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Expert Working Group Meeting
on the Production of Panels
from Agricultural Wastes

Vienna, Austria, 14 - 18 December 1970

PRODUCTION OF STRAWBOARDS BY THE "STRAMIT" PROCESS [1]

by

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England

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SUMMARY

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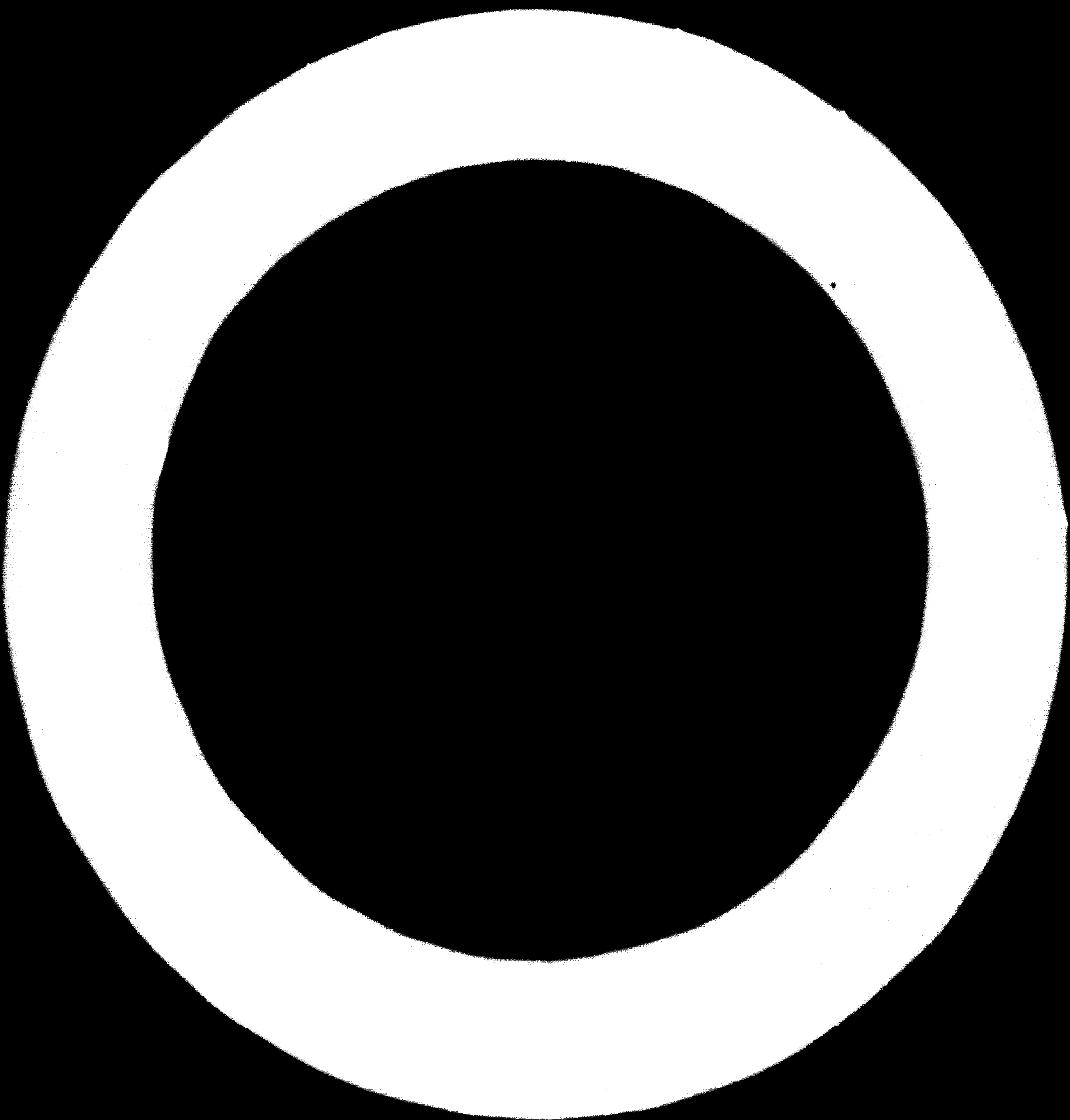


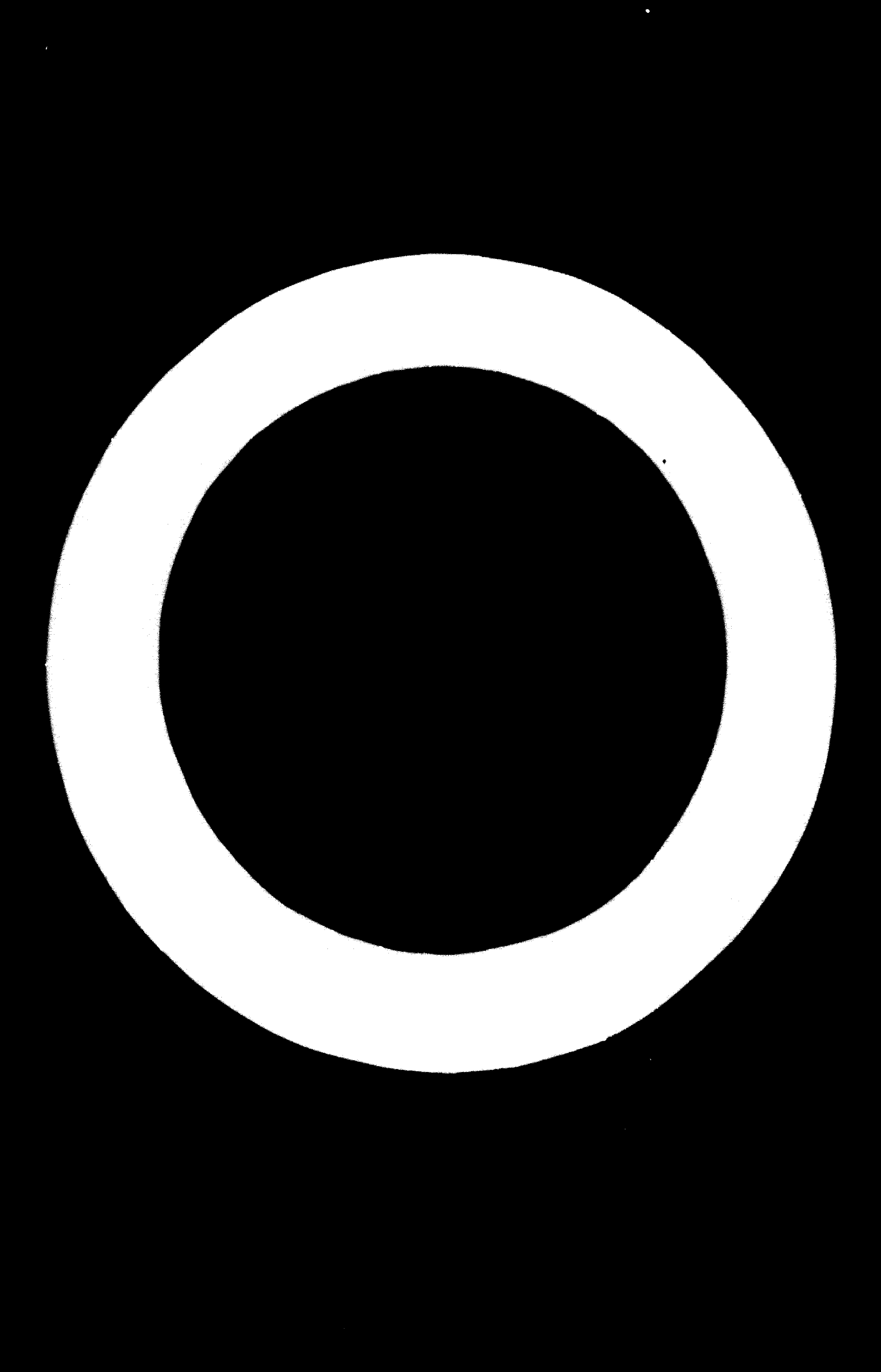
Of the non-wood fibrous materials available for the production of panel products, it is probably straw and reeds that have been most successfully used in manufactured forms. Developed out of the traditional thatchboards produced in many countries is the "Stramit" slab of compressed straw. It consists of unpulped straw with smooth facings, generally of stout cardboard. This panel is in many ways akin to a large plank of wood; traditionally it is produced in 50 mm thickness and 1.20 m wide by whatever length is convenient for the job in hand.

The Stramit process was first patented in Sweden towards the end of the 1920s and since then factories have been established in more than 20 countries with varying climatic conditions and building techniques. Small plants to produce 300,000 sq m per annum from approximately 6,000 tons of cereal straw are available but there still exists a large installation with a theoretical capacity of 100,000 tons per annum.

During its long period of development the Stramit process has been basically unaltered but the manufacturing techniques have been streamlined and some of the precautions that have to be taken in the use of any organic material under adverse conditions have become known and experience gained to assure the correct application of the Stramit slab under practically every type of construction conditions. In a developing country where cereal straws of wheat or rice etc. are available, a small plant to use 6,000 tons of straw in a year, working on a 3-shift basis, could be established or it might be possible to run it on a single shift basis to start with when the straw requirements would be even lower.

Generally it is not the availability of the straw or the manufacture of Stramit that presents problems but rather the marketing of the product. The happiest prospect would therefore appear to be where a building programme can be organised with the Stramit panels as a substantial part of the scheme. It is possible to construct low-cost buildings with Stramit for external walls, partitions and also for roofs under a proper weathering. Such lightweight dwellings are suitable even in earthquake areas and yet substantial enough to bear comparison with heavy traditional buildings. The amount of rigid framing required for these low cost houses is very small, and where timber is not available very light gauge steel framing is successful. The 5. mm thick Stramit panels have an insulation value equal to thick masonry walls, and their fire resistance is better than softwood.

Experience shows that, under favourable conditions, a sum of $150,000 may be sufficient to install a Stramit machine and a similar capital should be provided to cover other initial expenses. If a small bungalow requires, say, 65 panels, this would equal approximately 200 m2, which in turn indicates that a small plant would annually provide building material for 1,000 houses and in addition panels for other purposes. Under the conditions given as examples in the accompanying Paper, production cost of, say, $0.80 to $1 per m2 is indicated. Examples are also given of how the Stramit houses could be constructed without the use of other sheeting materials except for the weathering of the roof. Basically, therefore, the Stramit compressed straw panel is a low-cost product which is easy to produce from raw material available in very many parts of the world. To be successful the operation has to be guided by some experienced organisation and that experience is best obtained by a combination of a local firm with knowledge of the raw materials and building techniques and the supplier of the machine giving an undertaking to help promote and look after the industry. For that purpose the Stramit machines are sold on a franchise basis with a continuing service commitment.



Reed, straw and similar vegetable products are amongst our oldest building materials. Because they are readily available and cheap they are frequently used in their natural state. In more manipulated form reed and straw etc. have become established building materials and have proved their value in roofing of shelters or more permanent structures, in boat building in a few parts of the world, etc. The lasting value of straw and reed when used under naturally dry conditions or under protecting covers is well documented. Of cellulosic base, straw has up to 40% mineral content as measured on the dry substance of the ashes which helps to explain the lasting qualities of these raw materials and also their resistance to fire when compacted so that the oxygen required for burning is excluded or restricted.

Straw is an annual crop and as potential raw material has a quicker cycle of availability than forest products. It is also often to be had in countries where wood resources are scarce. The potential value of crop residues has often been quoted when considering available raw material for panel products. The point was made specifically at the first session of the F.A.O. Committee on Wood-based Panel Products in Rome reported in Document FO: WFP/66 of the 24th March 1967.

Panel products based on reed and straw are manufactured in many parts of the world and various machines have been constructed to mechanise the process. Generally the manufacturing method has been based on a weaving process involving strings or metal wires. Products in this field have variously been known as "Thatchboard", "Solomit", "Bremmerboard". This range of low cost products is distinguished by not making use of any cement or glue but purely mechanical ties.

In more recent years particle boards incorporating fairly substantial quantities of artificial resins as a binder have made use of non-wood products like flax shives.

In the following will be described a process of compressing straw and similar vegetable fibres by a patented process of combining heat and pressure, best known under the trade name "Stramit". This process was originated in Sweden during attempts to provide finished surfaces to the old type of woven thatchboard. It was soon found that the factory application of a lime-plaster finish increased the weight and was too brittle to make the product commercially viable although technically acceptable.

Further developments brought about the Stramit patents which incorporate paper o r similar facings glued to the straw core. It was found that by applying the correct amount of heat and pressure the unpulped straw could be softened during the manufacturing process to acquire a stable compressed form within an extrusion tunnel and in the progress through this tunnel the straw slab was given its facing of stout cardboard liner.

Since the first slabs of this type were incorporated into buildings about 1928, progress has been made mainly in improving the manufacturing technique by establishing a greater automation of the process and better quality control. The original concept of using unpulped straw without any binder incorporated between the straws themselves and compressing them in an extrusion tunnel and applying a suitable dry lining has not been varied. The resultant product is low in cost because no binder whatsoever is used except to apply the facings to the straw core, and it has proved itself over more than 40 years to be a building product acceptable under various climatic conditions and for a wide range of uses.

Stramit plants have been established in some 25 countries using existing local cereal straw varieties and adapting the products to the local methods of building. In addition Stramit slabs have been exported to other parts of the world which do not offer either the raw material or a market of sufficient size to warrant local production. Plants of the more sophisticated types are established in Western Europe and Japan, whilst the simpler types of Stramit machines are operating in such countries as Thailand, Ceylon, Colombia, Mexico and Canada. Although other types of agricultural residue can form an acceptable raw material, all present plants are utilising cereal straws from wheat, barley and rice. Of the many types of grasses and agricultural wastes laboratory-tested, only one has proved unsuitable for use in the Stramit process on technical grounds. Apart from a requirement that the fibres should be reasonably long with only a limited proportion of strands less than 10 cm, the raw material is accepted as it comes from the harvest fields and with its moisture content as satisfactory for the successful threshing of the corn. If for occasional parcels of the straw a drying or a cleaning process is required, then these functions can be carried out within the

Stramit plant. A moisture range from 10% to 16% is normal.
In addition to the basic raw material of straw, the requirements are for a dry facing, usually stout cardboard, which is applied by the Stramit machine to all faces and edges of the panel which comes out as a continuous band and is cut off to the desired lengths.
The third raw material of consequence is the glue to apply the cardboard liner to the compressed straw core. This can be an animal or vegetable glue although in practice an artificial resin of the urea formaldehyde type is generally used.
The Stramit process is a simple one in terms of capital cost and manpower once the straw has arrived at the factory. The accompanying simple diagram indicates how the straw in its natural state is fed either mechanically or manually into a hopper from where it is driven by a reciprocating piston or ram into a heated extrusion tunnel. The size of the tunnel is conventionally 50 mm by 1.20 metres giving the product the corresponding dimensions (approximately 2 inches thick by 4 ft wide).
The paper liner is introduced within the extrusion tunnel and glued to the straw core and the combined panel that comes out from this tunnel is therefore a continuous length of straw slab covered with paper. By cross-cutting this endless slab as it comes from the Stramit machine, panels of conventional lengths are obtained ready for immediate use. In many ways these panels resemble planks of softwood of dimensions normal for plywood sheets but much thicker.
The Stramit production method allows alterations to the sizes, facings and density of the slab produced. A typical panel of 50 mm thickness, 120 cm width and length of 2.50 m would weigh 50 to 55 kg., which

means that normally two men would be required to handle it on site, but in emergencies it is possible for a single experienced operative to fix what is effectively a ready-made wall unit. Sound reduction is about 28 - 30 dB at 100/3200 Hz. Thermal conductivity is equal to 0.101 W/m2 degree C.

Although technically combustible, the Stramit slab does not support fire as has already been stated due to the comparative lack of tars and resins and the presence of mineral compounds in the straw itself. There is evidence from many fires that the Stramit panels have stopped their spread, thus supporting worldwide laboratory test results.

Due to the fact that the straws are predominently across the width of the slab as it passes through the machine, the Stramit is 2.5 times stronger in width than length. It is not lead-bearing when used on its own as a partition but it is strong enough to be used as a roof deck on open framework. The typical slab described here will deflect about 3 mm under the weight of a man standing in the centre of it when supported only 25 mm in on the four edges; it will not break under the load of ten men. As Stramit can be nailed, glued and cut almost like a timber plank, the similarity presents itself again.

Like other organic materials Stramit needs to be protected from water and stagnant moist air. Used for external walls with weathering of cement-lime rendering (stucco), Stramit has proved efficient in Sweden over 40 years and elsewhere over shorter periods without showing signs of deterioration. In countries with milder climates and traditional skill in stucco work, low cost Stramit houses are erected with walls of single thickness Stramit supported at the panel edges with light steel coupling pieces that are also covered with the stucco so as to give a smooth unbroken wall surface. In this design the inner faces of the walls are given a coating of plaster so that the overall wall thickness is only about 75 mm; even so the walls are strong enough to carry the roof. These houses are well insulated and the lightness of the construction is thought to have special value in earthquake areas.

Another external use of the Stramit panels is for roofs which can be weathered with metal, asbestos cement sheets, roofing felt etc. In appropriate cases the slabs can be laid as a loadbearing deck under felt or asphalte on open framework. Even when used under roofing that is self-supporting, the Stramit often proves to be low in cost to provide insulation and a smooth ceiling because it requires only little support to remain flat.

Most Stramit is used within buildings to give insulation and a dry self-finish ready for decoration if so wanted with wallpaper, paint etc. Linings to external walls come into this category; it is usual to place the Stramit panels away from the external skin of the wall and thus create a wall cavity. Being stiff and with very low moisture movements it is possible to place these wall linings with very limited support from the structure and without the need to cover the joints except with conventional decorative materials. There is no need to create a visual panel effect and unbroken wall surfaces are possible with dry techniques which include a method of glueing one Stramit edge to the next panel or even to the adjoining structural member. To divide up rooms with single thickness Stramit panels is possible by utilising the same edge-glueing technique. The partition wall normally needs fixing only to the ceiling, floor and adjoining walls. Factory preparation of complete wall linings and of whole partitions with the necessary doorways is a practical proposition where building cranes are available on site. A further use of the Stramit panel is as permanent shuttering for in-situ poured concrete, but it is not suitable for re-usable formwork. Earlier it has been indicated that the Stramit manufacturing process is a simple and relatively inexpensive one.. The smallest plant currently on the market produces 50 m2 per hour of 50 mm thick and 1.20 m wide Stramit. This gives an annual production of 300,000 m2 of panels when the machine is worked 120 hours per week, i.e. on a shift basis. For this one ton of straw is needed per hour, say 6,000 tons annually. Single shift working is possible but leads to some loss of efficiency. The electric power requirement is 85 kVA; no steam is needed and water is used only for the glue mixture. To operate the machine three men are needed which on a shift basis calls for about 20 men in all to include the foreman, fitter, straw handling and warehouse operatives, who are generally employed on a single shift basis only. A small Stramit machine can be housed in a building 8 m x 40 m which will also house the panels produced during a few shifts, and a stock of paper liner, glue etc. The space needed to hold the straw is difficult to define as it will depend on whether it becomes available once or twice a year and whether it can be held on the farms until actually required at the factory. Not less than three weeks' needs should be available at the factory in dry condition. Loosely bundled straw presents a fire hazard and very large stocks are better left in the frowing areas until needed. Generally the stocks can be properly protected against rain without the need for permanent barns, but local conditions decide these arrangements.

As suitable paper liners are often not available close to the Stramit factory, it is safe to hold 3 - 6 months' supply in stock. Glue stocks may similarly have to be relatively ample.

A small Stramit machine as discussed here costs at present about U.S.$ 150,000. Some additional plant items may have to be added in certain circumstances, and buildings, electricity supply and such items are so varied in cost that no generally applicable total figure can be quoted. It is almost meaningless to give production cost figures as circumstances vary between say temperate and tropical locations, high and low wage countries, etc. The following attempt at giving costings is therefore inclusive of quantities so that the prices can be adapted to known local conditions. The exercise is based on a small Stramit machine producing slabs of the panel sizes given above using cereal straw, paper liner and urea glue. It is assumed that the buildings are rented and that the panels can be sold to distributors or consumers immediately so that storage space and capital are not tied up:

<u>One Stramit machine</u> producing 50 m2 / 525 sq ft / per hour during 24 hours per day for five days a week for 48 weeks will produce <u>288,000 m2 per annum</u>

<u>Straw</u>	17 kg per m2 is required = 4,900 tons Say 6,000 tons at about $14 per ton	$86,000
<u>Paper liners</u>	based on 320 gr/m2 for each face of slab = 190 tons plus end seal papers Say 210 tons at about $157 per ton	$33,000
<u>Glue</u>	Say 150 tons when mixed = 0.5 kg/m2 of Stramit	$15,000
<u>Labour</u>	Factory supervision and operatives (5 men x 3 shifts + 4 men x 1 shift) ...	$48,000
<u>Factory rent</u>	incl. electricity, insurance etc. ...	$36,000
<u>Royalty</u>	payable on production at $0.06 per m2 ..	$17,000
which equals about <u>$0.80 per m2.</u>		$235,000

If to this assumed production cost is added 25% as the likely requirement for spares and maintenance and a 20% plant depreciation, the full cost of the Stramit panel would be $1 per m2 under the circumstances given.

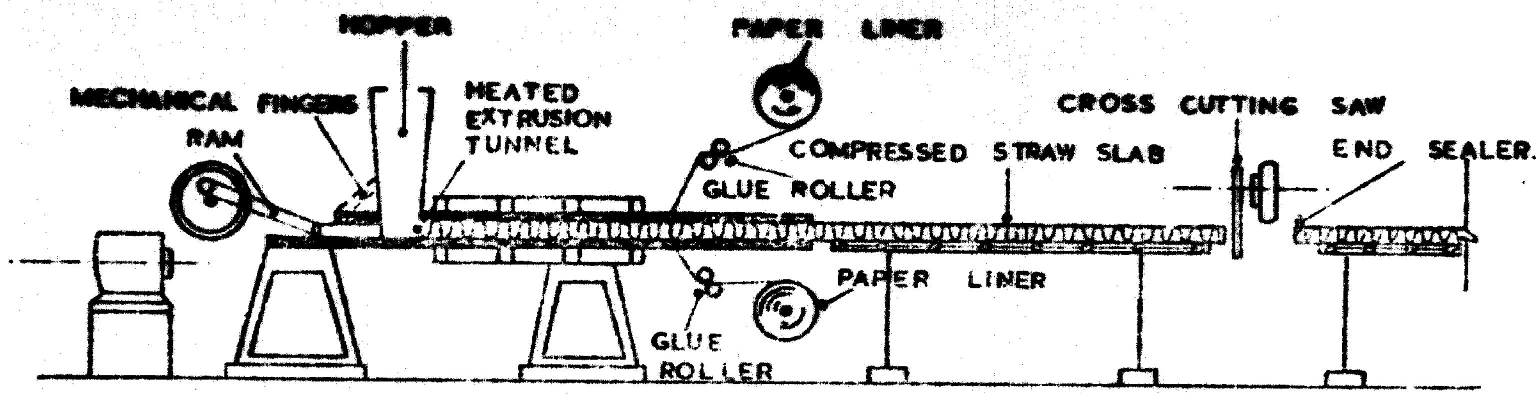
With regard to the capital requirements it is reasonable to quote a figure of $150,000 as the approximate cost of the machine and its necessary equipment. If no import duties are involved and if electricity and other services are laid on to the site, this price could, under otherwise favourable conditions, mean the installed cost. It would be prudent to assume that a similar sum would be needed to procure a stock of straw and other materials, pay for staff during the running-up period, buy some auxiliary plant in special cases and to cover general expenses until production and sales are providing the cash flow. Once again it is wise to point out that local circumstances vary so much that a reliable estimate of cash and credit requirements is subject to specific calculations. As an example, some Stramit factories have been built from the first slabs produced on the machine, giving the producer cost savings and assuring that customers do not have to accept "start-boards".

To the above outline description of the manufacturing process and the characteristics of the Stramit compressed straw slab may be added the versatility of the product. Apart from the modifications possible to density, facings etc. in the machine itself, simple additional plant as used in woodworking factories will convert standard slabs to special sizes and "housing sets", often enabling the manufacturer to avoid losing a standard panel with a small defect by reducing its size to suit the customer. It is possible to manufacture the panels in the machine itself with internal holes to [illegible] electric wires etc. and later to cut out recesses for sockets and other flush fitting items required. But for its unique manufacturing method, solid thickness and moderate weight, these "made-to-measure" facilities would not be possible in a low-cost panel. In practice it has been found that the facilities of altering the apertures etc. without much cost to the panel producer is a great help in his selling effort.

Some Stramit manufacturers have developed further by lining, in a separate operation, the standard machine-produced panels with decorative vinyl fabrics and supplying ready-decorated office partitions and the like. Others utilise falling waste from the Stramit production line to produce "blockboard" or Stramit core-panels. After cutting the slabs into strips of the required thickness and then turning these strips so that the individual straw strands stand upright, rigid facings of plywood, fibreboard or asbestos cement are stuck to top and bottom of the core strips, i.e. they are glued to the straw ends. Correctly assembled, these core-panels can become fire-check doors. Perhaps enough has been said to indicate that the Stramit panel can itself be treated as a raw material.

In conclusion, a Stramit plant benefits the agriculture and economy of a country by making use of what is normally a recurring waste and it benefits the building industry, whether modest or sophisticated, by providing a proven material for economical construction.

SCHEMATIC OUTLAY OF THE "STRAMIT" PROCESS



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