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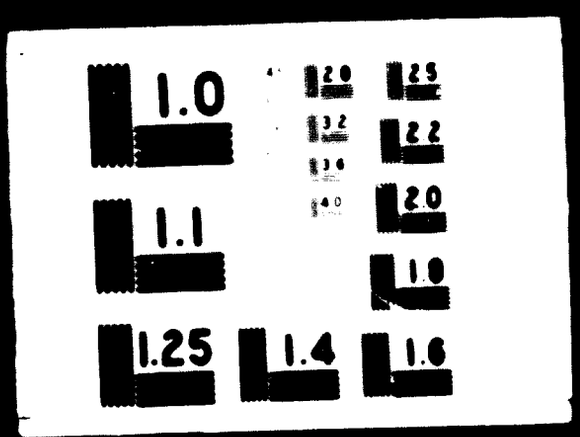

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ID/WG.83/10
4 December 1970

ORIGINAL: ENGLISH

Expert Group Meeting on
the Production of Panels
from Agricultural Wastes

Vienna, Austria, 14 - 18 December 1970

ECONOMIC AND TECHNICAL ASPECTS OF THE UTILIZATION OF CEREAL STALKS FOR THE PRODUCTION OF PANELS 1/

by

S. Bulakul
Managing Director
Stramit Board Co., Ltd.
Bangkok, Thailand

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SUMMARY

ECONOMIC AND TECHNICAL ASPECTS OF THE UTILIZATION OF CEREAL STALKS FOR THE PRODUCTION OF PANELS [1]

by

S. Bulakul
Managing Director
Strawit Board Co., Ltd.
Bangkok, Thailand

The main objective of this paper is to pass on my limited experience in promoting and operating a Strawit industry in Thailand to anyone who wishes to look into the possibility of promoting the same industry in his own country. The paper will cover only the economical and technical aspects of the project and not the financial and managerial aspects.

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Strumit compressed straw slab is a structural panel with good heat and sound insulation values and fire resistant properties. It has a fixed width and thickness but the length can be cut to any size. It is suitable for use as roof-decking, partitioning, ceiling, interior wall lining as well as other smaller applications.

At present our panel is marketed mainly in Thailand. It has been used in diverse types of buildings, but is found to be most suitable for institutional buildings, factories, low cost apartments and entertainment centres. There are obstacles in market development caused mainly by the newness, distinctive appearance and unfamiliar methods of applications of the product as well as the type of raw material (straw) used.

The panel is manufactured by a simple dry process of heat combined with pressure. The machine we use has a rated production cycle of the whole process of only ½ hour. There is no problem of waste disposal. The raw materials used are cereal straw, which is indigenous, glue and paper both of which are imported. The straw should have a moisture content of less than 16 per cent and for hand feeding the optimum length is 80 cm.

The availability of straw and the cost of straw in agricultural countries, which presumably many developing countries are, will pose no problem except the cost of straw transportation.

We use a ratio of 1 kg of rice paddy to 2 kg of straw. If the full length stalk is used, some areas will have a ratio of 1 : 3. In Thailand rice straw is also used as paper pulp, packaging material, cattle food and fertilizer.

The whole Strumit production line is run on electricity. A few operations are activated by compressed air. The manpower required for production with hand feeding in Thailand is 21 persons. They are 12 straw feeder/carriers, 2 machine operators, 1 glue mixer, 4 cut-off saw/sealing unit operators, 1 straw receiver and 1 electrician.

Plant layout depends on space requirements, production process and the size of operation. It is useful to have a master plan drawn up to include all possible future requirements. Plant location should be near the source of supply of raw material because this industry is material oriented and transportation facilities from raw material's sources of supply and the end-users of the finished products should be taken into consideration.

The industry creates economic benefits for the country by raising the farmers' income, making use of waste from agriculture, saving and earning foreign exchanges and making available a useful local building product.

In conclusion, a set of objectives have been presented so that alternative choices of utilization of agricultural wastes for the production of panels may be systematically evaluated. This paper includes two tables showing various operating cost elements, materials used per sq. metre of panel and per hour of production. There are also diagrammatic illustration of the machine process chart, plant layout and master plan for future development of the factory sites.

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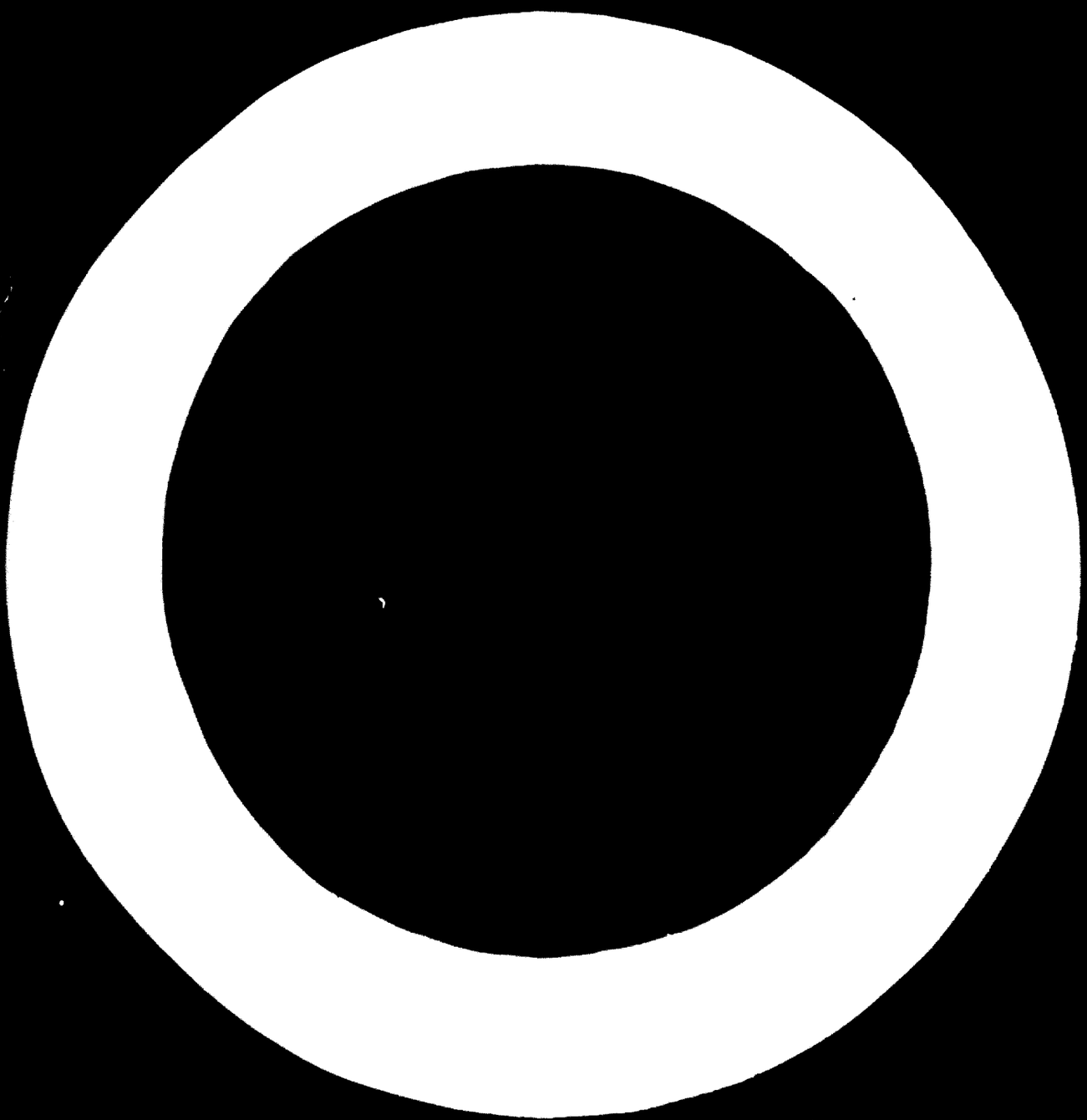


A. INTRODUCTION

In introducing this paper, I hope to pass along the limited first hand experience of my short time in promoting and developing a Stramit plant which is one way of utilizing cereal straw for those who would like to look into the possibility of starting a Stramit industry in their own countries. The word straw, according to the Encyclopaedia Britainica, is the dried stalks of certain cereals such as wheat, barley, oats, rice and rye. With this in mind I have set the following objectives for this paper:

a) To show the basic steps for starting a Stramit industry.
b) To show the various specific requirements in starting a Stramit factory.
c) To highlight the potential problems in starting and operating a Stramit business.
d) To offer suggestions to cope with these potential problems.
e) To serve as a source of reference for carrying out a feasibility study on a compressed straw panel project.
f) To emphasize how the compressed straw panel industry can contribute to the social and economical development of a country.

This paper is set out in such a way as to show the sequence of steps that I have taken in making a feasibility study on starting a Stramit factory in Thailand. The first step to do is to look at the available market for Stramit compressed straw slabs, to see whether the properties of the finished product will serve the need of any section of the building market. If this is so, then we will have to look into the cost of production to see whether we can get a reasonable return on our investment. Finally, we look into the technical aspects. In order to obtain promotional privileges or Pioneer Status in some developing countries which will

give the industry special privileges and exemptions from income tax and import duties on machinery, the feasibility study will have to show economical benefits to the nation.

The content of the paper will only cover the economic and technical aspects; it will not cover the subjects of finance and management, as these are specialised areas of concern which will have to be looked into by the individual promotor.

To produce a panel from cereal stalks is not difficult. The difficulty that arises will be whether the market accepts the product or not. Judging by the number of countries that produce this type of panel, it seems that there will be a wide market acceptance. At present there are 20 or more countries producing Stramit in all the continents and new plants are coming up every year.

B. ECONOMIC ASPECTS

B.1 The Product

A Stramit panel is a building slab manufactured from straw by a method of heat combined with pressure to form a 50 mm. thick rigid structure slab. It is covered on both sides with an integral tough card liner. The British Standard specification for compressed straw slabs is B.S. 4046 of 1966. The panel should be used in applications which fully utilise its thermal and acoustic insulation values together with its fire resistant qualities.

Properties

Strength the strength of the panel lies in the 1.22 m. (4') width. When correctly supported at 0.61 m. (2'0) centre, the panel will take a loading of 90.72 kg. on 0.0161 m^2 (200 lbs. on a 5" square) with a deflection of 1.524 mm. (0.06")

The panel has an average weight of 18.55 kg. per sq. metre (3.8 lbs. per sq.ft.)

Thermal conductivity (K value) 0.101 JM/m^2 S.degree C (0.70 Btu in/feet sq. h. degree F)

Acoustic properties The panel has a 27.7 db reduction average 100-3200 cycles per second.

Fire Resistance Fire exposure, penetration and spread of flame tests have been carried out by the Fire Research Station in UK with these results

As roofs decking

Designated AA, AB, or AC (British Building Regulation 1965) depending on the weatherproofing materials used.

As partitioning and ceiling

Fire resistance : Classified as ½ hour partition, 1 hour when a skim coat of plaster is applied.

Spread of Flame

Class 0 when skim coat of plaster is applied.
Class 1 when coated with intermescent paint.
Class 2 when finished with paint.
Class 3 untreated.

This type of panel has never been known to be attacked by termites or other insects.

Usage There are a few important points on how to use Stramit

1. The right grade Ensure that the right grade of the panel is being used. Roofing grade has a bitumen impregnated liner on one face and is intended for roofing, wall lining and ceiling; plain liner and plasterboard liner types are intended to be used for partitioning.
2. Handling Always carry the panel on edge. This will minimise the damage to the surface.
3. Storage The panel must be stored dry, preferably on edge irrespective of its size.

Cutting The panel can be cut (with difficulty) with a carpenter ordinary hand saw, but the most efficient way is to use a circular saw. When cutting across the width of the panel, a straight edge will help to guide the saw. Alternatively a trimming knife making a deep cut on each side gives a clean cut across the width of the slabs. All cut edges must be resealed.

Fixing to Structure There is a limit to the load carrying capacity of any fixing to a light weight partition. Screw fixing is recommended, using the largest gauge and length screw possible. Such fixing is the most effective when glue is injected into a pre-drilled small hole before the screw is inserted.

Sizes

Due to the method of manufacture the dimensions in its thickness and width are fixed at 50 mm. and 1.22 m, but the length may be cut to any size required.

B. 2 APPLICATION

Roofing The panel may be used as a pitch or flat roof. It has to be supported on all its 4 edges and 0.61 metre centre along its length. To avoid the danger of intrapped moisture, it is essential to weather-proof directly as the panel is laid. Its advantages here are its heat insulation, and fire resistant properties. Weather-proofing may be applied direct. This cuts cost and erection time.

Partitioning The panel may be used as partitioning with either timber or aluminium frame or with glue joint. It may be fixed in such a way that the partition is demountable. The surface of the panel is ready to receive any decoration, such as painting, plastering and wall papering.

Ceiling It provides an economical ceiling with good heat insulation and sound absorption values. The advantages are that the panel may be removed for easy access to the space above the ceiling to carry out maintenance if required. Due to its strength the slab may be walked on, thus making it a safe ceiling. All the panel needs is support on 4 edges.

Other applications are wall lining and as component for wardrobe front and in-fill panel.

B. 3 MARKET FOR COMPRESSED STRAW PANEL

I started a Strawit industry in Thailand because I believe that there is a great need for an economical building panel with some distinctive properties in our market. The prospect became attractive when it was learned that this type of panel could be made from an agricultural waste. Since Thailand is an agricultural country, any contribution towards the income of the farmers will be beneficial to the economy. Another crucial factor was the comparatively low level of initial investment providing a reasonable return on capital. The need for this type of material stems from a demand for mass housing in a developing country like Thailand, which requires materials that are durable, economical, easily and quickly put up.

There is a booming building industry in most developing country. By looking at the available products in the market you will be able to judge whether a compressed straw panel will satisfy a certain sector of the building industry, taking into consideration its price and its distinctive characteristics. Another factor will be the size of the total building industry, the larger the total market, the more chance will be for accepting a larger volume of production of a new product. This provides of course that the production of existing materials do not exceed the market demand.

Another indicator of the growth of the building market, especially in mass housing could be the population growth. It seems most of the developing countries in the world has a high population growth rate. Thailand having one of the highest growth rate of 3.3% per annum.

From an analysis of the benefits derived from the properties of the panel to the various building markets, I have selected the followings as being the most appropriate outlet for this type of panel.

1. Institutional Buildings Hospitals, schools and universities require materials which are economical, functional (as against fancy) and good sound absorption property. This type of panel will meet these requirements as it has shown by having wide acceptance in this market throughout the world.

2. Factories Being light, relatively strong, economical, with heat insulation and fire resistant properties, it serves as an excellent material for roofing or ceiling, especially for industries where temperature or humidity control inside the factory is required. The installation of the ceiling or the roofing is extremely simple. If there is a large growth in the industrial sector in the country, then this will be the market to look into seriously.

3. High-rise Low Cost Apartment In many developing countries the government is putting up this type of building for the mass and it needs partitioning which are economical, quick and easy to put up. The partition should have adequate sound absorption and heat insulation. Thus, if a country has a mass housing program, be it the individual housing unit type or the high-rise apartment type, a compressed straw panel will be a good alternative to the existing materials.

4. Recreation Centres In cinema, sport stadium and bowling centre, the panel has found wide application in roofing and ceiling.

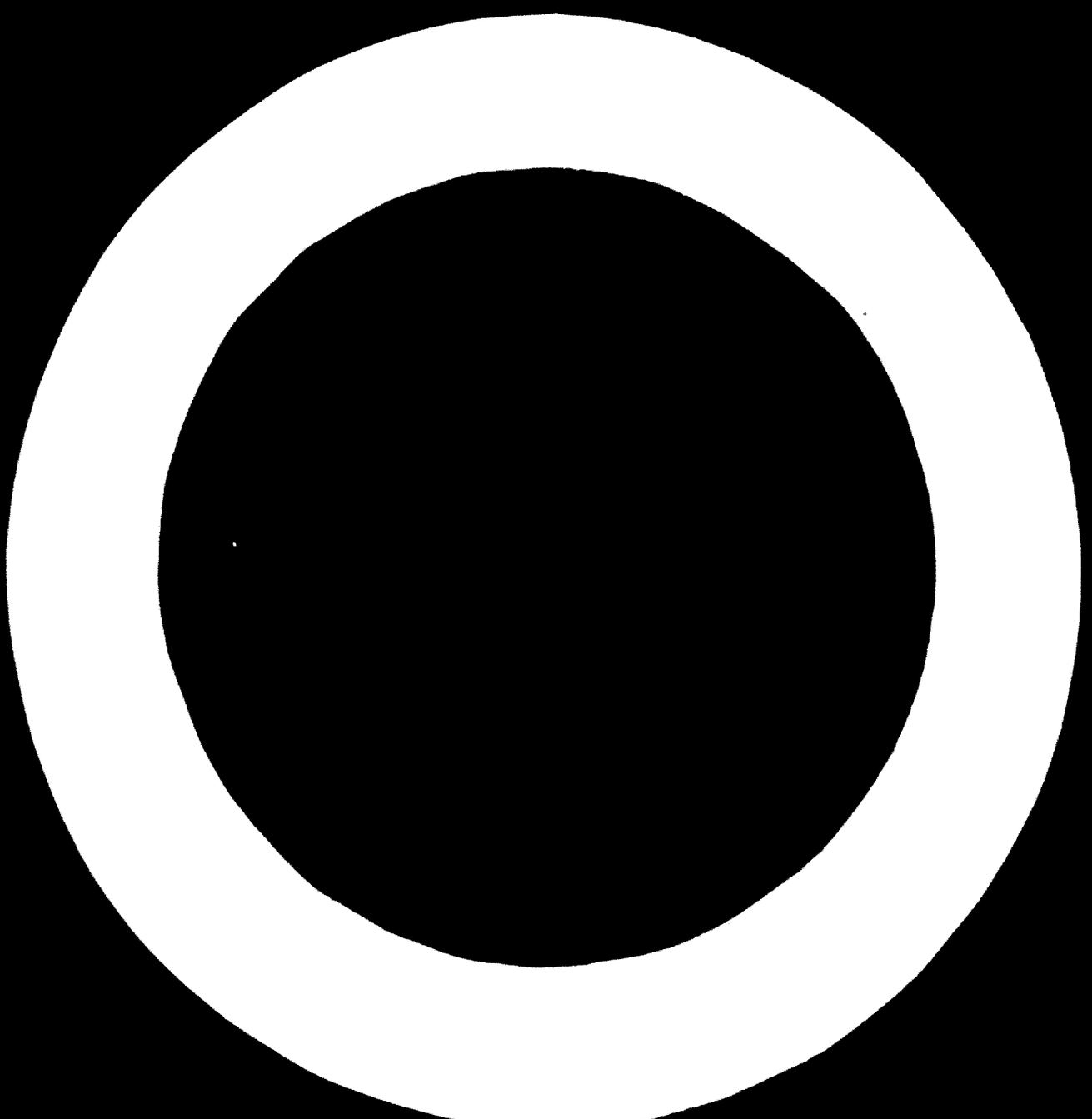
We believe it will also be useful as internal wall lining, as most entertainment centres in Thailand are air-conditioned and the panel offers two suitable distinctive properties i.e. heat insulation and sound absorption.

B. 4 OBSTACLES IN MARKET DEVELOPMENT

The rate of market development depends among other factors on the complexity of the product, its degree of newness, and the presence of competitive substitutes, benefits to the customer and your marketing strategy and sales promotion effort.

In the case of compressed straw panel the distinctive features such as the raw material used i.e. straw, the appearance and the technique of application serve as a resistance to market development. It is not a direct substitute of any existing product, therefore the public will be less quick to perceive as something it requires. This makes the task of the promoter difficult in the initial stage. Another added difficulty that may arise is the purchasing decision taken by one or more key persons in the building industry which may influence a group decision to revert to a more traditional material. However, a new product of this type also has its beneficial side as long as we have taken the precaution to survive the difficulty of the initial launching period. It may take time to establish itself, but once recognized it will have a lasting acceptance.

One way to quicken the progress of market development will be to make the product fashionable among leading citizens. Their acceptance will influence a large number of potential customers who watch from the side line. From experience it is important that customer has a favourable first experience with the use of a new product, because of its newness, customers take particular notice of it and will be impressed if the result is up



demand for setting up a plant is assured, there shall be no need to test market. This will be the case where most of the country mass housing are constructed by the government. Another method of minimizing the risk will be to obtain a few large contracts before going into production.

B.5 COST ELEMENTS

Since the manufacturing process is simple, it is therefore easy to work out the out of pocket costs to quite an accurate degree. Period cost per annum can also be computed with accuracy.

As for the various cost elements, I do not anticipate a great variation in labour or electricity, but the cost of spare parts can be difficult due to different types of straw being used. The cost will depend on the cleanliness and toughness of the straw and the density of the board required. This list of cost elements is more indicative than definitive. My intention is to show the various cost elements to be taken into account when computing the cost of the final product.

It will depend on how your financial expert will interpret the information given here. He may say that any price above out of pocket cost will be contribution to overhead or that any price out of pocket cost plus manufacturing expenses will be contribution to overhead. He would have to take into account the local tax condition and the law of the country.

Of course the selling expenses and the general administrative expenses will need to be broken down into smaller cost elements, but this depends on the type of organization you are going to have. If it is a state enterprise the sales force may be extremely small. You may also decide to ask an outside sales organization to market the product on your behalf.

Financial charges depend on the structure of your company and whether you will have a high or low percentage of borrowed money.

Typical Operating Cost Elements

Out of pocket costs

- Raw materials
- Production labour
- Electricity (1 kwh per sq.m.)
- Repairs and maintenance
- Wastes (maximum 2%)
- Direct tax on production
- Transportation (optional)

Period charges

- Manufacturing expenses
  - Staff
  - Insurance
  - General maintenance
  - Product development
  - Depreciation
  - Staff Welfare
  - Small tools & equipment
  - Travelling
  - Entertainment
  - Miscellaneous
- Selling expenses
- General and administrative expenses
- Royalty
- Financial charges

C. TECHNICAL ASPECTS

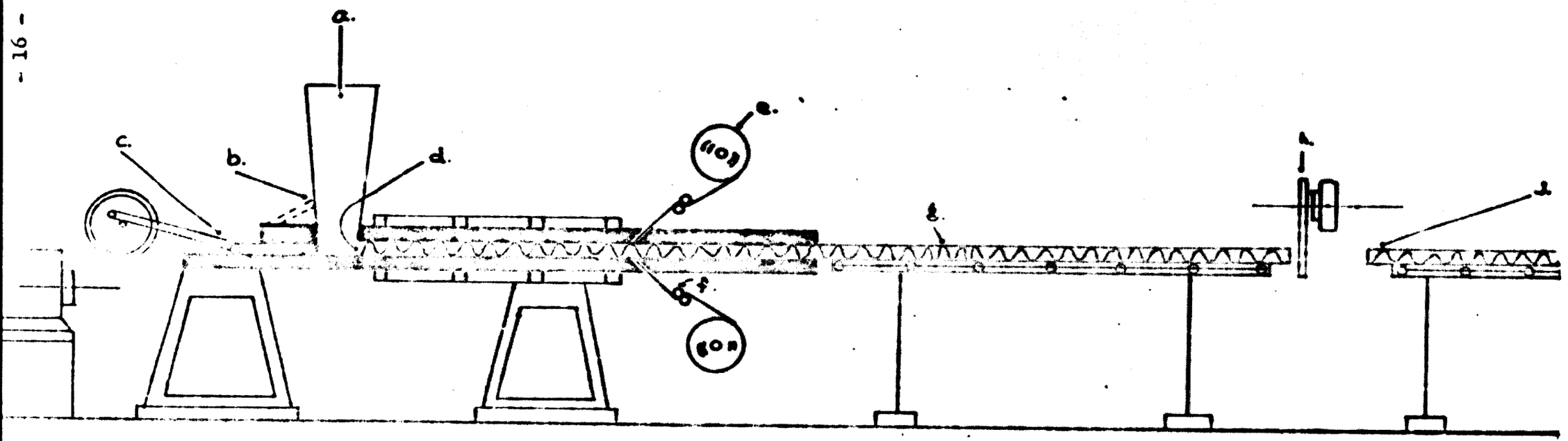
C. 1 Manufacturing Process Stramit process originated from Sweden in 1933. It is a unique method of producing straw board by using heat with pressure to compress straw and sandwiching the compressed straw between layers of paper. If you take a look at the process flow chart you will see how simple it is to manufacture the compressed straw slab, and the total production cycle takes only ½ hour from feeding the straw to removing the finished panel from the end sealing unit. There are altogether three distinctive operations in the actual manufacturing i.e.

1. The making of the straw board.
2. The cutting of the board into sizes.
3. The end sealing of the straw board cut ends.

Please refer to Fig. 1 for machine illustration and Fig. 2 for process chart

Straw may be fed either by hand or by a mechanical feeder depending on the cost of labour, the cleanliness and the length of the straw. In our case it is fed by hand. It is important that the straw must be evenly distributed across the width of the chute and the rate of the feeding must be maintained in order to keep the fork of the machine covered. The straw should be well shaken up before dropping into the hopper, otherwise the slab will have uneven density, faulty edges, burst, nit marks, and paper creasing as well as serious loss of production.

If a mechanical feeder is used it will carry out the following operations:-



KEY

a—HOPPER c—RAM e—PAPER LINER g—COMPRESSED STRAW SLAB

b—MECHANICAL FINGERS d—EXTRUSION TUNNEL f—GLUE ROLLER h—CUT OOF SAW j—END SEALER

FIG 1 DIAGRAMATIC ILLUSTRATION OF STRAMIT MACHINE

PROCESS CHART

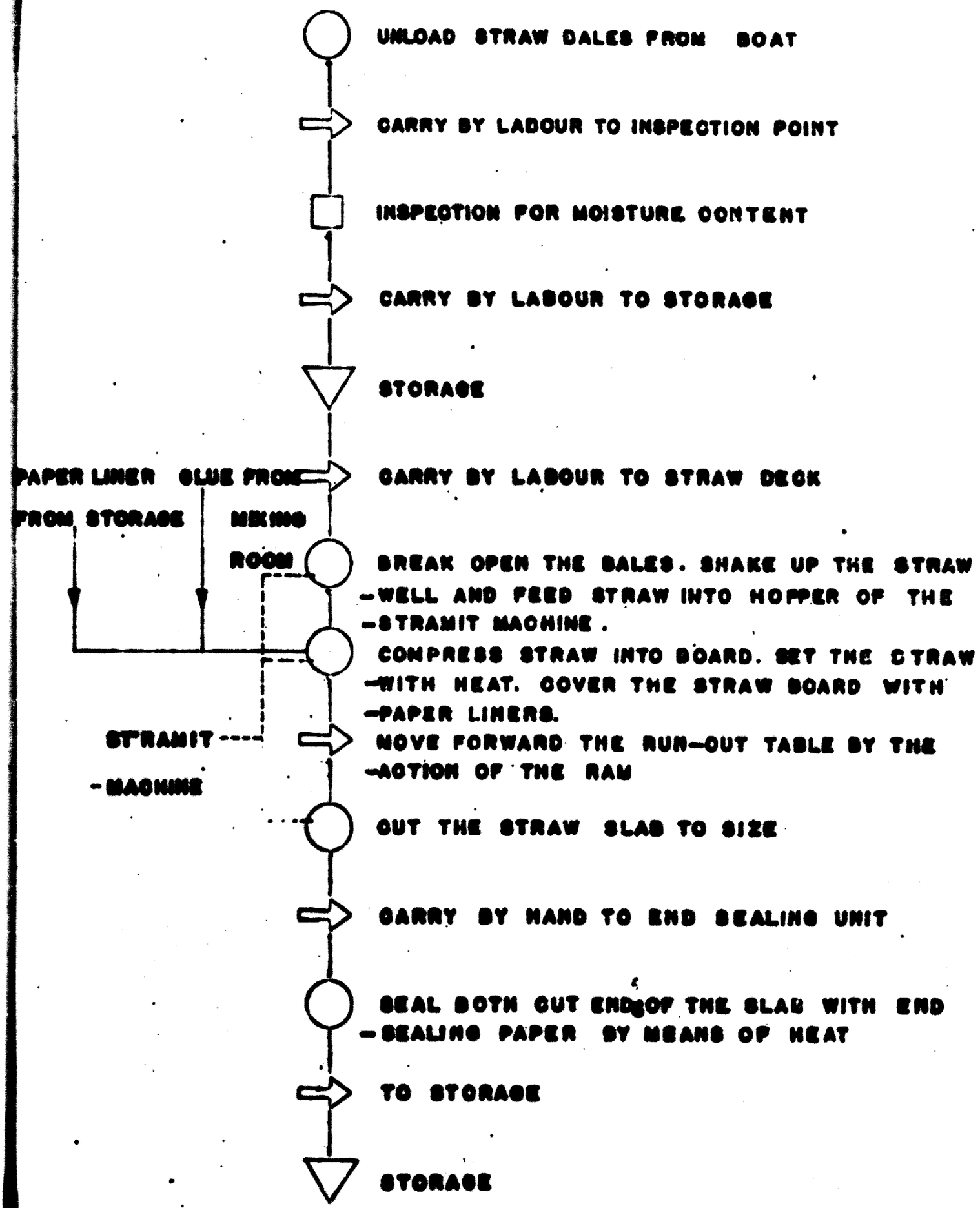


FIG.2 PROCESS CHART

1. Will break open the straw which comes in bales.
2. It will clean the straw by separating out dust and other foreign materials, and feed the straw into the machine in an even and well mixed mat.

When we put our machine into operation there were practically no problems except two that are connected with the change in the straw used and rapid wearing of the cut-off saw blade i.e. the cut off saw was under power. The designated power for the cut-off saw was based on cutting straw board made from wheat, barley or rye straw, not our rice straw which is much tougher.

The potential problems of using Stramit process are:-

1. <u>The inflexibility of the machine</u> Since the process is unique, it therefore requires a machine which is made specially for this particular method of producing straw board. It is not applicable to any other production process.

2. <u>High cost of spare part storage</u> Due to similar reasons mentioned above and being a very specialised machine, the source of supply of spare parts is practically limited to the machine supplier only.

C. 2 Raw Materials

The three essential material components required in the manufacture of straw board are straw, glue and paper liner to cover the surface of the board and for end sealing. Normally in a developing country, only the first component will be an indigeneous material, the rest being very specialised materials will probably have to be imported.

Cereal straw

Cereal straw to be used in the process must be clean, dry and above certain length. The simplest way to find out if the local straw is suitable or not is to send a quantity to the nearest Stramit plant to be tested. If the raw material does not meet the necessary requirements additional cost is needed to carry out pre-processing.

The method of drying the straw that is chosen will depend on the type of heat energy and the availability of space. It also depends on other operations you hope to carry out in conjunction with the production of Stramit slab which might require some form of heat, such as in making Stramit panel with hardboard facing.

The price that we pay for straw in bales deliver to the factory storage is US$20/ton, compared to the price of the cheapest wood, used for construction which is US$1.35/cu.ft., or US360/M.ton.

In Thailand the other uses of straw are as follows:-

1. Raw material for the manufacture of paper pulp.
2. Packaging material for glass and earthware.
3. Food for the farmers' cattle and for cattle being

shipped abroad.

4. Soil fertilizer.

The price that the paper manufacturer pays is about US$10/ton US$25/ton as packaging material because they require specially long straw, and US$20/ton as animal food for cattle for export.

By far the largest consumption of straw in Thailand at present is in the manufacture of paper, but ultimately the manufacture of straw board will also take up a substantial amount as you can imagine the amount of straw required to produce 1 m^2 of slab compared with the amount of straw required to produce 1 m^2 of paper.

It is most likely that the cereal stalks available in any developing country which has an agricultural base will be sufficient to feed more than one line of Stramit machine. The amount of straw available can be easily computed from the amount of grain per unit area of cultivation. In Thailand we use a ratio of 1 kg. of rice paddy to 2 kg. of straw available. If we use the full length of stalk, some areas would have a ratio of 1:8. Thus, if you can find the total production of cereal in the country then the total amount of cereal straw available could be computed. The only difficulty in utilising the whole amount available will be the means of transport, as the cost of this type of raw material to its end user will be proportional to the distance of transportation from the paddy field to the factory site. It will also depend on the type of transport used to deliver the straw. The cheapest method would be by boat. Another factor which should be taken into consideration would be the method of harvesting the cereal from the field. In most developing countries, it would be expected that the harvesting will be done by hand. This would provide straw with sufficient length for the manufacture of compressed straw board by hand feeding.

The most important quality that we look for in the straw is the moisture content. The optimum should be below 16%. If the moisture content is higher than 18% it can cause serious trouble in the manufacturing process. It can provide a sub-standard slab and it can disrupt the production altogether. The trouble can be in the form of soft edge, paper crease, lack of adhesion between the paper liner and the straw board, variable density of slab, etc... If the straw is dirty then it will create a lot of dust around the Strawit machine area and reduce strength of the board by lack of adhesion. If the feeding is done by hand it will also reduce the efficiency of the straw feeders due to the very dusty atmosphere.

Short straw can also be a problem. If it is in small amount it will not have much adverse effect, but if there is a large amount of over 25% of short straw of less than 20 cm. being fed into the hopper it will create slab burst due to no interlacing of the straw, resulting in lack of internal strength. The optimum length of straw for us is 80 cm.

The supply of straw to the factory will also be an important factor to take into consideration in the plant layout. For example, Thailand has a long rainy season and for the large part of the year the straw will have extrmely high moisture content. We therefore have to take special precaution in transporting the straw to the factory and in selecting only dry straw for baling.

There are many alternatives to overcome this, we could produce only during the dry season, similar to what they do in the sugar industry, or we could have an extremely large storage area for straw which we will take in during the dry season, or we could install a straw drying unit which would reduce the

moisture content of the straw to the acceptable maximum just before feeding into the Stramit machine.

Glue

The glue which is used to produce straw board is a urea-formaldehyde based glue. If the board is going to be used for special purposes then it may need another type of glue, but so far the urea-formaldehyde type of glue has proved satisfactory for normal application. The glue should have a viscosity of 19 poise at 21°C when mixed in a glue mixer. The main requirement will be it sticks and cures under the Stramit machine conditions.

Paper liner

As for the paper liner, the 3 main types used are

1. Plain kraft liner.
2. Bitumen impregnated liner.
3. Plaster board liner.

The paper liners which are used by Stramit factories throughout the world normally come from Finland, as they are special types of paper which very few manufacturers produce. For us to receive our order of paper liner take 5 to 6 months. This indicates that a large stock has to be kept.

Material Balance

Typical Material Balance based on

a) a compressed straw panel of 1.22 m x 2.44 m weighing 18.5 kg. per sq.m.

b) A production rate of 55 sq.m. per hour.

Material	Per m^2	Per hour Production
Straw	22.20 kg.	1,221.00 kg.
Paper Liner	2.25 m^2	123.75 m^2
End sealing paper strip	0.83 m	45.65 m
Glue		
Urea Form-aldehyde based powder glue	0.170 kg.	9.35 kg.
Conditioner	0.034 kg.	1.87 kg.
Thickener	0.074 kg.	4.07 kg.
Extender	0.025 kg.	1.38 kg.
Water	0.085 l.	4.69 l.

You will notice that the unit weight of straw used is higher than the unit weight of the panel. I still do not understand and cannot account for the cause of this large difference after having consulted experts in other producing countries and having weighed all the wastes around the Stramit machine and the cut-off saw. This difference should be borne in mind when computing the production cost of the panel and storage requirement.

C. 3 MANPOWER

I shall only touch upon the requirement of manpower in production. The number of persons required is based on 1 eight-hour shift.

1 Straw receiver - He schecks the incoming straw bale for its freshness, cleanliness, moisture content, and weight. He sees to it that strict fire precaution measures are kept in the straw storage area. He must be a conscientious and trust worthy person.

12 straw feeder-carriers - Their job is to carry the straw bale from the storage area to the straw deck above the Stramit machine, open up the bale, shake up the straw, inspect for foreign material in the straw and feed the straw into the machine hopper. These people must be strong as they have to carry straw continuously to keep up with the rate of production which requires approximately 1 ton of straw per hour. They must also work well with their hands, since the consistency of the feeding of straw has an important bearing on the quality of the slab.

1 glue mixer - His job is to mix glue according to specification to inspect the quality of the glue and ensure that the glue line of the machine is adequately filled. His job is very routine and therefore no special qualification is needed. A slight knowledge of chemistry can be useful. We use him as a reserve when one of the assistant machine operators is absent.

2 machine operators of Stramit machine - One acts as assistant to the other. Their job is to start the production operation by turning on the heat, cut the paper liner, fill up glue line

etc. They control the machine operation during production to ensure a satisfactory rate of production, density of the board, ram mark, paper crease etc. They also give instruction to the straw feeder if they think that the feeding is uneven and they stop the production operation at the end of the day. They are responsible for the feeders and glue mixer. A background in mechanics and machine operation would be advantageous. The appropriate qualification will be a graduate from Technical High School.

4 cut-off saw and end sealing unit operators - They cut the board to size, seal both ends, carry the panel from the end sealing unit to storage area, carry out quality control checks at regular intervals on adhesion between the straw board and paper liners, and the density of the board. If they find deviations they will report back to machine operators.

1 electrician - His job is to ensure that there is no break down due to failure in electrical equipments. He should have experience in maintaining and repairing electrical switches and motors. He is more qualified than others and we make use of him as a shift supervisor.

The number we use to operate one machine line is 21.

C. 4 LAYOUT

The plant layout of a Stramit factory will depend on all the space requirements and the production process. Our factory has a total covered area of about 2,000 m^2 as shown in Fig. 3.

Space requirements may be divided into the followings:-

1. The Production Line

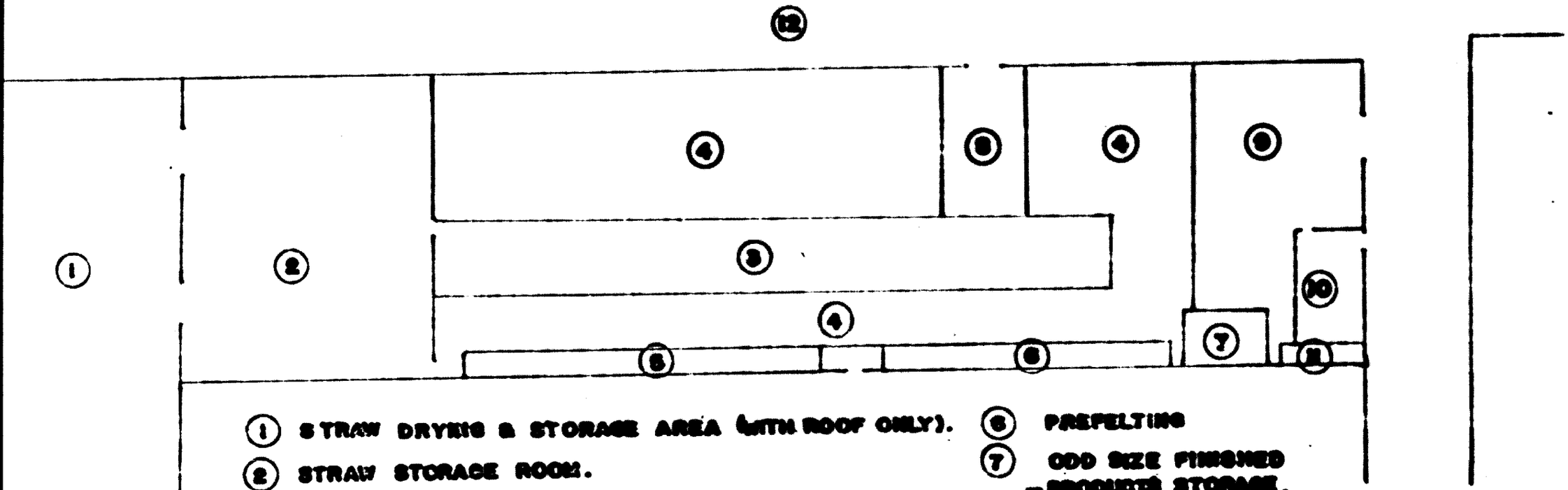
The production line itself takes up 3m x 30m and the space it requires will be only 35m x 4m (140 m^2). This area is adequate and there is no need to add some extra area as a safety factor.

2. Storage area for Raw Materials

Straw Normally straw is stored in bales of about 25 kg. each. We have standardised on this weight per bale due to the fact that it is the optimum amount our labour can carry over a long period without getting too tired. If it is too heavy then the total amount that they are able to carry during the same period will be less. The area required will depend on the regularity of supply of the straw and also on the demand of the finished product. In Thailand we are affected by a very long rainy season and also we have only one harvest per year. Ideally the straw should come direct after harvesting to our factory storage if we have adequate storage space. If we continue to receive straw supply during the rainy season, the moisture content of the straw tend to be on a high side, and it will take sometime for the moisture to evaporate enough to bring the moisture content down to 16%.

SCALE 1:400

FIG. 3: LAY OUT



1. STRAW DRYING & STORAGE AREA (WITH ROOF ONLY).
2. STRAW STORAGE ROOM.
3. PRODUCTION LINE.
4. FINISHED PRODUCTS STORAGE
5. GROUND FLOOR: GLUE MIXING ROOM, TOOLS ROOM, EXPERMENTS ROOM, STORE ROOM.
   1ST FLOOR: OFFICE & CONTROL ROOM.
6. PREPELTING
7. ODD SIZE FINISHED PRODUCTS STORAGE.
8. CUT-TO-SIZE
9. STRAW CORES AND STORAGE
10. VISITORS ROOM
11. TOILET
12. ROAD

Our original intention was to provide just adequate buffer stock i.e. a storage of straw sufficient for 25 days production. We plan to take straw delivery every day throughout the year but in fact we run into problems due to the high moisture content. We therefore intend to enlarge our storage area.

We find that storing our rice straw in bales is the most economical way as the cost of land is extremely high in Thailand. If we are to store our rice straw loosely as in the condition when they are harvested then we will require extremely large storage area, and it will also increase the transportation cost of the straw from the paddy field to our factory. As straw is an extremely light material, if the boat delivers the straw in loose form then the amount it can carry will be extremely limited, i.e. a boat which can be carried bale of 5 tones will be only carry loose straw in only 2 tons.

Paper liner is usually stored above and below the run-out table, therefore this item does not require additional floor space.

Glue powder and other glue components also take up an extremely small amount of floor space, but in warm humid climate, the materials should be stored in area with good ventilation.

The storage for the finished product depends on how many types of finished products you produce, the number of standard sizes, and whether you use mechanical handling or not. Our storage space at present is sufficient to store a maximum of 40,000 m^2 of Stramit slabs. The slabs may be stacked up to 80 pieces high manually, but the optimum number would be

about 30 pieces high which is equivalent to a height of 1.5 metre. One of the contributing factor in our requiring a large storage area is that in Thailand there are no standard dimensions to keep to i.e. the partition height may vary from 2.2 metre up to 2.8 metre. Therefore we have to stock many more sizes than other countries which have standardized the height of their partition and dimensions of their building components.

Storage area for other materials vary with the number of other operations you intend to carry out in conjunction with the production of compressed straw slabs. You may wish to make panels with hardboard or asbestos cement sheet facing, or you may want to pre-felt your Strasit slabs for use in roof decking in order to reduce work at the job site. In our case we require additional space to carry out other operations such as cutting to size, pre-felting of the panel and in future producing panel with sheet facing such as hardboard and asbestos cement sheet.

There should be adequate office working space for 6-10 persons and an area for the workers to rest and smoke.

An additional space requirement may be needed in case your raw material requires pre-processing treatment such as drying or cleaning. It will be difficult to be specific since the area required will depend on the drying or cleaning process you have in mind. Different methods may need different space requirements.

For a Strasit factory, the building requires no special consideration as the machine is light and straight forward. You only need a factory floor and a roof. The wall needs not be put up until the plant is in operation so that the finished

panels from the test run may be used as the factory wall. This serves 2 purposes:

1. The wall provides an outlet for the test run material which will probably be below standard.
2. It serves as a training job in installing the product so that the staff will have a first hand knowledge on the installation.

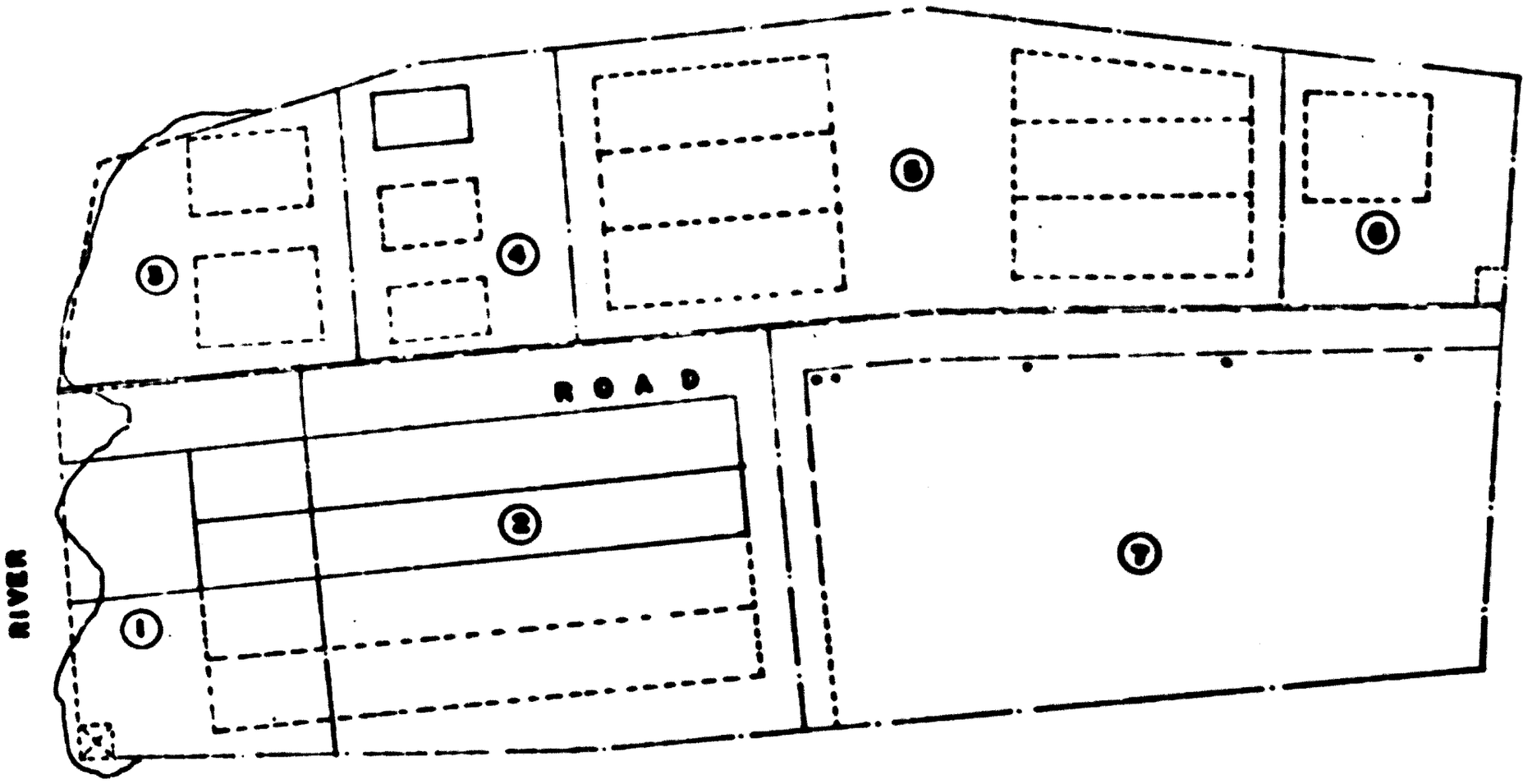
It may also act as a job reference for your potential customers to come and inspect. You may also carry out product performance trials at a certain section of your factory wall, i.e. the performance of various types of finishes on your compressed straw panel and the environmental effects on your unprotected panel. The different type of jointing details may also be put into experiment.

The greatest potential problem in the plant layout is the inadequate provision for future space requirements. It is difficult to be 100% correct in determining the space requirement of any factory in the planning stage. Thus, it is most probable that additional space requirement will be needed after the plant has been in operation for sometime.

A master plan which takes into account all the likely future requirements on factory space will be extremely useful in this case, as both raw materials and finished products require a lot of storage space. Please see Fig. 4 for master plan of our factory site.

FIG.4 : MASTER PLAN

SCALE 1:1000



① STRAW STORAGE ③ GUEST HOUSE ⑤ ADDITIONAL STRAW STORAGE

② PRODUCTION OPERATIONS ④ STAFF QUARTERS ⑥ OFFICE ⑦ ASSOCIATED PROJECT (PRODUCTION OF HOUSES)

TOTAL AREA 23,700 M^2

C. PLANT LOCATION

For the basis of plant location, projects can be classified into 4 different types

1. Raw material oriented
2. Market oriented
3. Utility oriented
4. "Foot-Loose"

A Straw plant is the type of project which utilises a large quantity of raw materials that are bulky and the process requires several units of the raw materials to produce one unit of the final product. This type of project should therefore be located near the source of raw material i.e. near the area of cultivation of the cereal straw. Another consideration which should definitely be taken into account is transportation. An investigation should be made into the facility available for transporting both the raw material and the finished product. If transportation facility is not available at the proposed site, the provision of such facility may require additional investment.

The road to connect the plant with a main highway could constitute another important factor. If the plant is located far from the main road, a linkage may have to be constructed which also means additional cost.

At least 3 locations should be evaluated so that the cost involved in each of the possible site may be appraised to find out which is the most advantageous. Local authority's special rules, regulations and taxes should also be looked into. Another factor which could be of importance is the proximity of an existing plant using the same raw material.

This can lead to the adverse effect of two factories competing for the same source of supply of raw materials, thereby putting up the cost of raw material.

C. 6 UTILITIES

This type of factory has a total demand of electrical power of only 75 kw. It requires negligible amount of water as it only needs water for mixing the glue. Steam is not required in the production but might be required in drying the straw with high moisture content. Compressed air will be needed to operate all the control valves of the cutoff saw and the end sealing unit. The compressed air should have a pressure of 75 p.s.i. and a rate of 10 cu.ft. per minute.

C. 7 WASTE DISPOSAL

The waste disposal of this type of compressed straw panel factory constitutes no problems as it is a completely dry process. The only waste will be the short straw deposited around the Stramit machine and the straw dust from the cut-off saw. Both these wastes may be burnt if not required but they are extremely good fertilisers for the growing of plant such as roses or for the growing of mushrooms. This process therefore contributes no contamination to the environment.

B. NATIONAL ECONOMIC BENEFITS

Traditionally the only yardstick for a private entrepreneur in evaluating the return of a project will be the financial return on investment. This has been the only overriding consideration, but now there is an additional factor of importance. In Thailand as well as in many developing countries, the government will grant special privileges to pioneer industries in the form of income tax exemption, exemption of import duty on machinery and possibly on imported raw materials if the project has special effect on the social and economic well-being of the country. Strawit industry in Thailand is such an industry.

The compressed straw panel industry provides economic benefits to the country in the saving of foreign exchange where materials with similar properties to Strawit are being imported into the country.

It creates employment for unskilled and skilled labours. The majority of the labour in the Thai plant comes from farmers who use to work in the paddy field. They receive training and acquire new skill. The industry increase the income of the farmers by providing an outlet for their straw which has been considered as waste before. In most developing countries, farmers are considered to be the back-bone of the nation. Normally the income of this group is extremely low and any additional income will benefit them and the country as a whole.

It may also bring in foreign exchange if the plant is successful in exporting the product to neighbouring countries which either have no raw materials for its production or which have not look into its production possibility yet.

It is also possible that it helps to increase the demand for an associate material, such as waterproofing material, to an extent that local production become viable and thereby creates need to start another pioneer industry.

It definitely helps to increase the utilization of the country's resources by making use of a waste material. It serves the need of a developing country by providing a building material which is extremely suitable in housing program.

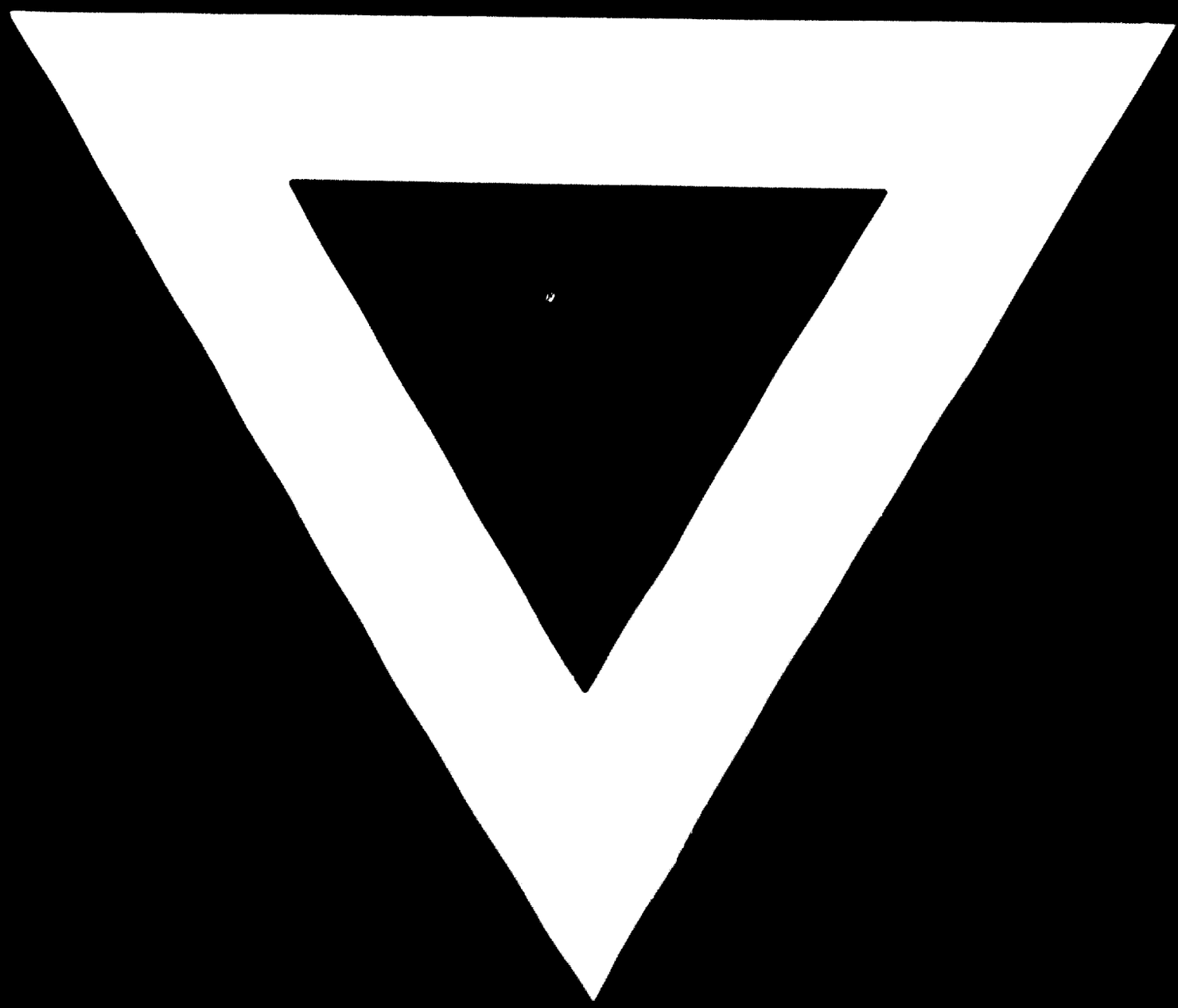
8. CONCLUSION

For a decision to be made on the choice of process in using agricultural wastes in the production of panel, there will be many viable alternatives which should be evaluated against a set of objectives or considerations. A list of such objectives is shown below. Of course other objectives would have to be added to the list according to your own requirements but I hope this list will serve as a reference to majority of cases.

1. High demand expectation in a growing market.
2. Rapid rate of market acceptance.
3. Low level of initial investment.
4. High return on investment throughout the life of the project.
5. High economic benefits to the nation.
6. Exclusivity of process.
7. Non-critical requirement of raw materials.
8. Abundance of raw materials from agricultural wastes.
9. Simple process.
10. Short production cycle.
11. Close association with existing set up.
12. Independence of foreign expert in plant operation.

Starting a Strawit industry is one way of making use of agricultural wastes, i.e. cereal stalks, in producing panels. It is a simple process which turns a waste material into a type of panel with highly desirable characteristics. With the universal urgent need of developing countries in providing housing for the mass, the end product from this project fulfils the requirements of an economic and durable building panel with

good heat insulation, sound absorption and fire resistance. It is a material with many applications in the building industry. It would therefore be logical to assume that this material will satisfy the needs of one or many sectors of the building industry of a developing country.



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