditions of the surrounding air. The hygroscopicity of the boards is of great importance when they are under different stresses of short or long duration. The hygroscopic behaviour of board is decreased through a heat treatment that happens at the right time. This reduces the humidity equilibrium and dimensional changes in the board. Owing to its porosity, medium board can absorb and emit moisture without altering its dimensions to any noteworthy degree.

Fundamental elements in the joinery industry

Generally speaking, the joinery industry uses four basic elements in its constructions. They are (fig. 1.16):

1. Bearing elements (ceilings, floors, bottoms and shelves)
2. Supporting elements (side walls)
3. Free standing elements (light partition walls, doors)
4. Covering elements (external and internal wall coatings, painted or printed sheets, back walls)

Bearing elements require great bending strength and high modulus of elasticity, at least in the outer surfaces of the construction.

Supporting elements demand sufficient buckling and bending strength.

Free standing elements demand high dimensional and form stability as well as possibility of fixing the board from the thin side. High impact resistance and low density is beneficial.

Covering elements should be thin. Their density should, however, be so high that sufficient bending strength can be attained.

Hardboard is well adapted for items 3 and 4 when the product, for example a door, is manufactured as a honey-combed construction. Thick, heavy medium board, smooth on one side or on both sides, can be used especially in the building industry for items 1, 2 and 3 as both indoor and outdoor covering, painted or faced. 10 - 12 mm vertical or horizontal panels are particularly popular for external use (fig. 17-18). Soft board is fitted in the building industry for item 4.

The mechanical-physical properties of the above mentioned elements can be determined scientifically and a quality can be manufactured that will fulfil the technical requirements in the best way according to place of use and object. In this way, the most economical solution can be reached and too good or poor quality is not used. At the same time, the assortment of qualities remains as small as possible.

Surface and appearance of the joinery product

Products from the cabinet-making industry should have two essential characteristics:

- attractive appearance, surface and colour, which is often a matter of taste
- a surface quality that agrees with the chemical-physical properties of the product and with use.

When these requirements are applied to the fundamental elements mentioned above, we arrive at the following conclusions:

The outer surface of bearing elements should be attractive and stand hard mechanical and chemical wear.

The outer surface of supporting elements should be attractive and stable to light and to some extent washable and resistant to moisture.

The surface of free standing elements should be first-class as regards quality, stability to light and appearance.

The surface of covering elements should be well adapted for environment and use.

In general, joinery products should have a hard surface that is stable to wear, impact heat and light and that gives a hygienic general impression.

The use of processed hardboard and medium board in the joinery industry

Standard hardboard is cheap board and naturally, it must also be processed at a low cost, otherwise it would be more profitable to use more expensive material.

The surface of fibreboard is even by nature, compact and smooth and works little signature to the surface. Furthermore, it can be covered by many modern techniques, such as:

- covering with ivory pulp (white ground wood pulp)
- puttying or filling
- painting and lacquering
- printing by roller coater or silk screen
- lamination
  - for architechtural and construction use
  - for industrial applications
- extrusion covering
- form pressing
- profile pressing
- radiation chemical covering (impregnated with drying monomers and then cured by radiation)

Surface improvements are done for fuller utilization of the timber resource by converting - structurally adequate but difficult to finish - low appearance quality surfaces to attractive and serviceable premium products. The overlay serves the function of a finish for decoration or production and must be great enough to justify the added costs to the panel. Overlays open new markets for board panels and will be based upon end use. Improved application equipment will aim toward automatic sensing and filling of defects in a continuous line operation.

Generally, the joinery industry uses ivory faced hardboard for closet backs, bottoms of drawers and beds.

Filled board is a good basis for paint, and smooth surfaces can be achieved. Filled hardboard can be readily used as base board in cupboards and closets.

Hardboard and medium board, ready painted with polyester or alkyd paint, is a normal commercial joinery product, primarily designed for different furnishings and wall coverings.

Printed and painted hardboard is much used as walls, furniture and fixture backs. The pattern is of universal, phantasy and wood imitation type. It can be varied without putting the laminate into the top cost bracket. This is done by modern silk screen printing techniques, which can be done at a reasonable cost.

The architectural and construction surface lamination is done with thermosetting melamin, urea, phenol, polyester, plastic veneer or PVC films which are soft plasticized or hard and semi-hard unplasticized. The resin-treated fibre overlays include three types of overlays:

- High density
- Medium density and
- Special.

Semihard internal panel, covered with soft PVC film or fabric at the mill is a handy product for internal wall covering. 0.5 mm thick hard plastic is used for covering vertical surfaces in rooms and in furniture and 0.7 mm thick hard plastic is used in kitchen equipment and in drawers where great impact resistance is not needed. In places where the surface of hardboard or medium board is exposed to great wear, impact or rough handling, 1.5 mm thick plastic veneer is used.

The industrial lamination application may increase strength, stiffness, wearing, impact and weather resistance. The overlays can be fibreglass re-inforced plastic or metal overlays. The most common procedure is a wet application with FRP/board composite, and hot and cold setting adhesives are covered by metal overlays. The cold setting glues have the advantage of avoiding most of the dimensional stability problems encountered in hot pressing material, with dissimilar thermal expansion properties.

Medium board and frames are covered by extrusion, in which case the board is coated with hard thermoplastics. Drawers and other parts of furniture can be covered in this way with 0.5 - 0.7 mm thick

PVC film. This board-film compound is for example cheaper than if the corresponding parts were made of beech throughout, or of PVC preformed to follow profiles. The plastic corset affords good humidity insulation and increases the bending strength of the core by abt. 30 %. Germany is a big user of covered fibreboard and 6 million $m^2$ faced hardboard was manufactured there in 1969. The major part of this was used by the joinery and television industry.

Hardboard (thickness 2 - 3.5 mm) can be wet or dry hot pressed into different shapes if it is first heated for 5 seconds at about 400°C and then rapidly cooled to normal temperature. In this step, its strength does not decrease to any degree worth mentioning. Different form pressing techniques for hardboard are much used in U.S.A. There 50.000 tons form pressed hardboard is manufactured per year for the furniture and motor industry, primarily to be used as core material in car seats and car walls.

Profile pressed and punched hard and medium board is commonly used by the radio, television and furniture industry. Thick, dry processed medium board, specific gravity 0.6, is easy to mill, and the result after it has been worked, is good.

Ray-chemical fibreboard can be successfully impregnated first with chemicals and then cured. This technique is still being developed but nevertheless, new fields of application are anticipated also in the joinery industry.

The present use of hardboard and medium board in the joinery industry can be summarized as follows:

1. Kitchen equipment and cupboards are widely standardized, so that external dimensions of different units are the same, irrespective of manufacturer. These dimensions are such that different parts of the equipment can be cut from the ready board with very little waste of material. Due to this joineries order their boards also in standard dimensions that are most favourable pricewise.

2. In the manufacture of kitchen equipment, one cannot now nor in the future completely abandon the use of fibreboard to the benefit of plastics. On the contrary, a return to the good cozy kitchen is noticeable.

3. Due to the above mentioned and to general regional building the series in the joinery industry are long.

4. The Swedish joinery and furniture industry use about one third of their home fibreboard production, which represents about one and a half times the amount of total fibreboard consumption in Finland.

5. Typical of the joinery industry is an overall very strict economy. Good results achieved by a single coating are already common, but it is possible only by using a dense surface hardboard.

6. Work was carried out in England in conjunction with the Furniture Industry Research Association in cored panels and this revealed the superiority of the paper honeycomb core in the door performance test for hard body impact resistance.

7. Work was completed at FPRL (England) on tests in the structural properties of hardboard. It now seems reasonable to claim that 4.8 mm tempered hardboard can be used for structural tasks demanding good shear strength and bending qualities. In this respect it compares favourably with 6.4 mm plywood (fig. 4.9). Some limitations of its use may occur due to its low modulus of elasticity, particularly under conditions of bending deflection, e.g. structural flooring.

8. A FPRL (England) report on the racking strength of timber frame wall units shows that a slightly better performance overall was obtained with a panel sheathed in 6.4 mm tempered hardboard and 9 mm panel board when compared with a similar panel made up with 12 mm sheathing grade Douglas fir plywood (figure 4.19).

9. Thick 6 - 20 mm medium board, density (600-800 kg/m$^2$) is very suitable for joinery purposes and special glued for outdoor uses in building industry. The most rapid manufacturing method is the dry method. Thin (3.2 mm) hardboard for doors and cupboards is usually made by the wet process. Fig. 4.22 gives a broad picture of the costs of different methods and of the production capasity when using a 4′x 24′ press. The

number of press layers finally determines the production capacity.

10. A new constructional grade (K) of standard hardboard, oil tempered hardboard and medium board is derived in table 4.2. The figures are devided into two environmental groups for strength purposes:

| | | r.h. |
|---|---|---|
| Group 1. | Most structural elements in heated buildings | < 75 % |
| Group 2. | Most structural elements in temporarily heated, ventilated buildings. Relative humidity up to | 95 % |

Basic stresses are derived by applying a factor of safety to the minimum stress values derived as in table 4.2 to take account of such matters as rate and duration of loading, accidental overlead, and size and shape of test specimen. For timber and plywood in bending and shear, a value of 2.25 has become acceptable. For hardboard an overall factor of safety of 3 is recommended by FPRL (England). A figure of 2.66 has been suggested for building regulation purposes in Sweden by Lundgren. Fig. 4.23 shows different beams of wood-hardboard with webs of oil tempered hardboard.

The status of fibre building board materials as a whole should benefit from their acceptance as stress-bearing components. It is obvious that a whole new range of structural applications of both hardboard, medium board and insulating board is now becoming possible.

Fibre building board is the most logical and competitive way of using timber in sheet form and it also serves to help woodworking firms find a good and economic solution of using materials in the building, joinery and furniture industry.

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Figure captions

Fig. 4.1. Capacity of the fibreboard industry in the USA, Sweden, the USSR, Romania, Fed.Rep. of Germany, Canada, Finland, France, Poland, Japan, Norway and the world 1922-1971. Unit: 1000 metric tons, Source: private Capacities at end of five year periods plotted on logarithmic scale. Equal vertical distances denote equal percentage changes.

Fig. 4.2. Regional development of capacity of fibreboard industry 1921-1971. Unit: 1000 metric tons, Source: private. Capacities at end of five year periods.

Fig. 4.3. Production, exports, imports and consumption of fibreboard in various countries and regions in 1961, 1964 and 1967. Unit: 1000 metric tons, Source: FAO and private Note: Bars represent total figures for production, exports and imports in the respective regions. In other words, internal trade between countries within the respective regions has not been eliminated. See also Table V.

Fig. 4.4. Consumption 1950 to 1969 and estimated future requirements of fibreboard 1970 and 1975. Unit: 1000 metric tons, Source: FAO The higher and lower estimates made are represented by the lines bordering the shaded areas.

Fig. 4.5. Price index for a part of goods and services in Norway Basis: 1947 = 100

Fig. 4.6. The covering ability for different paints versus hardboards of different mills. Spray painting case and basis of valuation.

Fig. 4.7. Tensile strain of different 3.2 mm hardboards versus loading time. Rh 73 %. Theoretical linear is marked with broken line.

Fig. 4.8. The elongation for an untempered, average- and well heat-

FIG. 4.1

Capacity of the fiberboard industry in the USA, Sweden, the USSR, Romania, Fed. Rep. of Germany, Canada, Finland, France, Poland, Japan, Norway and the world 1922–1969.

Unit: 1000 metric tons
Source: private

Capacities at end of five year periods plotted on logarithmic scale
Equal vertical distances denote equal percentage changes.

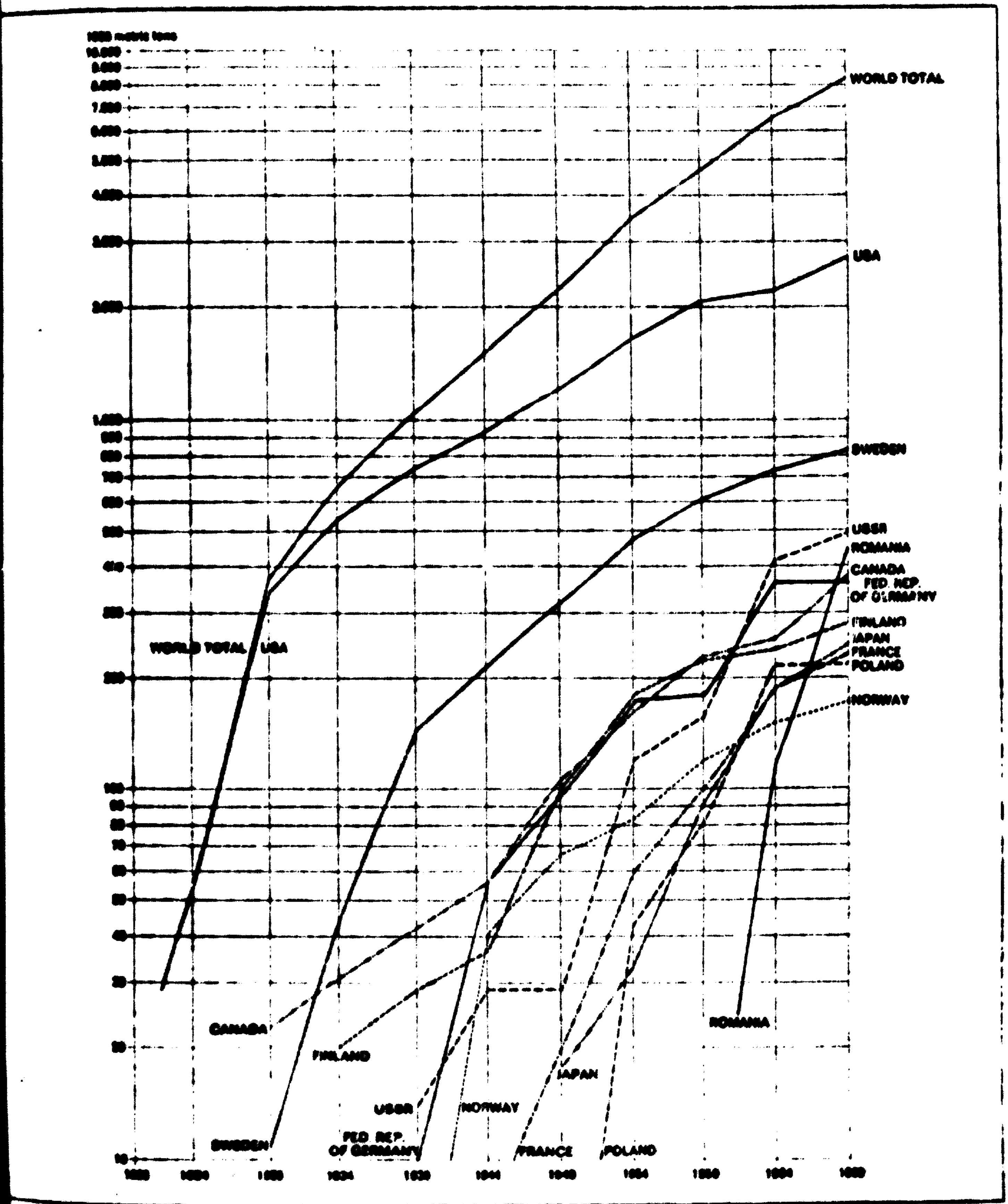


FIG. 4.2

Regional develo' nent of capacity of fiberboard industry 1929-1969.

Unit: 1000 metric tons
Source: private
Capacities at end of five year periods.

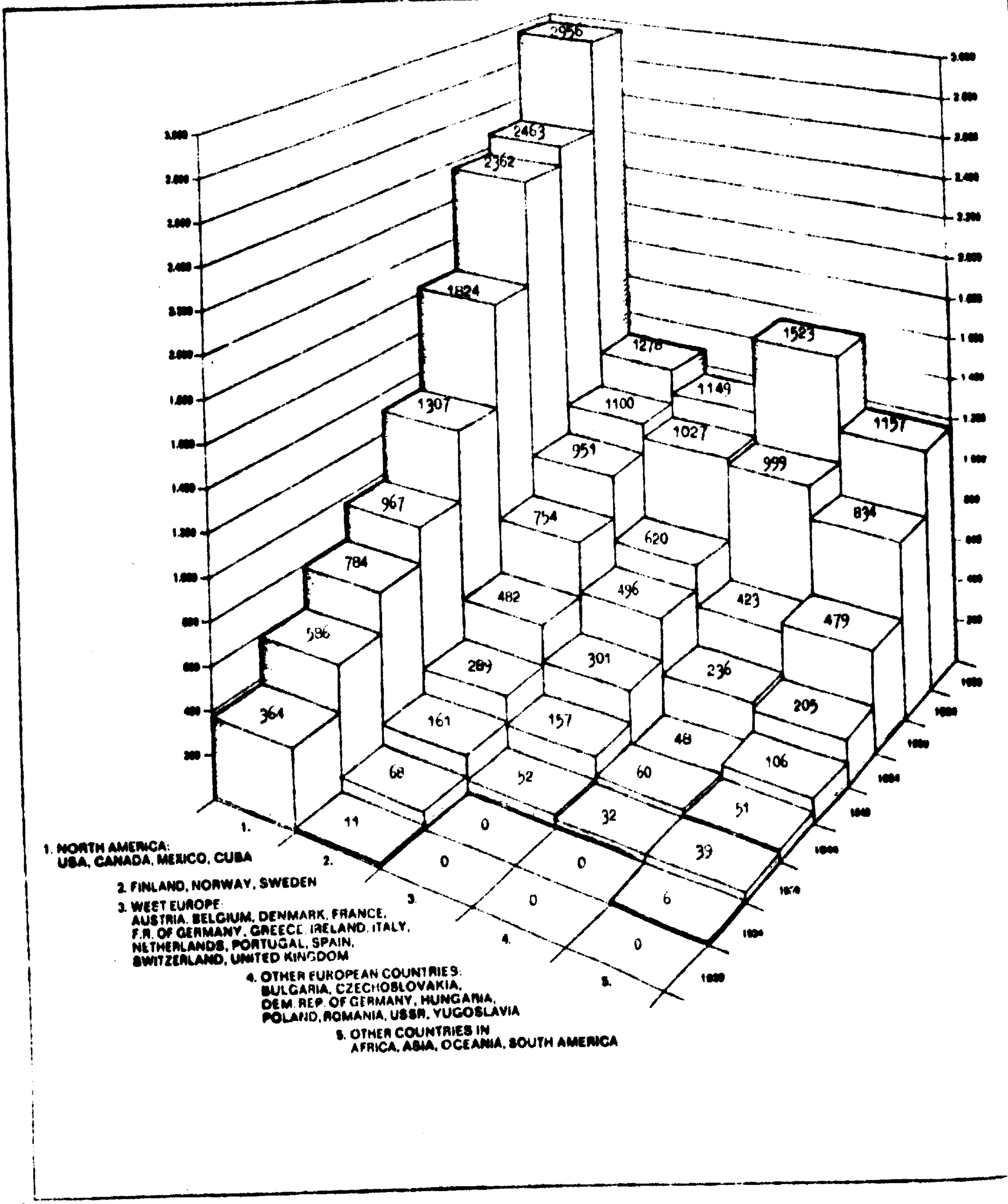


FIG. 4.3

**Production, exports, imports and consumption of fiberboard in various countries and regions in 1961, 1964 and 1967.**

Unit: 1000 metric tons
Source: FAO and private

Note: Bars represent total figures for production, exports and imports in the respective regions. In other words, internal trade between countries within the respective regions has not been eliminated. See also Table V.

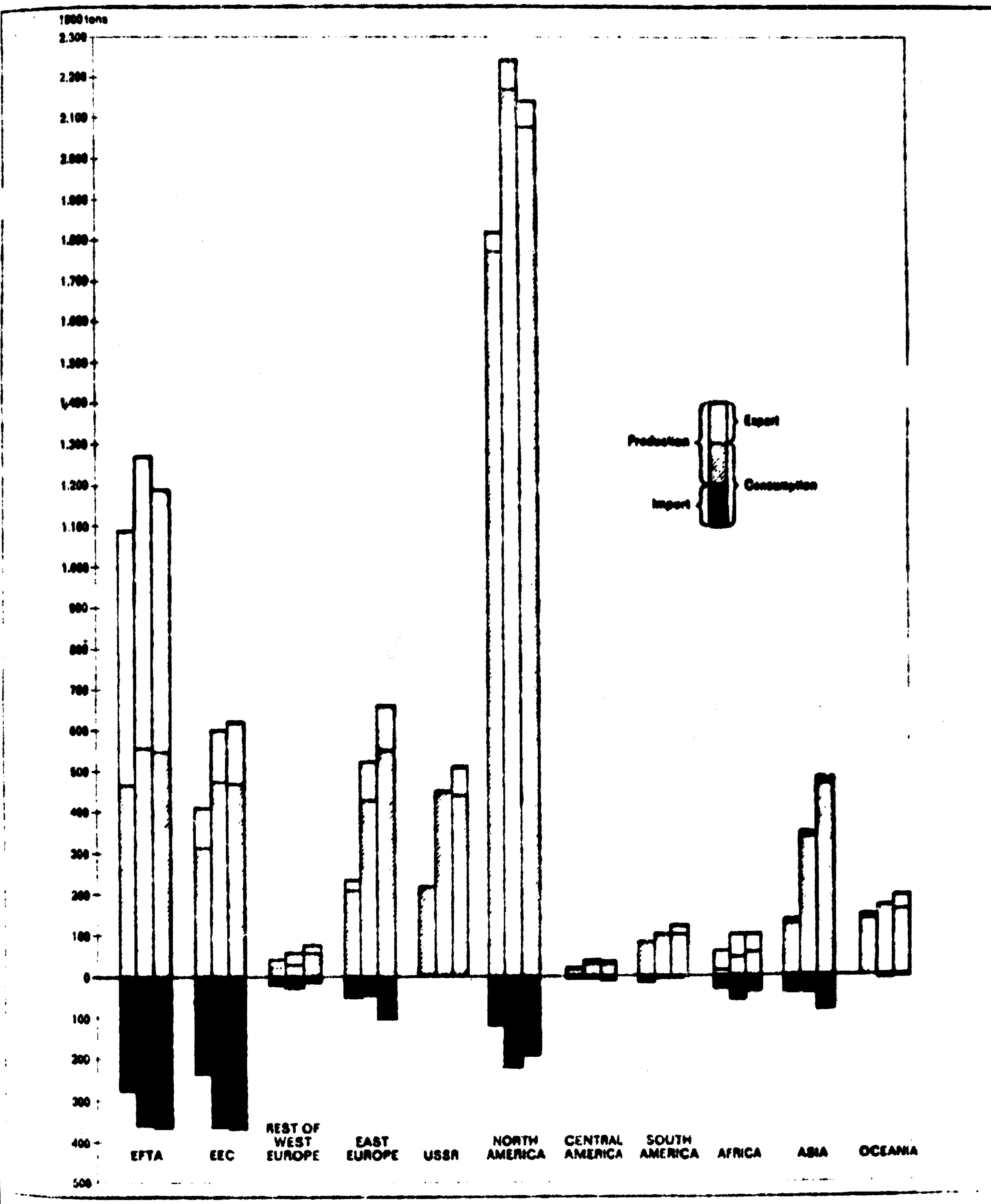
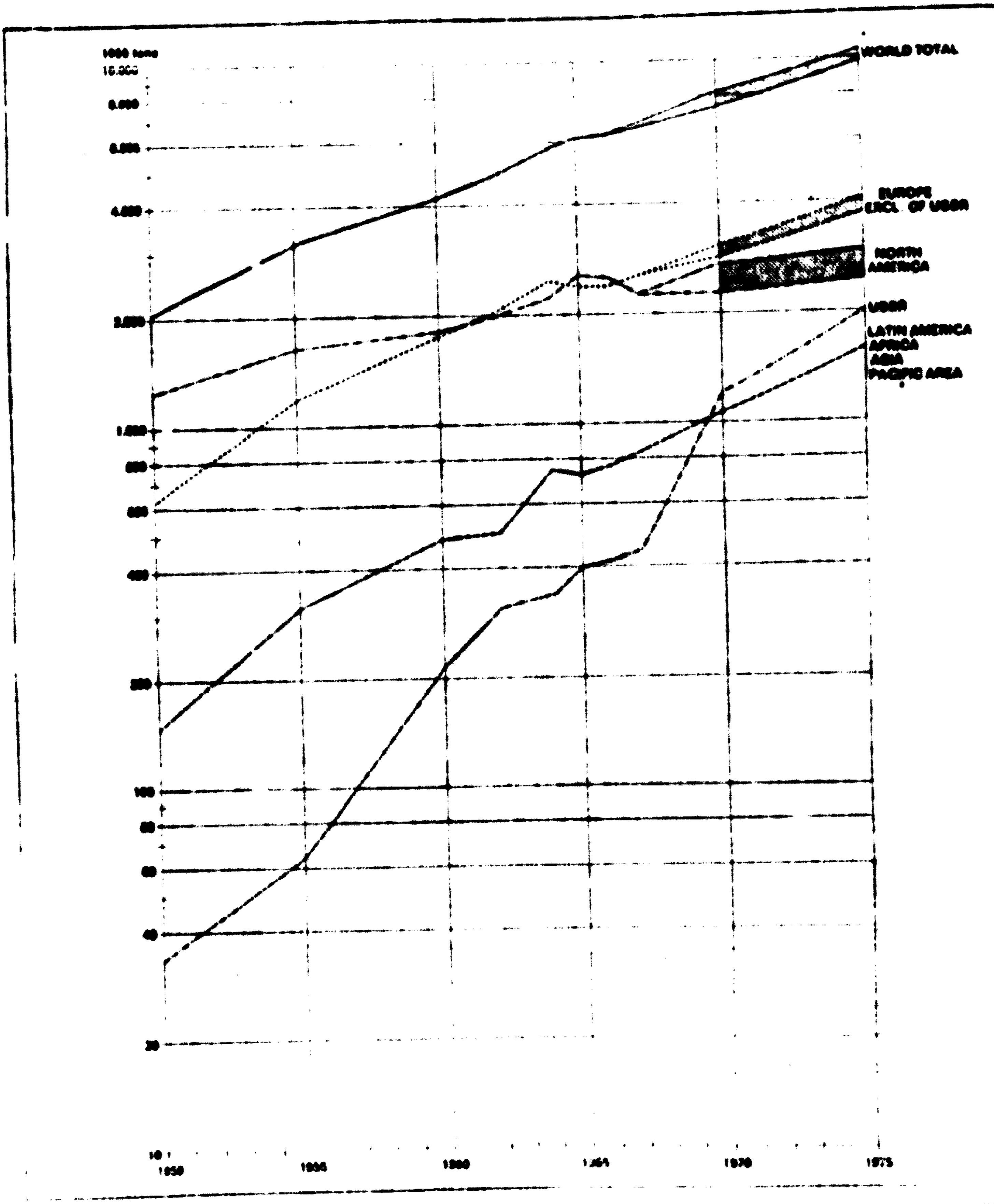


FIG. 4.4

**Consumption 1950, 1955, 1960, 1962, 1964, 1965, 1966 and 1967 and estimated future requirements of fiberboard 1970 and 1975.**

Unit: 000 metric tons

**Source: FAO (see Page 8). The higher and lower estimates made are represented by the lines bordering the shaded areas**



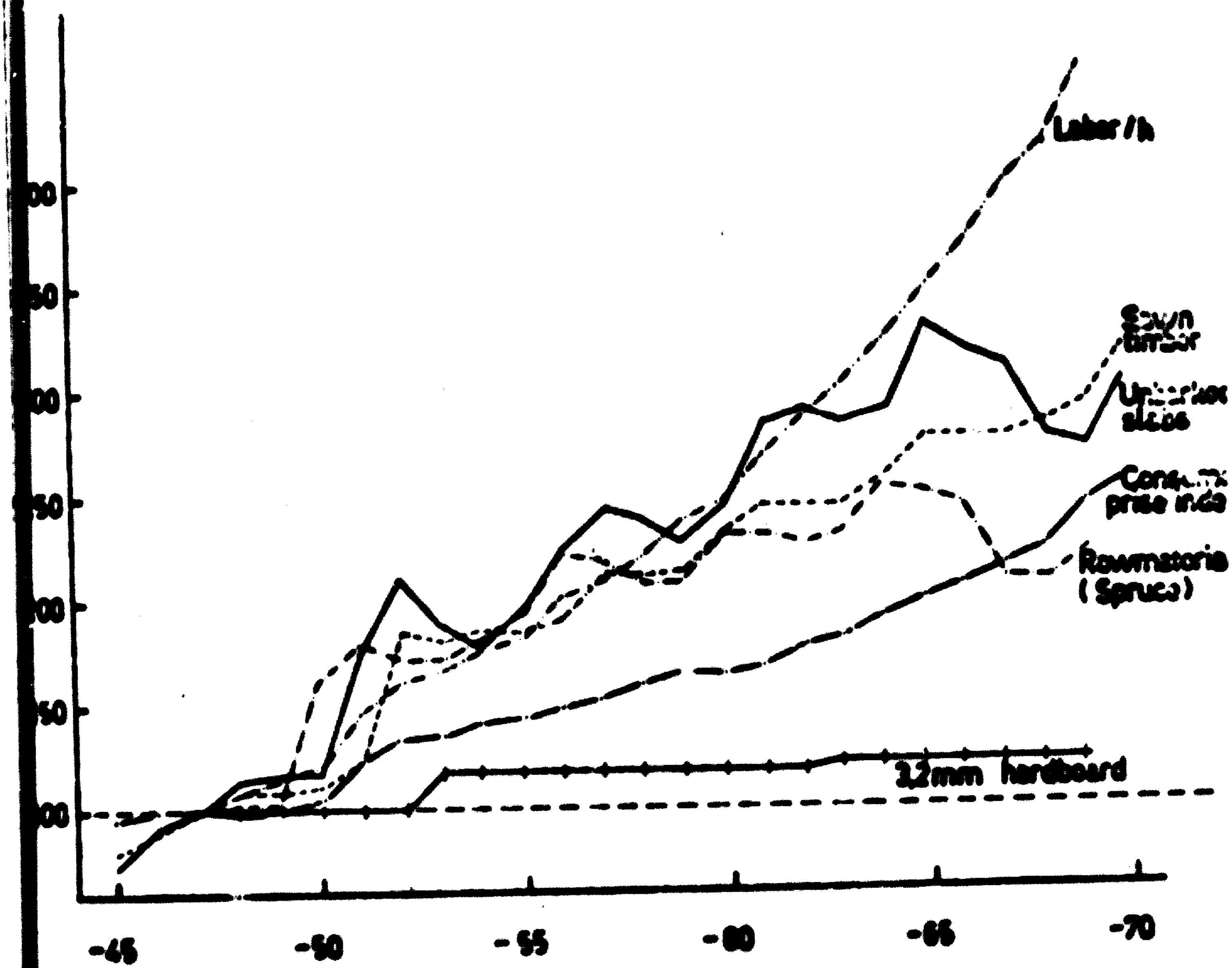
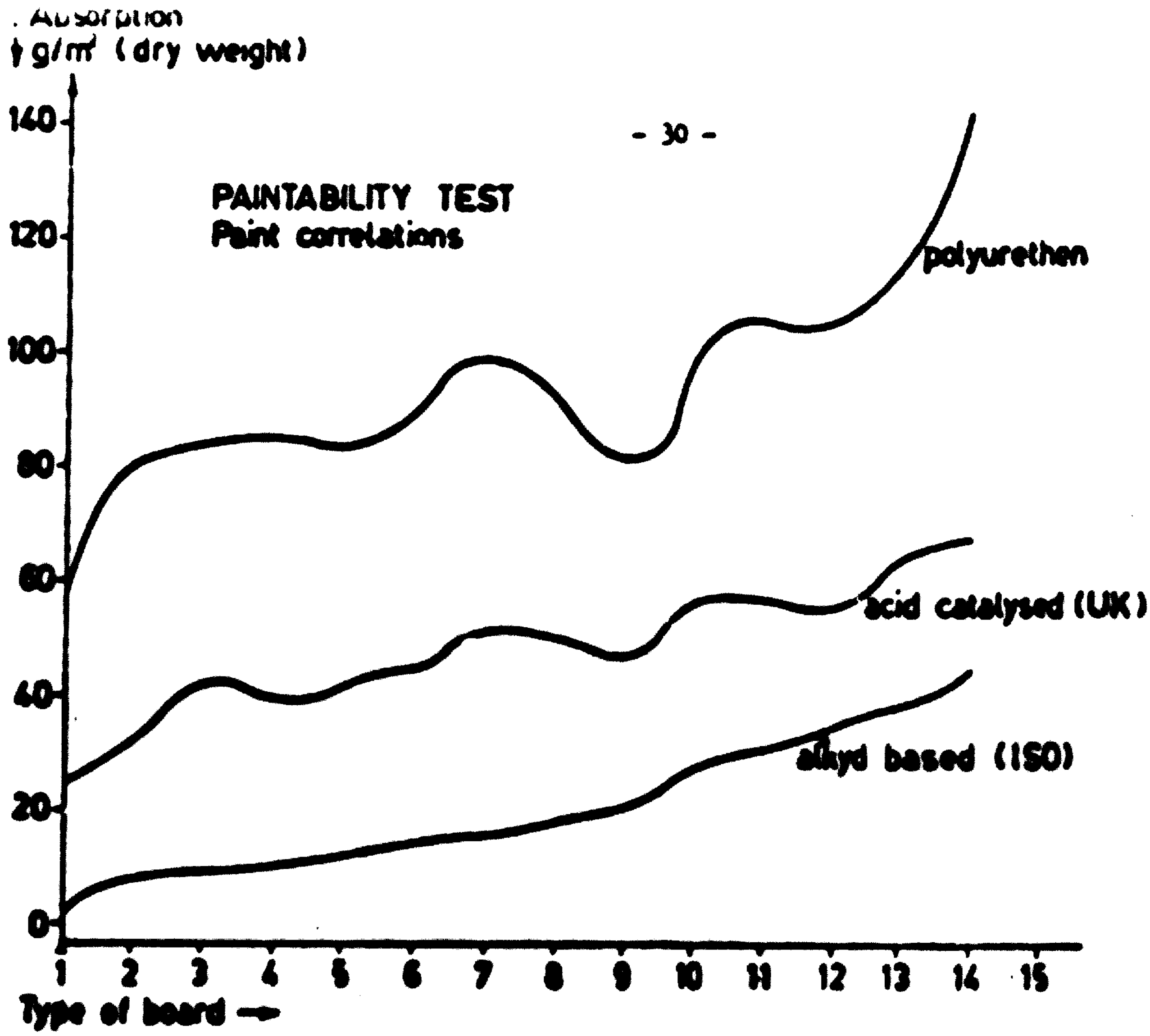
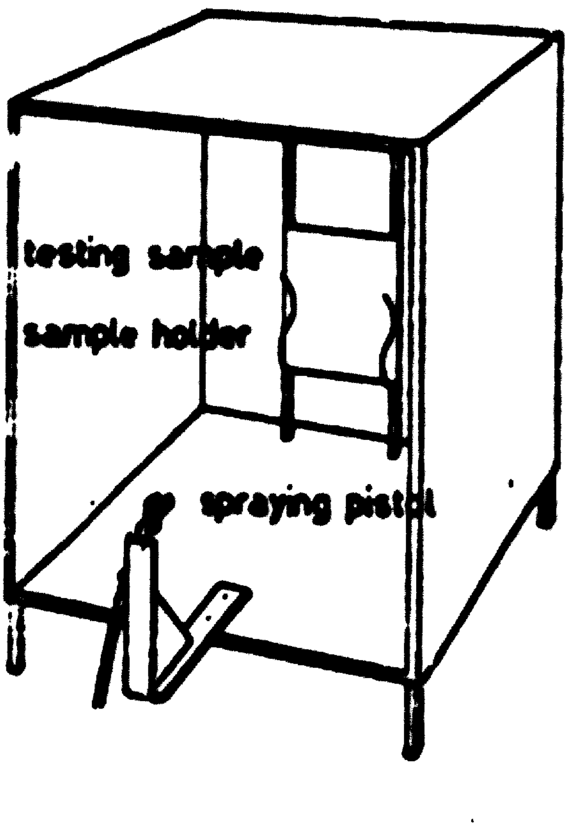



Figure 4.5. Price index for a part of goods and services in Norway
Basis: 1947 = 100



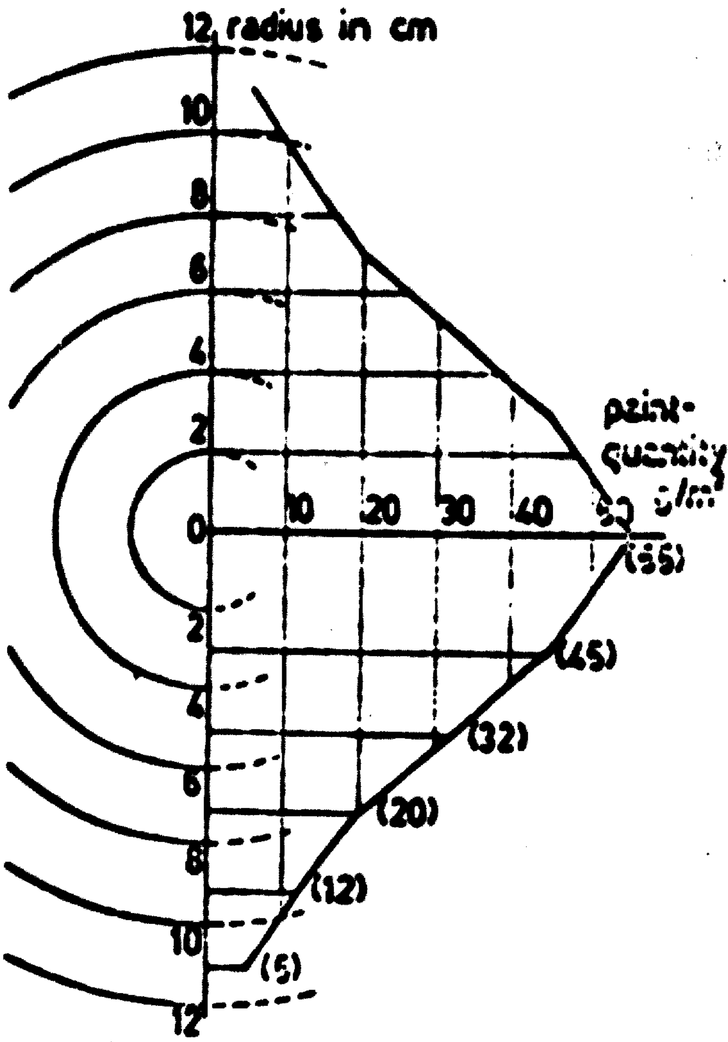




Figure 4.6. The covering ability for different paints versus hardboards from different mills. Spray painting case and basis of valuation.

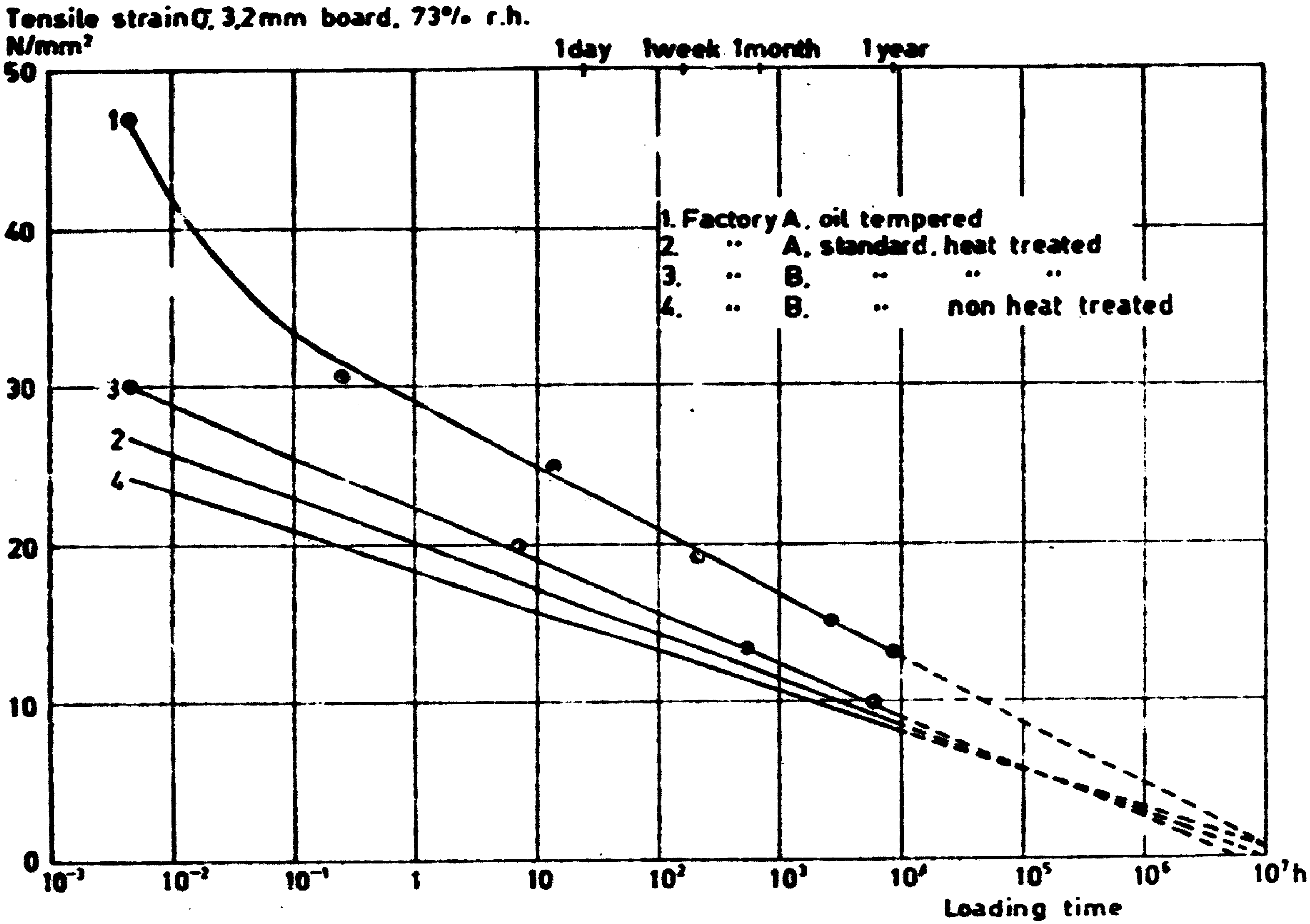



Figure 4.7. Tensile strain of different 3,2 mm hardboards versus loading time. Rh. 73 %. Theoretical linear is marked with broken line.

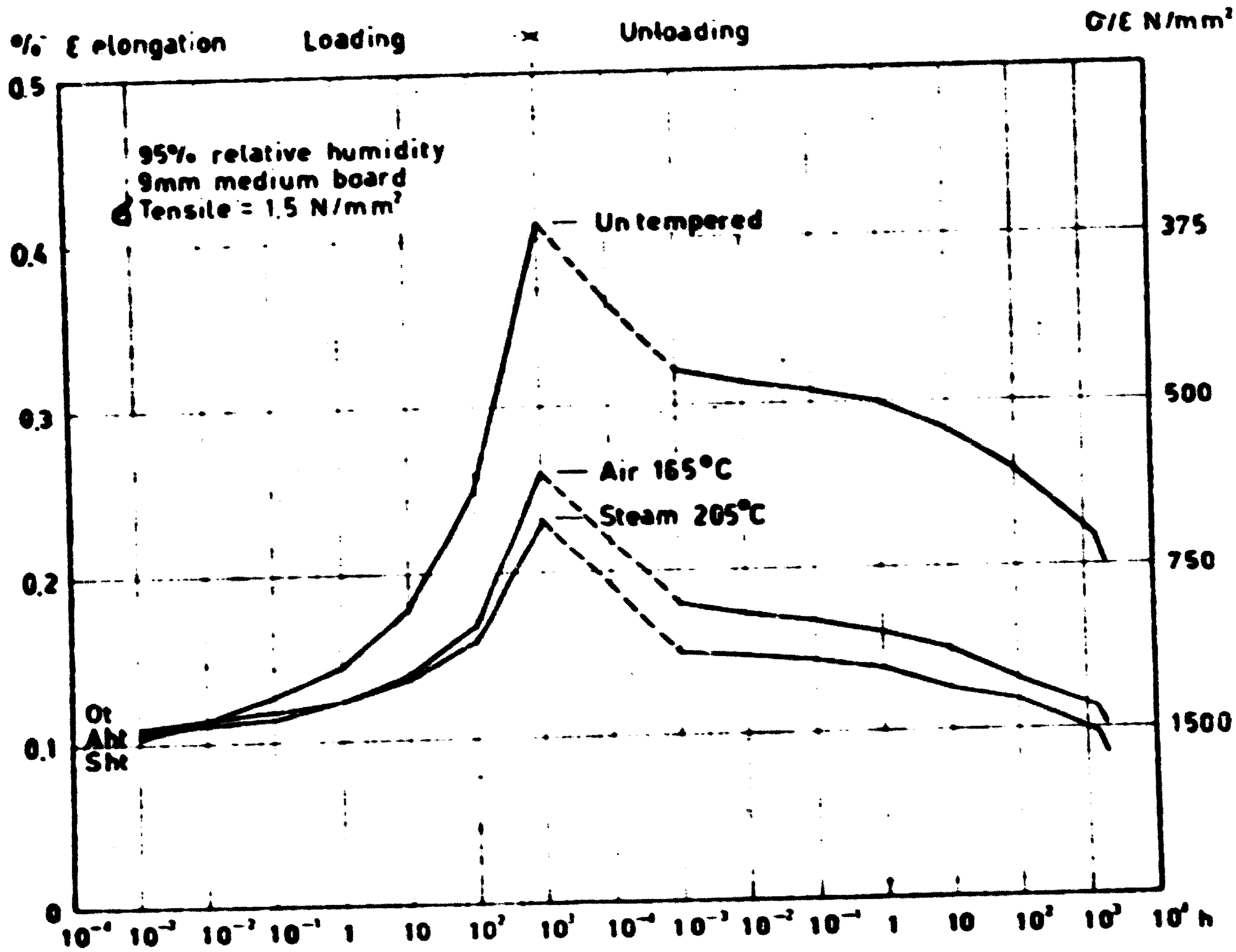



Figure 4.6. The elongation for an untempered, average- and well heat-treated Asplund mediumboard versus time, load 1,5 N/mm², R.h. = 95%.

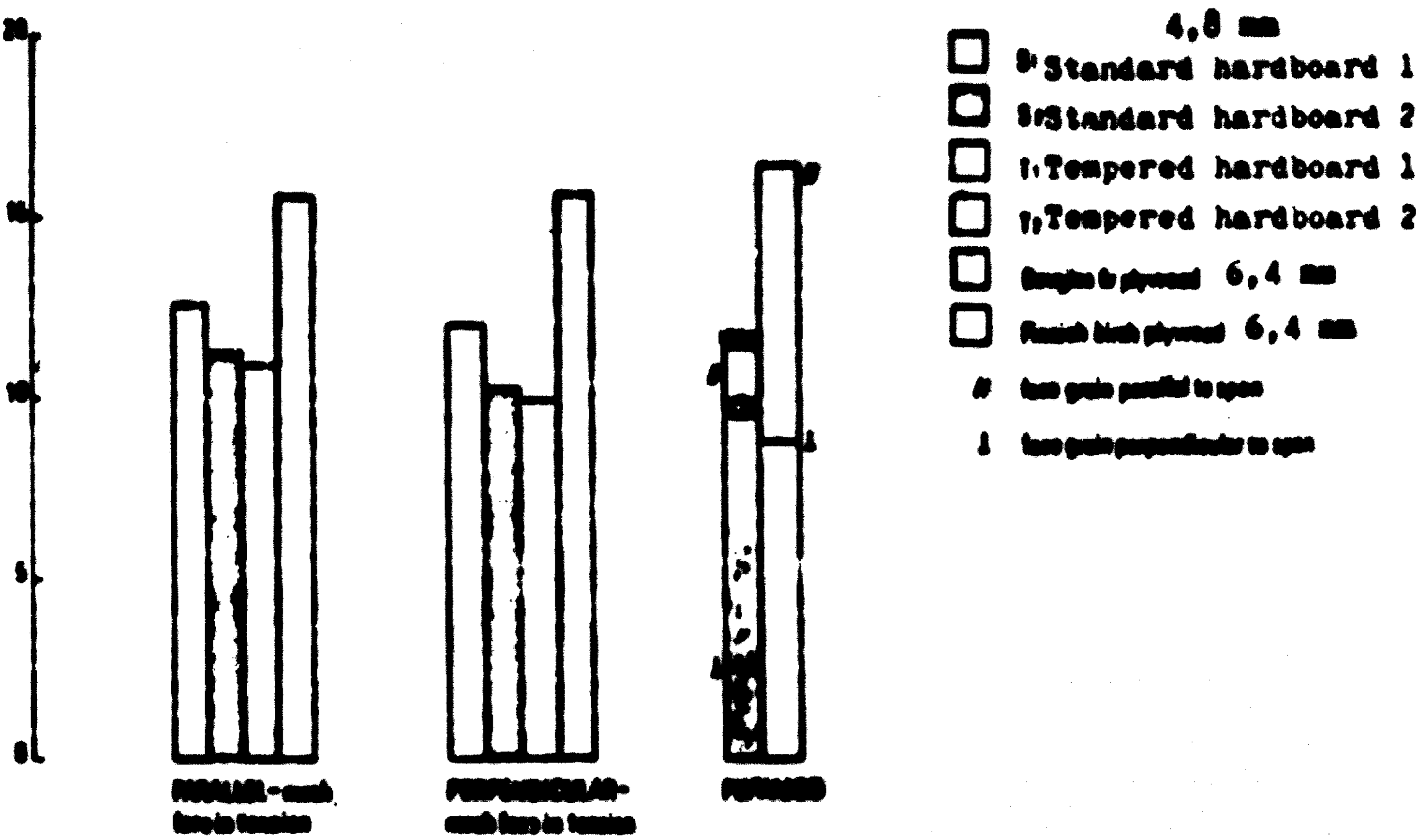



Figure 4.9. Basic stress in bending for hardboard and plywood. Hardboards, thickness 4,8 mm, plywoods thickness 6,4 mm

FIG. 4.10

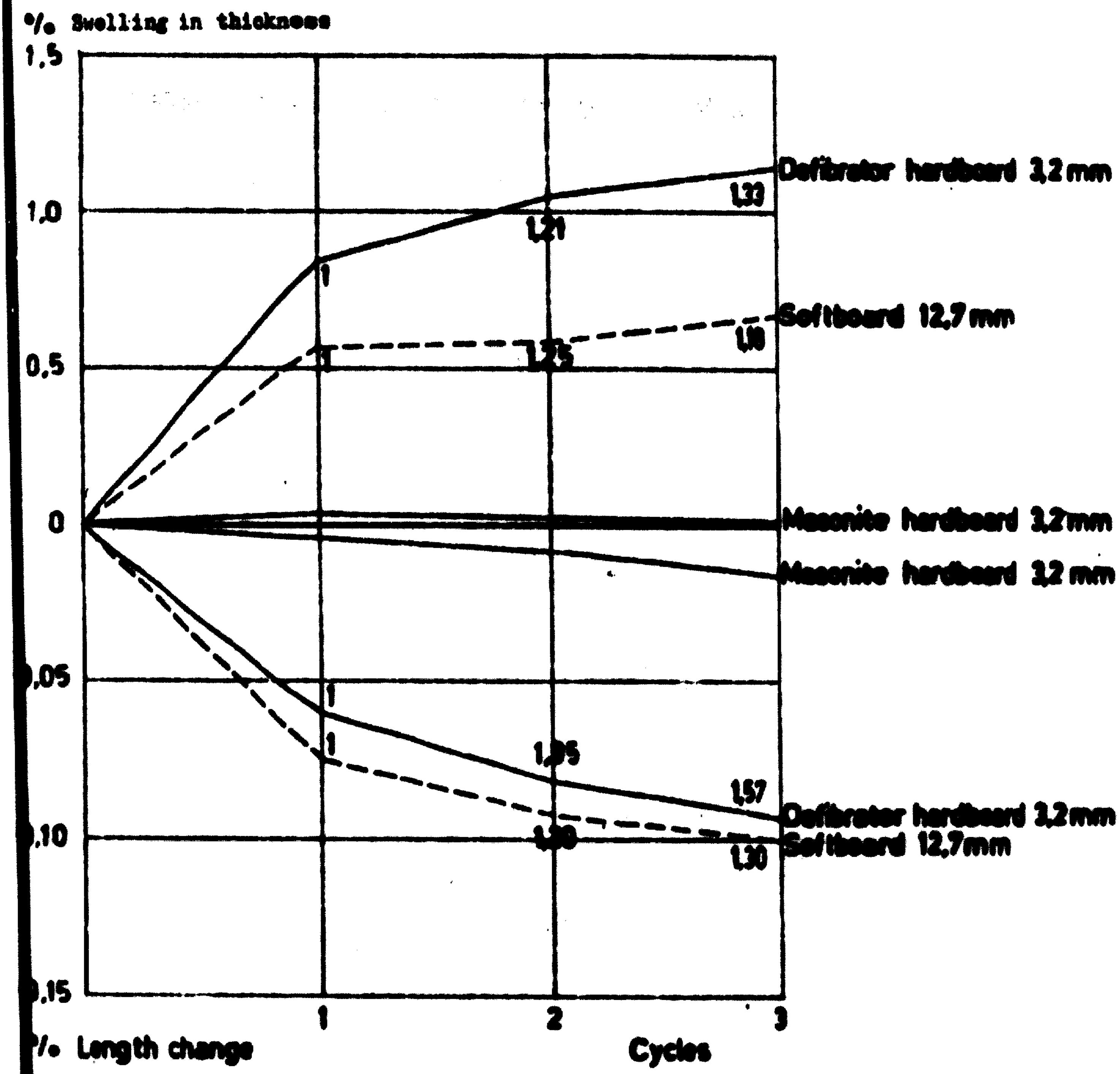



Figure 4.11. The permanent swelling in thickness and length expansion PDCE (0-3) (32-90% r.h.) for different types of board. The hardboards are heat treated

**PROPOSED FLUSH DOOR PERFORMANCE TEST FOR HARD BODY IMPACT**

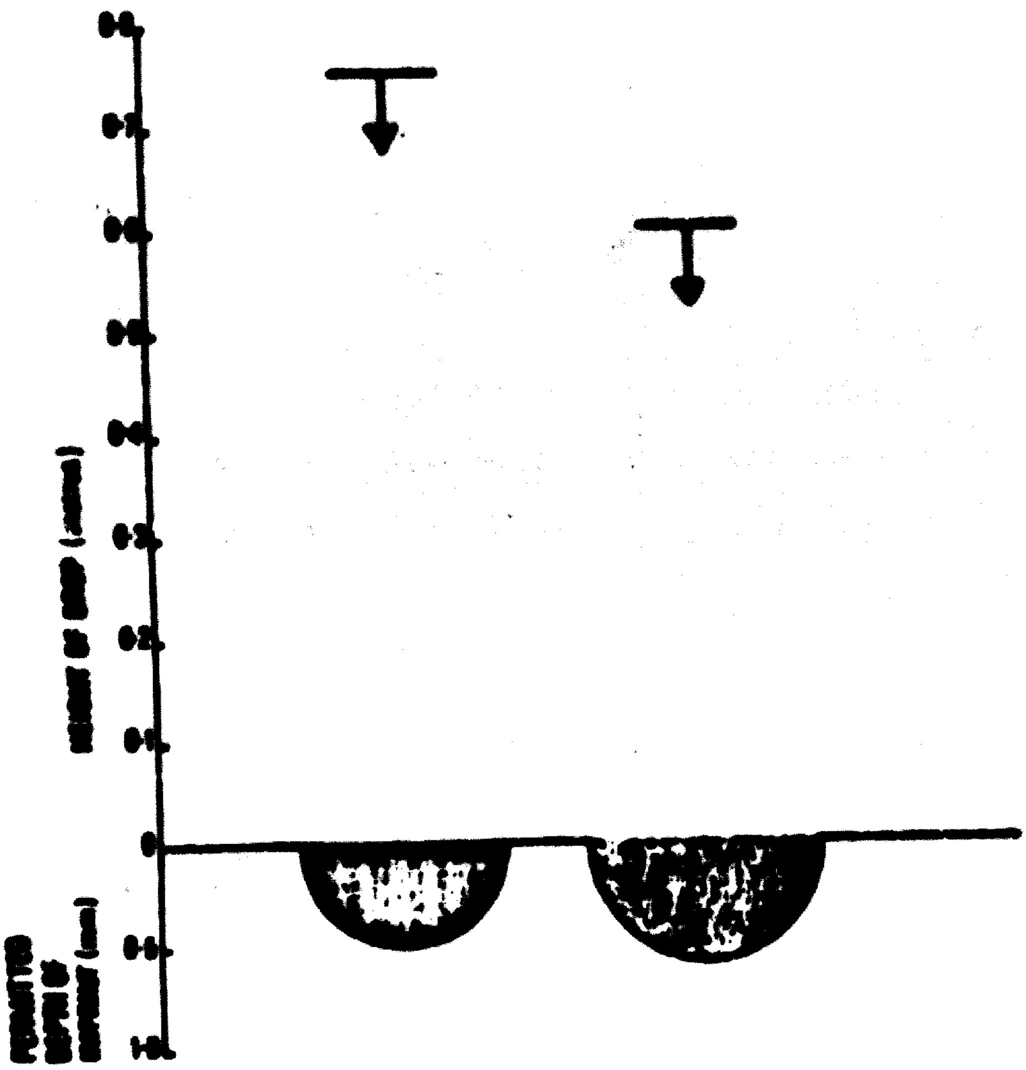


Figure 4.12.

## THE EFFECT OF IMPACT ENERGY ON THE DEPTH OF IMPRINT

**52mm hardboard skin sandwich panel– with E mesh (30mm) cardboard core**

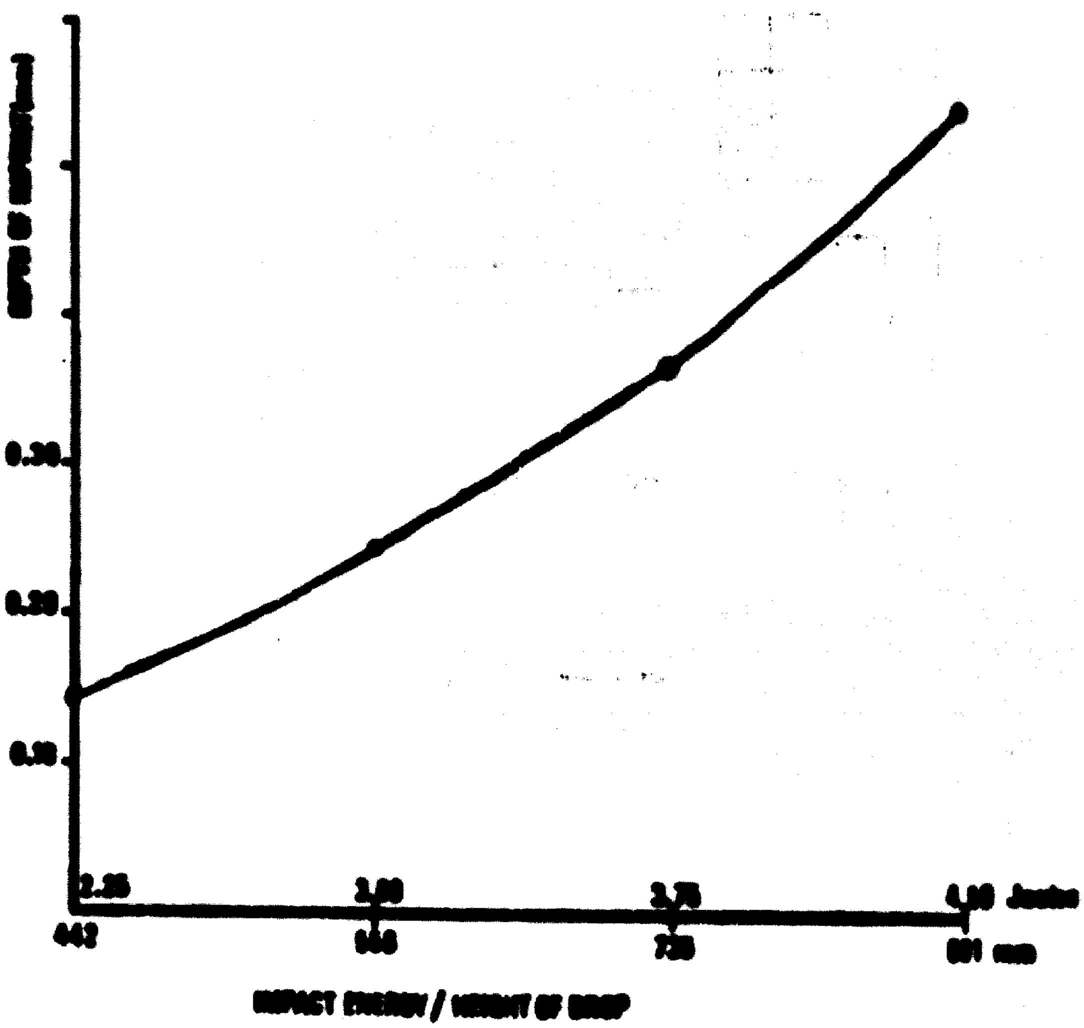
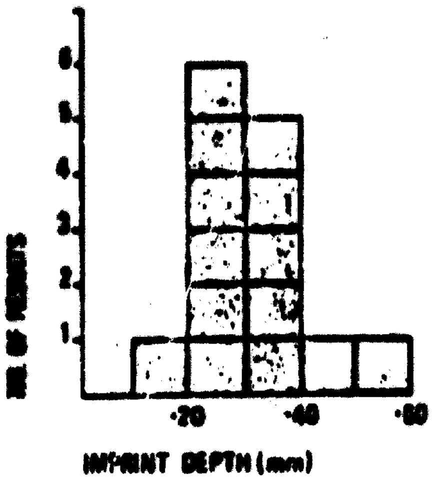



Figure 4.13.

## DISTRIBUTION OF IMPRINT DEPTH RESULTS

### E mesh 38 mm cardboard core




### D mesh 25 mm cardboard core

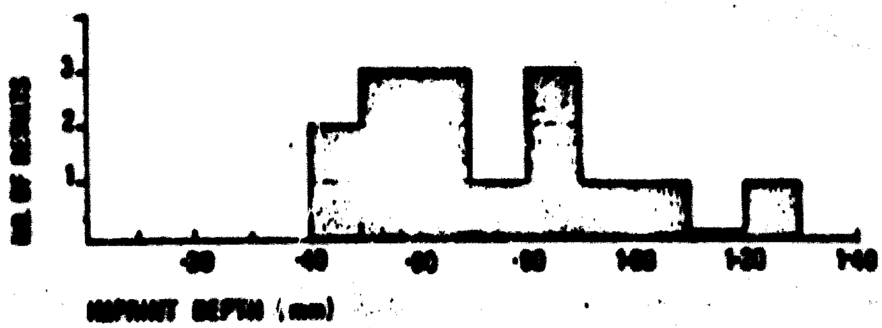
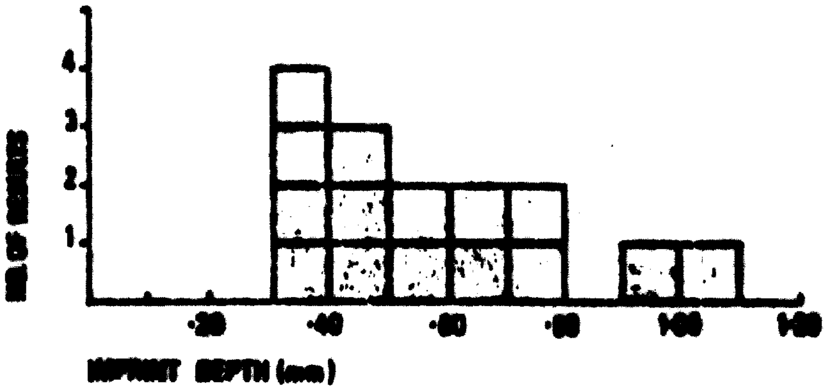



Figure 4.14. Distribution of imprint depth results.

B mesh 12 mm kraft core



D mesh 25mm kraft core

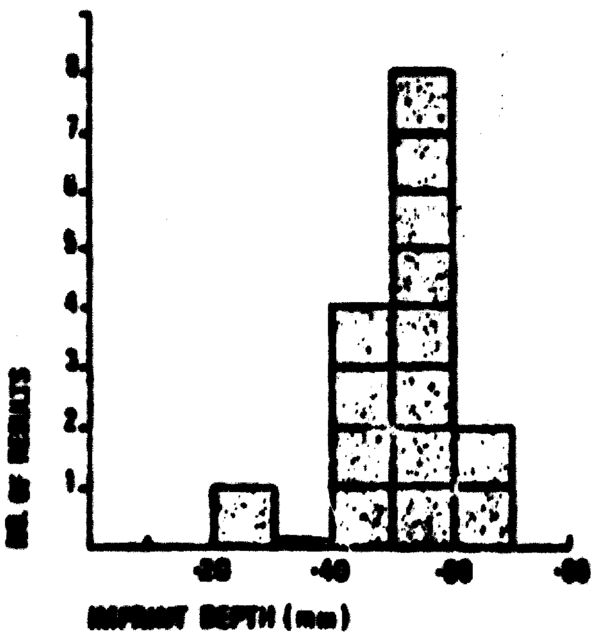


Figure 4.15. Distribution of imprint depth results.

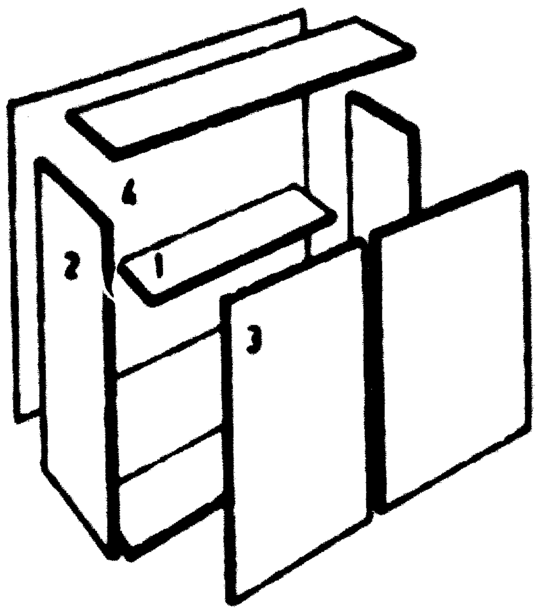



Figure 4.16. Fundamental parts of building and cupboard elements, schematically described; 1 bearing element, 2 supporting elements, 3 free standing elements and 4 covering elements

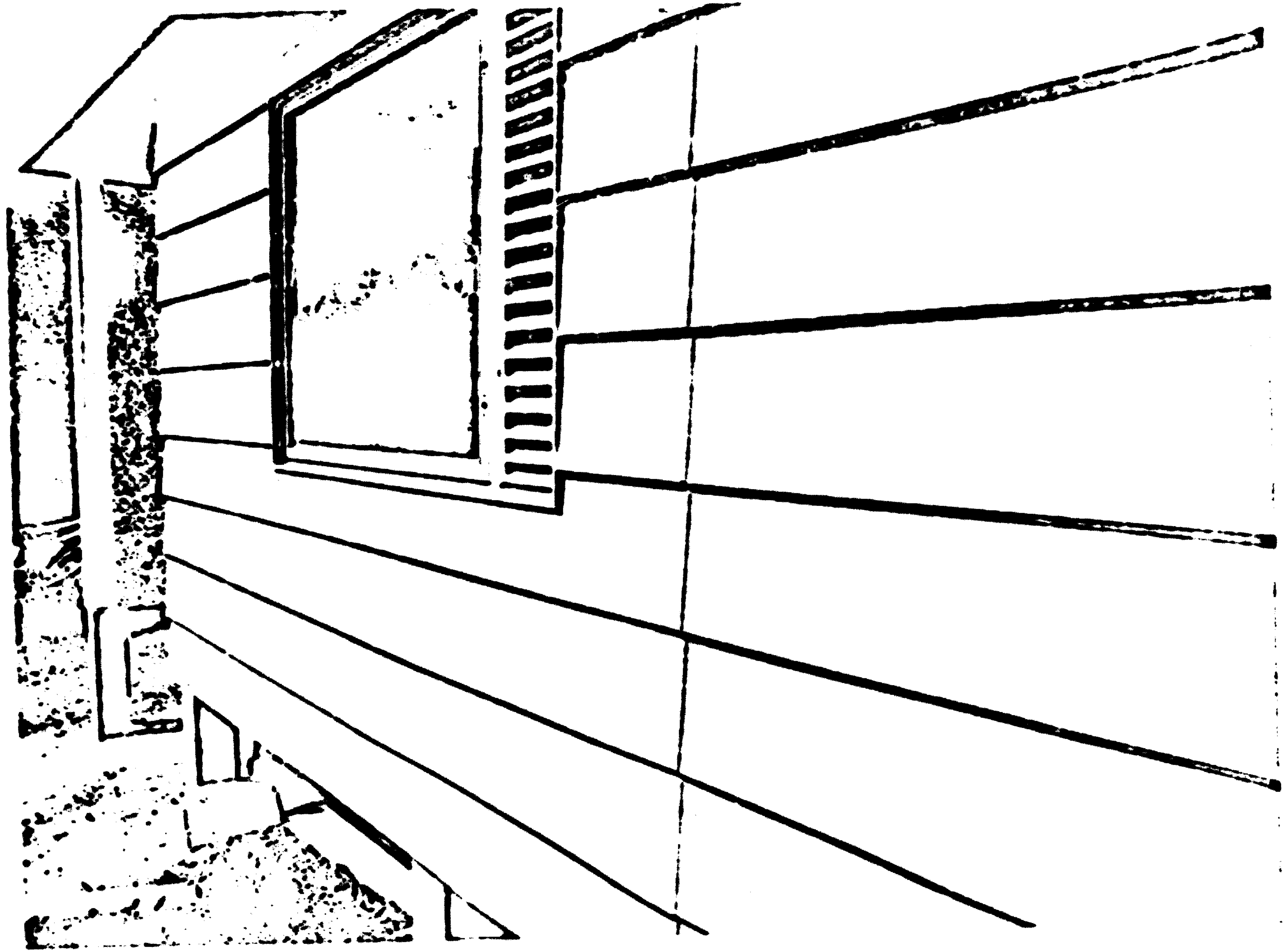


Figure 4.17. Horizontal 10 mm mediumboard (800 kg/m3) panels in a modern house.

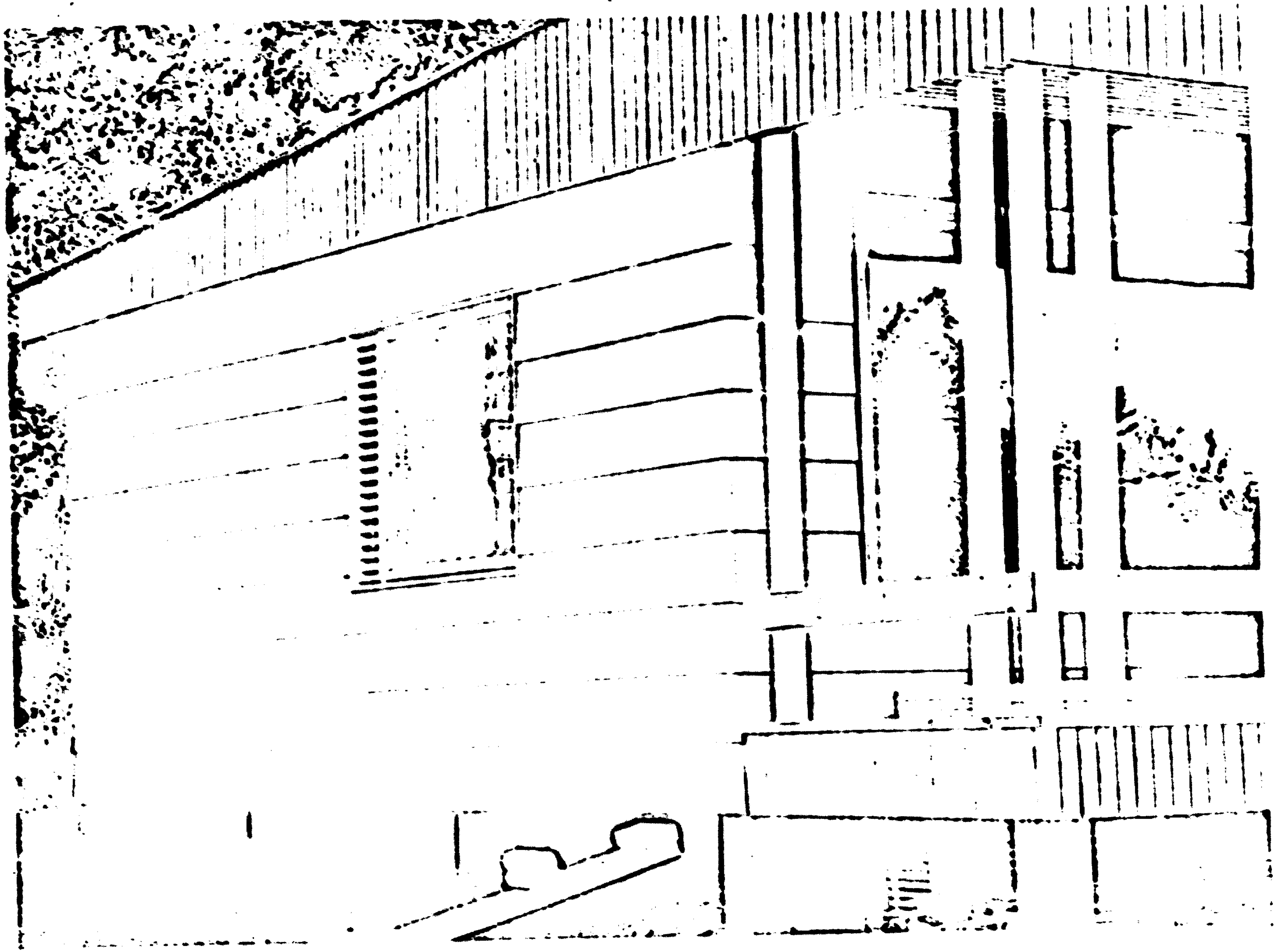


Figure 4.18. Horizontal 10 mm medium board (800 $kg/m^3$) panels in a modern house.

COMPARATIVE RACKING FORCES AND DEFLECTIONS AT VERTICAL LOAD OF 22·3 kN (5000 lbf)

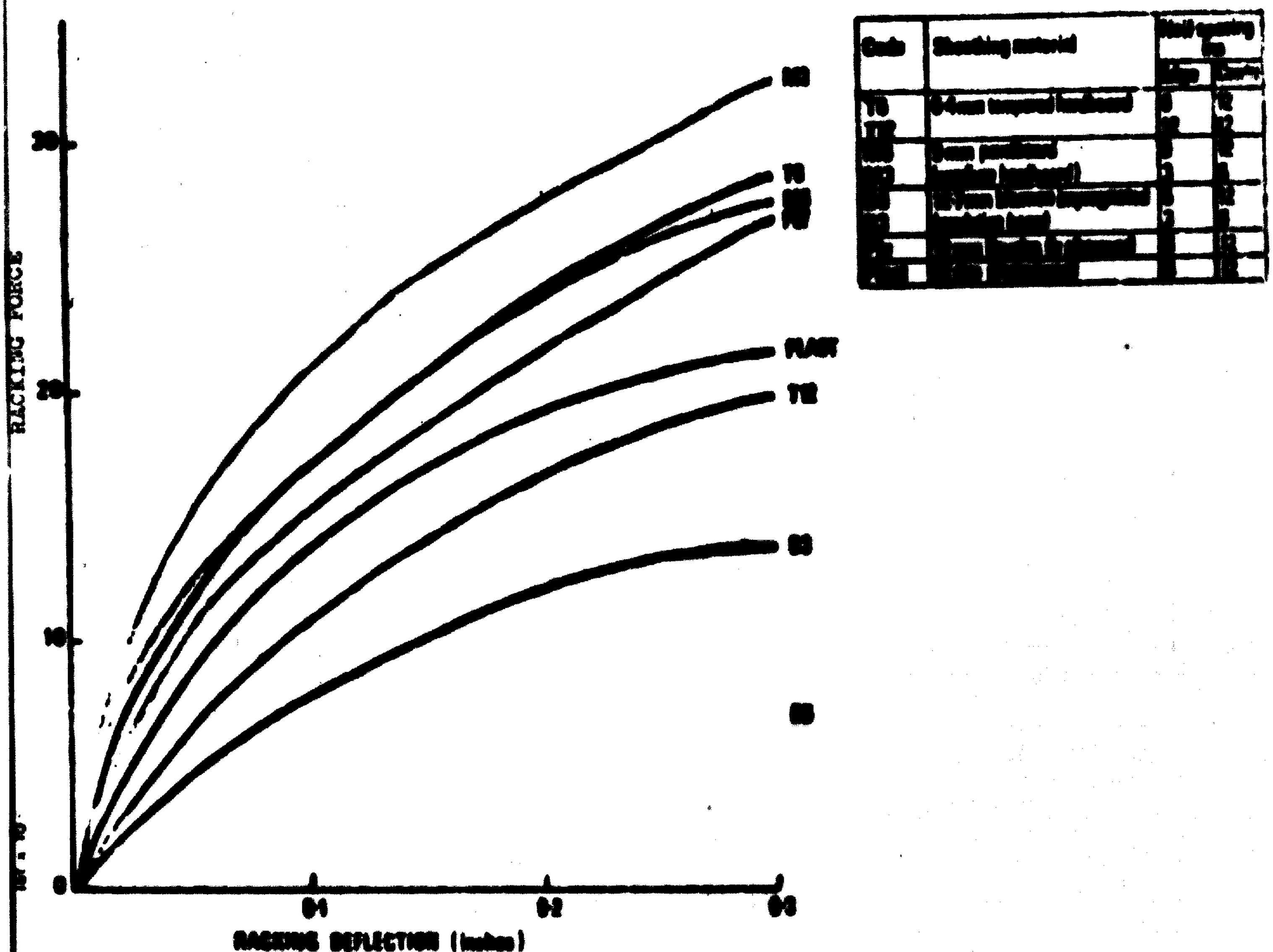



Figure 4.19.

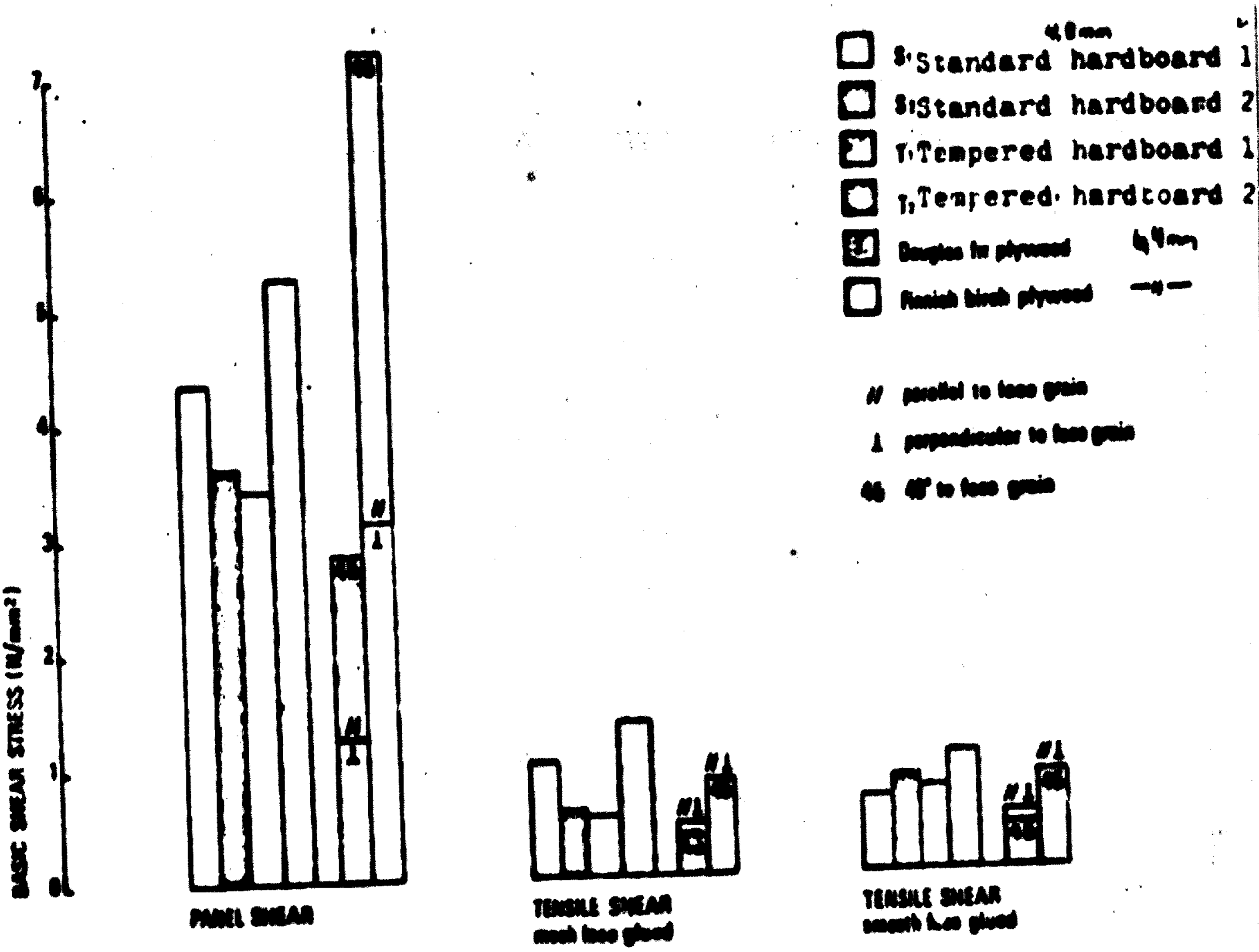



Figure 4.20. **Basic Shear Stress for 4 hardboards, thickness 4,8 mm and for 2 plywoods, thickness 6,4 mm.**

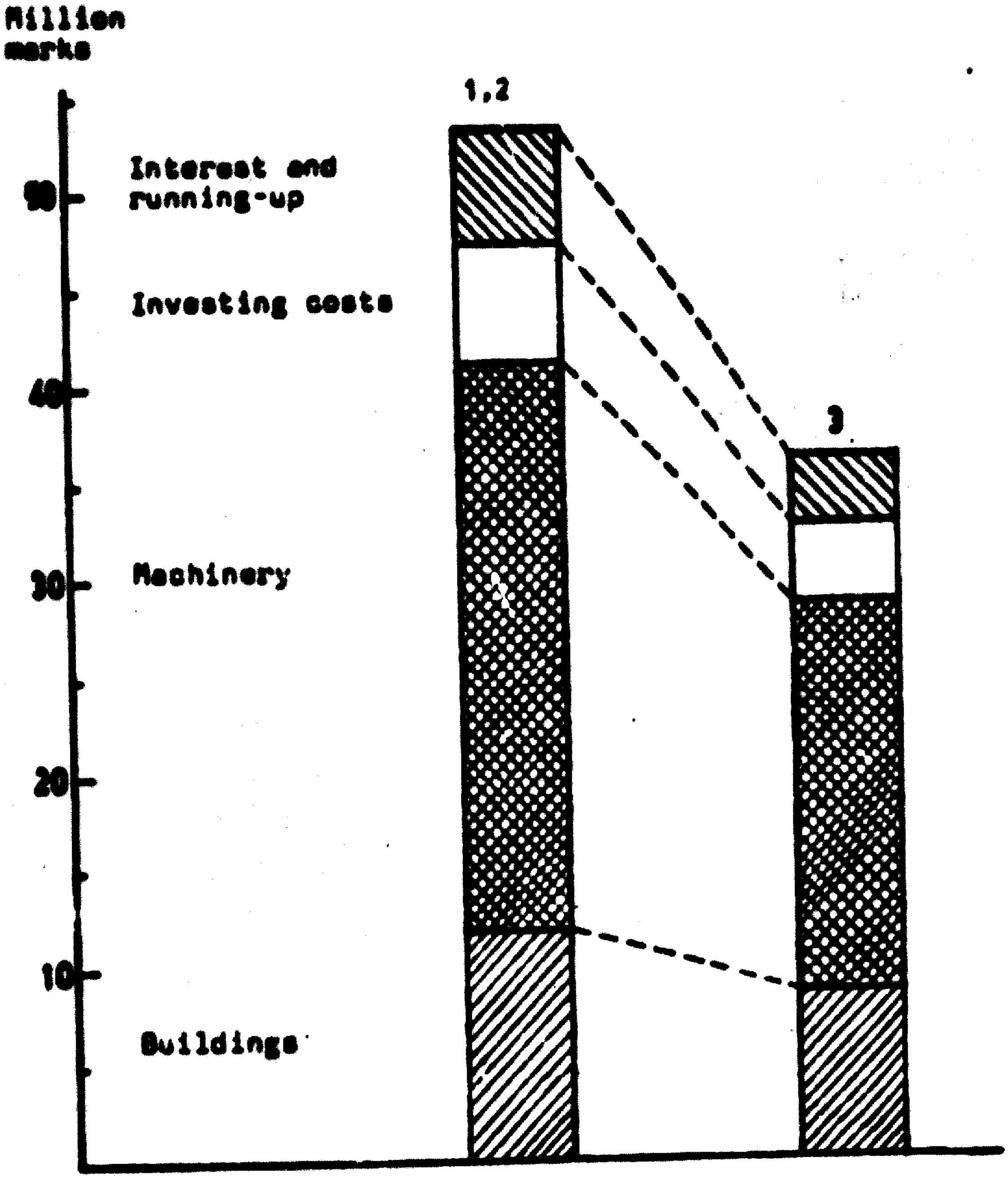
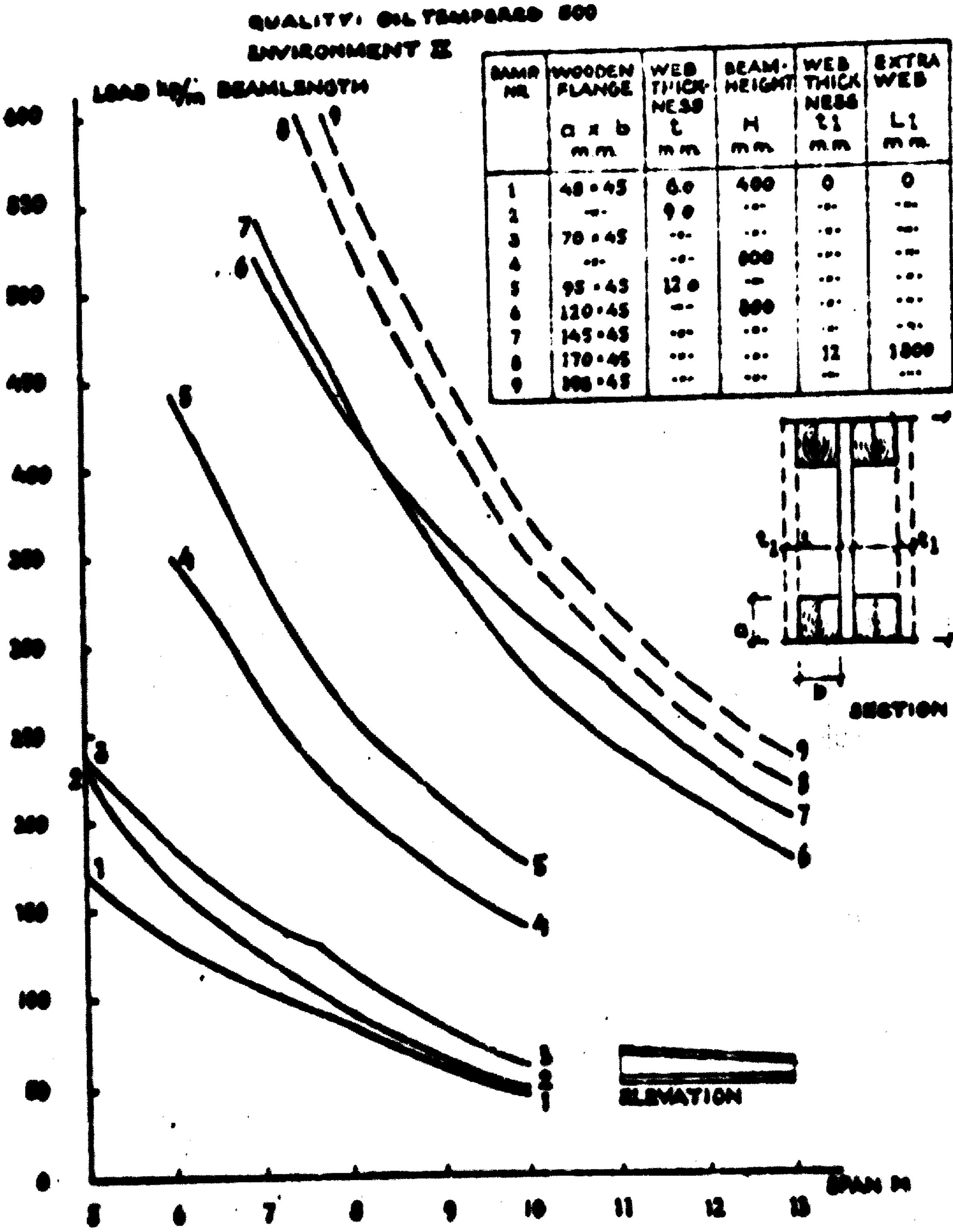
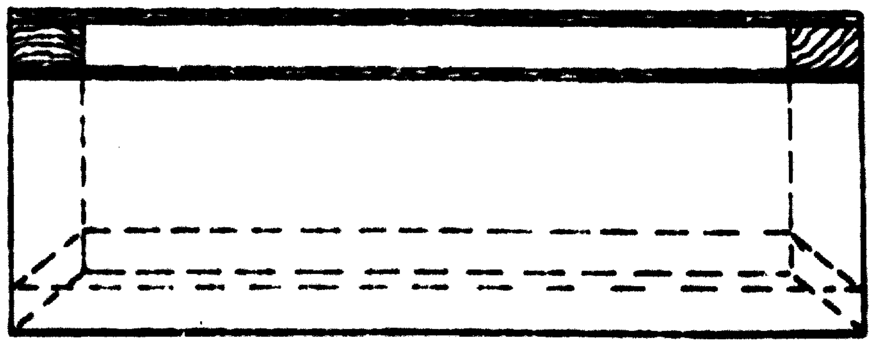



FIG. 4.21. Investing costs

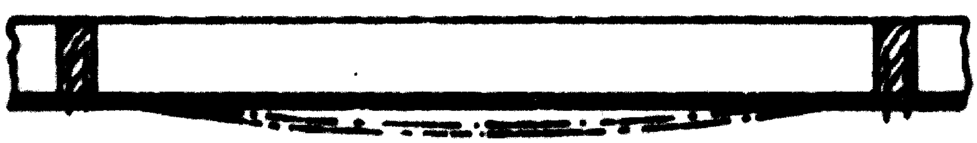



| BAMP NR | WOODEN FLANGE a x b mm | WEB THICKNESS t mm | BEAM-HEIGHT H mm | WEB THICKNESS t1 mm | EXTRA WEB L1 mm |
|---|---|---|---|---|---|
| 1 | 48 · 45 | 6.0 | 400 | 0 | 0 |
| 2 | -"- | 9.0 | -"- | -"- | -"- |
| 3 | 70 · 45 | -"- | -"- | -"- | -"- |
| 4 | -"- | -"- | 600 | -"- | -"- |
| 5 | 95 · 45 | 12.0 | -"- | -"- | -"- |
| 6 | 120 · 45 | -"- | 800 | -"- | -"- |
| 7 | 145 · 45 | -"- | -"- | -"- | -"- |
| 8 | 170 · 45 | -"- | -"- | 12 | 1800 |
| 9 | [illegible] · 45 | -"- | -"- | -"- | -"- |

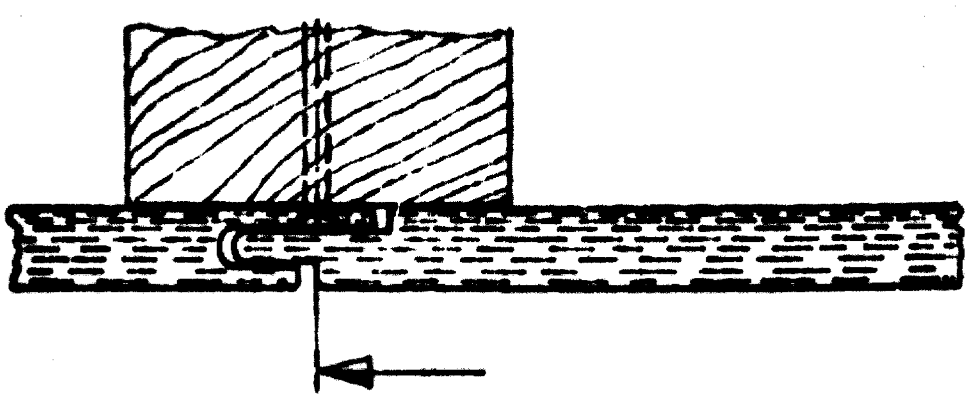
Figure 4.22. Different beams of wood-hardboard with webs of oil-tempered hardboards. Group 2.



**Side lists at door**



**Supporting at sides**



**Constructive joint**

FIG. 4.23. Constructive details for fibreboard support

Table 4.1

TABLE 4.1

| Property | Value for structural insulating board | Value for medium board 2) | Value for special densified medium board 3) | Value for high-density hardboard 3) | Value for tempered hardboard | Value for special densified hardboard | Unit |
|---|---|---|---|---|---|---|---|
| Density | 160–400 | 529–800 | 310–343 | 300–1[illegible] | 960–1230 | 1300–1[illegible] | $kg/m^3$ |
| Specific gravity | 0.16–0.[illegible] | 0.53–0.80 | 0.32–0.33 | 0.30–1.23 | 0.93–1.23 | 1.30–1.[illegible] | |
| Modulus of elasticity (bending) | [illegible]–0.39 | [illegible].23–3.94 | 3.10–4.26 | 2.31–5.[illegible]2 | 4.57–7.73 | 8.79 | $10^3\ N/mm^2$ |
| Modulus of rupture | 1.40–5.[illegible] | 13.30–31.75 | 28–42 | 21.1–4[illegible].2 | 33.4–7[illegible].3 | 70.3–37.[illegible] | $N/mm^2$ |
| Tensile strength parallel to surface | 1.40–4.50 | 10.0–15.0 | 13.0–23.0 | 2.11–42.2 | 25.3–54.[illegible] | 5[illegible].0 | $N/mm^2$ |
| Tensile strength perpendicular to surface | 0.07–[illegible] | 0.3–0.6 | 0.5–0.[illegible] | 0.7–[illegible].5 | 1.12–3.16 | 3.51 | $N/mm^2$ |
| Compressive strength parallel to surface | | 10.0–12.0 | 14.0–16.0 | 1[illegible].7–42.2 | [illegible]–42.2 | [illegible]36.3 | $N/mm^2$ |
| Shear strength (in plane of board) | | | – | | [illegible] | | $N/mm^2$ |
| Shear strength (across plane of b.) | | | – | | 1[illegible].7–23.9 | | $N/mm^2$ |
| 24h water absorpt. | 1–10 | | – | | | | percent by volume |
| [illegible] water absorpt. | | 9–14 | 7.5–10 | 3–3[illegible] | 3–20 | [illegible]3–1.2 | percent by weight |
| [illegible] thickness swelling 24 hour soak | | [illegible]–5 | 5–[illegible] | 1[illegible]–25 | 8–1[illegible] | | percent |
| Linear expansion [illegible] 50 to 90 percent r.h. 4) | 0.2[illegible] | 0.2–0.[illegible] | [illegible]–0.30 | [illegible]–[illegible].45 | 0.15–0.45 | | percent |
| Thermal conductivity at mean temperature [illegible]°C | 1.4[illegible]–2.[illegible] | [illegible].3[illegible]–3.[illegible] | 1.0–4.0 | [illegible].[illegible]–7.2[illegible] | [illegible].3[illegible] [illegible].7[illegible] | [illegible] | [illegible] |

1) The data [illegible] are general round figures [illegible] accumulated from numerous [illegible] fi[illegible] [illegible] [illegible] [illegible] are [illegible] [illegible] [illegible] [illegible] [illegible] conditions of [illegible]

2) [illegible] [illegible] [illegible] [illegible] manufacture [illegible] [illegible] [illegible] high [illegible]

[illegible]

[illegible]

[illegible]

| | | r.h. |
|---|---|---|
| Group 1. | Most structural elements in heated buildings | <75 % |
| Group 2. | Most structural elements in temperarily heated, ventilated buildings. Relative humidity up to | 95 % |

| Type of board | Bending | Tension | | Compression | | Shear | | E-modulus | G-modulus panel shear |
|---|---|---|---|---|---|---|---|---|---|
| | | // | ⊥ | // | ⊥ | layer | panel | | |
| Group 1. | | | | | | | | | |
| Oiltempered | 9,5 | 5,5 | 0,2 | 5,5 | 5 | 0,35 | 3,5 | 2700 | 1350 |
| Standard | 6,5 | 5 | 0,15 | 3,5 | 5 | 0,25 | 3 | 1300 | 650 |
| Mediumgrade | 3 | 1,4 | | 1,4 | 0,9 | 0,04 | 0,8 | 700 | 350 |
| Group 2. | | | | | | | | | |
| Oiltempered | 5,5 | 3 | 0,08 | 2,5 | 5 | 0,3 | 2 | 1800 | 900 |
| Standard | 3,0 | 2 | 0,05 | 1,3 | 5 | 0,2 | 1,3 | 900 | 450 |
| Mediumgrade | 1 | 0,8 | | 0,4 | 0,5 | 0,04 | 0,6 | 450 | 180 |

Table 4.2 Permissible stresses in $N/mm^2$ for normal constructional (K-) board in environmental groups I and II. Lundgren.

4. 4. 74