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Study Group on Production Techniques in Wooden Houses under Conditions Prevailing in Developing Countries

Vienna, Austria, 17 - 21 November 1969

PREFIT WOODEN HOUSES FOR TROPICAL CLIMATES 1/

by

Bruynzeel Suriname Houtmaatschappij N.V.
Paramaribo, Surinam

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SUMMARY

PRECUT WOODEN HOUSES FOR TROPICAL CLIMATES 1/

by
Bruynzeel Suriname Houtmaatschappij N.V.
Paramaribo, Surinam

After a geographical, ethnographic, climatological and economical survey of Surinam (the former Dutch Guyana, situated on the North-East coast of South America) and its multi-racial population, the author tells of the vast tropical virgin forests, covering approximately 3/4 to 4/5 of the country, consisting of specimens of almost 1000 species, many of which are unfit for commercial purposes, which in its turn results in deplorably low exploitation yields of 10 - 15 m^3 logs per ha. (2.5 acres) highland forest and only about 5 m^3 per ha. swamp- and marsh forest.

He further explains why it is so extremely difficult to design mass-produced houses suiting not only the living customs of the various ethnic groups, but also fit for export to the many islands of the Caribbean area, the natural market of

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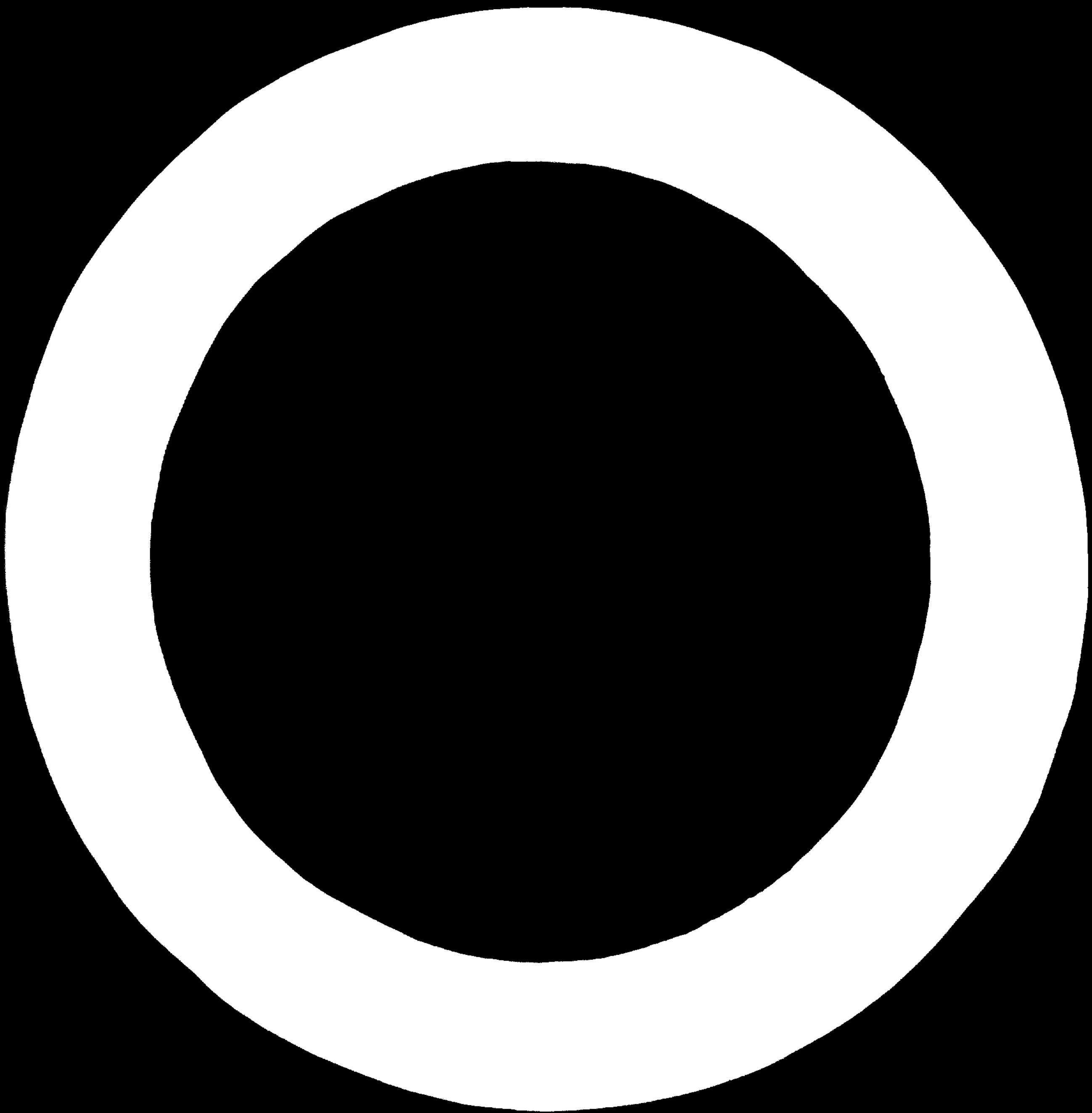


Suriname, where they are to be occupied either by the local population, or possibly by comfort-conscious American tourists.

After dealing with the various requirements to be met by a well designed house for use in tropical regions, such as good ventilation, adequate heat isolation (horizontally as well as vertically), proper protection against rain, etc., the various roofing materials are dealt with summarily, of which corrugated aluminium sheets are considered best, but corrugated galvanized iron sheets offer the optimal compromise between initial costs and longevity.

Wood offers over concrete or cement blocks the advantage of its extremely low heat accumulation capacity, together with a good heat isolation-coefficient, resulting in a very cool house. Another advantage of wooden houses over concrete ones is the ease with which they can be enlarged or re-planned if for instance changes in the family composition require it. This is especially important when the houses, like most in Suriname, are built on stilts in order to catch even the gentlest breeze.

The most widely spread argument against wood, is its more expensive maintenance, which can easily be contradicted with the thesis that "maintenance-prevention begins on the drawing board", meaning generally that already the draughts-man must be mindful of preventing moisture absorption, mainly by keeping the lumber away from moist soil and by preventing possible capillary action.

Bruynzeel Suriname started producing precut houses in 1954, partly because of its abundant stocks of unsaleable short lengths of perfectly sound lumber, unwanted by the local contractors, who mostly buy long lengths only, to be cut up on the building site to short ones, partly because transportation of precut lumber is more economical than of random lengths, thus contributing to the opening up of the Caribbean market a little more, which otherwise was rather inaccessible because of the high freight rates.

After keeping its production programme restricted to only a few types for some years, in 1965 the idea of redesigning the existing series on a modular base was conceived, mainly because the non-modular houses required vast storage accommodation, which could be reduced by strictly standardizing the various components. Four feet was chosen as the most practical module (M), because of the 8' x 4' size of the sheet material, notwithstanding the fact that 3' offers a better compromise between the width of doors and windows. The 3' module was adhered to only for very low-cost projects of simple walled barracks, etc. A macro module of 3' (12") was introduced for the centre to centre distance between the stilts, in both directions. The precut series, constituting the bulk of our sales volume, is designed on this modular basis.

The author then makes a comparison between the most apparent advantages of precut and pre-fabricated components for industrialized houses, choosing his arguments from the various relevant aspects, such as financial, practical, constructional and general aspects, as well as the consequences in the field of design-flexibility and transportation.

Though he strongly prefers prefabrication, even in its ultimate consequences - the manufacture of entirely prefabricated finished turn-key houses - the author strongly stresses the point that any manufacturer or future manufacturer of prefab building components, in regions like Surinam and its natural outlet, the Caribbean, should very carefully study the pros and cons of both systems: prefabrication versus precutting.

Generally, the most apparent arguments in favour of prefabrication are: substitution of skilled labour in the field by mechanized semi-skilled labour in the factory, the absolute avoidance of waste on the site, the increased erection speed; whereas the arguments in favour of precutting generally bear down to: the sizable savings in transportation costs (especially over long distances, bad roads, with inadequate means, poorly equipped trucks, etc.), savings in the investments for jigs, lifting gear, etc. and finally the ease of replacement of damaged parts.

If these arguments for both systems are carefully evaluated and weighed, the balance might very well tip in favour of precutting the required components, instead of assembling them too early to bulky elements. The decision to start prefabricating houses should never be taken for the mere sake of being modern. As far as constructional aspects are concerned, the prefabrication of interior partitions is less objectionable than of exterior walls, because in many cases the former are non-loadbearing, whereas the latter mostly get more lumber-intensive and are more difficult to make waterproof.

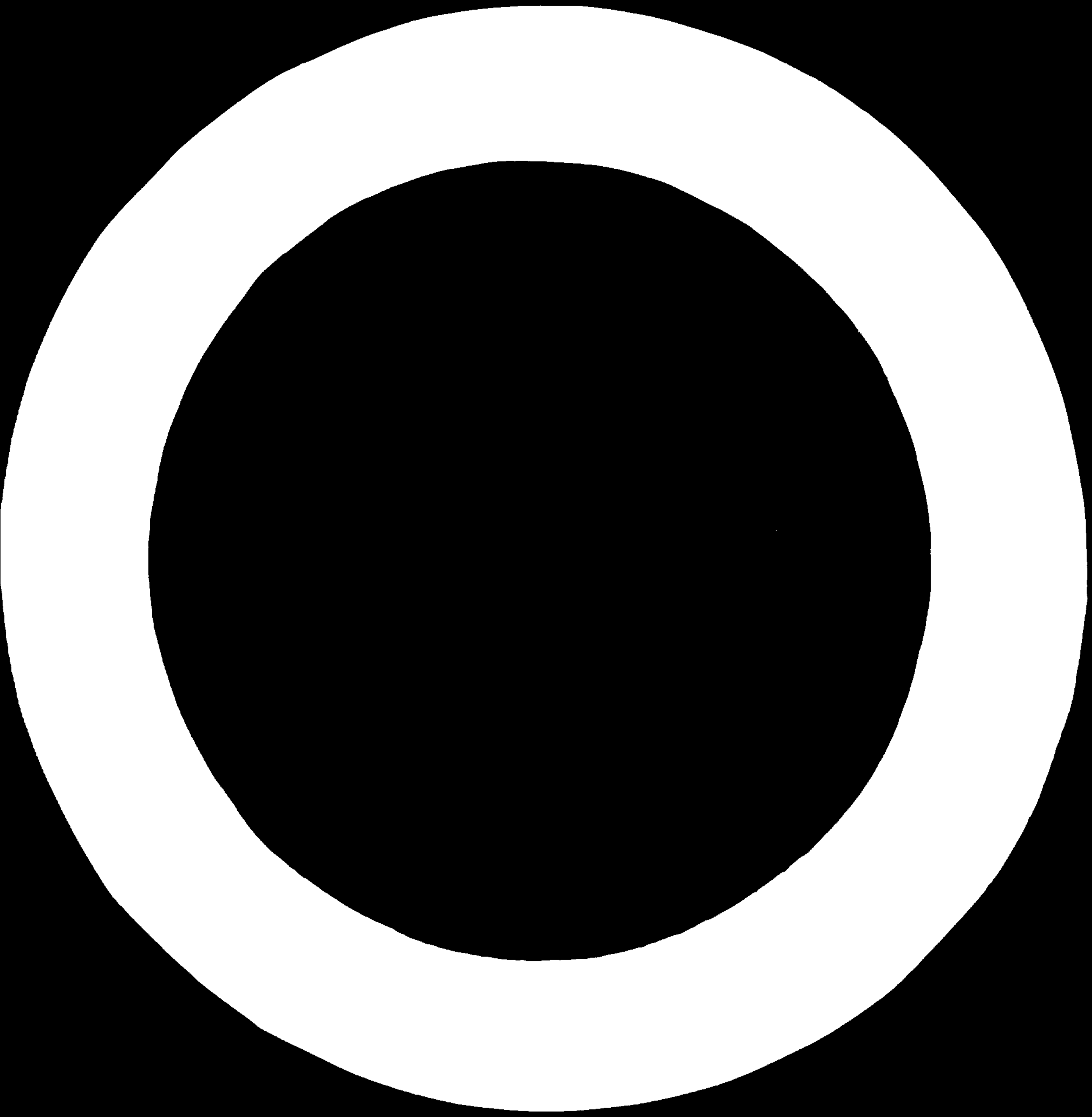
The smaller the module, the less the designer or private customer is hindered in the design he wants to realize with the available prefab panels.

Summarizing, the author comes to the conclusion that for several reasons in regions like Suriname and the Caribbean area with its relatively isolated string of small islands, the lumber industry - or rather prospective producers of wooden houses - should carefully watch their step in deciding whether or not to engage in the process of prefabricating housing components.

Financial and practical aspects like investments, transportation costs, damageability, availability of trained labour, savings in wages, speed of erection, training needs, etc. should be taken into consideration and carefully weighed prior to taking the final decision.

Under the given local circumstances, Bruynzeel has up to now always felt that in a stringent system of precutting a series of modular houses, it has found the optimal compromise in its dilemma of either just selling lumber to the building trade, or offering prefabricated components.

As soon as the local government or the government of one of the smaller Caribbean countries guarantees continuity in a sizable long-lasting order for a specific type of house or a rather identical series of houses, it will certainly re-consider its stand-point and possibly enter into the prefabrication business.



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INTRODUCTION

Pertinent facts and figures about climate, geography and ethnological and social conditions in Suriname.

Suriname is an autonomous part of the Kingdom of the Netherlands. With its 150,000 km2 it is 4,5 times larger than Holland of which it formerly was a colony.

Situated on the north coast of South America, in between (British) Guyana and French Guyana, just a few degrees (2^0 - 6^0) north of the equator, it has a tropical climate.

The average daily temperature is 26^0 - 27^0C, with a fluctuation of only approx. 9^0C between max. (day) and min. (night) temperatures and a yearly amplitude of only 1.5^0 - 2.2^0C.

The relative moisture content (R.M.C.) of the air averages approx 80%; 90% in the early morning, 70% in the afternoon.

The north-eastern trade winds, with an average force of 1.4^0 Beaufort, make the climate nevertheless agreeable.

Its location, just outside the Caribbean cyclone area, leaves Suriname virtually free from hurricanes, though gusts of wind preceding rainstorms do cause some slight damage to trees now and again (mostly in August and/or September).

The total rainfall in the coastal plain averages 2300 mm per annum. Showers of 300 mm per 24 hours do occur.

There are two rainy seasons (2 and 4 months), alternating with two dryseasons (3 months each), causing only very slight alterations in temperature, but appreciable extremes in rainfall (300 and 60mm monthly respectively).

Extremely dry years are said to appear with intervals of 14 years, but are hard to prove with the available inadequate statistic data.

As a result of this intermittent, heavy tropical rainfall, Suriname is blessed with many rivers (all of them flowing north), fed by a multitude of tributaries and creeks, together constituting a tremendous network of natural waterways, only interrupted by a large number of waterfalls and rapids in the region where the coastal plain changes into the foothills of the mountainous hinterland.

These cataracts are highly obstructive to the upsteam transportation of goods per dugout canoe, but only from a minor, boresome hindrance in logging operations, when northbound floats of logs have to be brought downstream into the coastal fringe, where the lumber industry is situated.

The fertile coastal region, consisting partly of swampy marshlands, streaked with shellridges, partly of a sandy savannah-belt, comprises the approx. 100 km wide northern strip of Suriname, alongside the coastline of some 400 km.

The remainder of the country, the southern 300 km, is hilly to mountainous, climaxing in the up to 900 m high Tumak-Humak mountainrange, which not only forms the border with Brazil, but also the watershed with the Amazone river.

Apart from the towns and villages and the scarcely inhabited agricultural areas surrounding them, and with a further exception of the dryest parts of the savannahs, the entire surface of Suriname is covered very densely with virgin forests.

The swamp and marsh forests in the lower regions of the country supply the logs for the plywood industry (mostly Baboon, Virola Surinamensis) and for the particleboard factory (Baboen and Mierenhout, Triplaris Surinamensis), whereas the more mountainous grounds generally supply the various species used for construction purposes (Basralocus, Angelique, Dicorynia Guyanensis; Copie, Goupia Glabra; Wana, Ocotea Rubra; Pisie, Ocotea Spp; Bruinhart, Brownheart, Vouacapoua Americana; Groenfolos, Qualea coerulea; Rode Locus, Red locust, Hymenea courbaril, etc. etc.).

Our ancestors apparently freely cut down every easily accessible tree suiting their purposes, leaving the hard to reach ones for their descendants. As a result of this happy go lucky logging system, present logging operations are increasingly cost consuming. Up to say 50 or 60 years ago it still was possible to cut down only those trees (of the desired species and of sufficient diameter) that grew close to a river or creek, but presently, with growing local and export demands, skidding trails of ever increasing length, leading to government built logging roads, are necessary in order to still the growing need of the lumber industries in the vicinity of the shipping facilities of the port of Paramaribo, the Capital of Suriname (120.000).

The forests of Suriname, covering more than 3/4 of its total surface and renowned for their vastness and their abundance, actually are so extremely diversified in species (1000 approximately) and sizes, that a yield of 10-15 m3 commerciable logs per ha is considered a fair average for the highland forests, compared to 5 m3 per ha for the swamp and marsh forests.

Though many of the Suriname-species actually are equal to or better than the best species from other tropical parts of the world - as far as quality, beauty, strength, hardness, durability etc are concerned - they on the other hand lack one big advantage of many foreign species, i.e. the size of the logs in which they are available.

In simple terms, there seems to be a certain but regrettable interaction between diameter and length of the logs coming to the mills: the thick ones are mostly short and the long ones usually thin. In combination with crookedness, heart defects and oversized sapwood, this only leaves regrettably few fine logs, so indispensable for a good and profitable output of a sawmill or a plywood factory.

Apart from this low output/input ratio, resulting in a considerable increase [illegible] of the sawn products, this imperfection in size and shape of most logs reaching the mills also means that heavy sizes and really wide planks only seldom are available. In some types of construction where heavy sizes cannot be dispensed with (harbour piers, bridges, etc.), they have to be handhewn from preselected logs.

This hewing is usually done in the woods, immediately after the felling of the tree. The job is expertly done by "bush-negroes".

These people live in the interior and the logging business is their only possible means of existence and they practically control all logging operations, except perhaps those of big companies like Bruynzeel, though even these would be unthinkable without their aid.

Apart from these bush-negroes, the forests of Suriname are inhabited only by the aboriginal Amerindians, belonging to some three or four tribes, constantly decreasing in number, some of them on the verge of becoming extinct, presumably for lack of resistance against civilisation's epidemics as influenza etc.

Immigrant labour from British India and from the Dutch East Indies (Java), have flourished in the field of less important agricultural products (rice, vegetables, bananas), cattle breeding and retail trade and now constitute a considerable portion of the national potential, numerically, financially and scientifically.

A very numerous and therefore important group of people, forming a substantial part of the Surinam population, the more or less integrated or pure-bred descendants of the emancipated negro slaves (preferably calling themselves "Surinamers") generally brought together under the common denominator: "Creoles", though gradually losing ground, numerically and financially, to the Asiatic population groups, they (up to now) still form the most important part of the population, occupying most functions in Government.

Religiously, this Asiatic block is split up into two major components: the Moslems and the Hindus, whereas the African block consists mainly of Roman Catholics and Protestants, the latter of which in a great variety of denominations. In addition to these two main groups of Asiatic and African descent, Surinam has some Chinese (mostly tradesmen), some Lebanese (textile business), Portuguese, and finally a minority of European and American whites, partly descendants of the former colonists, partly representatives of Western industrial and trading companies.

All these ethnic and religious groups, diverse as they may be, numbering approximately 350,000 in sum total, all happily live together on the very few km2, forming the inhabited narrow strip along the coastline.

The old phrase, that Suriname is the reflection of what the United Nations should be, is a very apt one.

A. Starting points in designing mass-produced houses in Suriname

No two people in the world being exactly alike, it is only natural that, in designing mass-produced houses, every designer, qualified architect or simple draughtsman, will be faced with the necessity to create a compromise, the greatest common divisor, between the various demands. the living-patterns of his future customers, of whom he does not know the names, nor the composition of their families, not to speak of their individual preferences.

The finding of this compromise being already a full-grown problem, which never was (and never will be) solved absolutely satisfactory not even in countries with a very homogeneous population, this very problem becomes even more complex and complicated in countries like Suriname, where the living-customs of the various ethnic groups forming the national population, vary so greatly, that the finding of the integral, omni-satisfying design not only is difficult, but highly improbable.

Add to this that the design upon which finally is decided as most suitable to local clients is likely to be exported sooner or later to the many Caribbean islands, where it will be sold to and built for either local families or American tourists, who only use it as a vacation bungalow, and the picture of the dilemma, the inward struggle of the industrial architect is complete.

Finally there are the various regional Building Regulations differing substantially from island to island, to be complied with, and gradually, it will be clear that both the design and the construction method of a really successful house have to be of great flexibility in order to have an adequate market to justify industrial mass-production.

The only common factor in all above-sketched, rather diverging local circumstances, is the tropical climate, the omnipresent heat, necessitating any design of any house to offer optimum protection against the sun and to take maximum advantage of the wind.

Protection against the heat of the sun requires from the industrial architect some general technical provisions, applicable to any house:

1st. There is the logical result of our company being a lumber company, making it only natural that the exterior walls (as well as the interior partitions, for that matter) are made of lumber, double-walled if economically feasible. It is a proven fact, that double wooden walls not only offer a better insulation against heat transfer through the wall, but are also very poor heat accumulators. This means that wooden walls almost instantly lose their heat once the radiation by the sun is over, in contrast with brick or concrete walls which retain the accumulated heat very long, resulting in a prolonged radiation of heat into the interior of the house, up to hours after sunset.

2nd. A further protection against heat is acquired by providing the houses with a robust overhang of the roof on all sides. This gives some additional protection against sun on the walls, especially around noon, but mainly prevents the sunbeams from entering the house through the window-openings, which actually are nothing but (indispensable) leaks in the surrounding insulating skin. (Apart from the protection against heat, these well-sized overhangs offer the extra advantage of preventing the walls from frequently becoming wet, which, in a minor way, adds to the durability of the paint and, therefore, of the house).

3rd. The insulation against horizontal heat-penetration being assured by the properties of the double wooden walls, the architect is left to cope with the problem caused by the vertical or near-vertical rays of the sun.
Here the roof has a twofold function: not only to seal the house against water penetration, but also to protect it from excessive heat radiation into the house, from the top down.

The roofing material with the best heat-protecting properties undoubtedly is aluminium, which maintains a very high heat-reflection percentage long after the initial lustre of the brandnew sheets has worn away. The price of corrugated aluminium sheets, however, usually is prohibitively high for mass-produced houses, which generally have to be built from too small a budget to permit such luxuries. This practical restriction is the more règrettable because all people concerned with housing for the lower income groups are fully convinced that in the long run, aluminium roofing sheets (either long or short span) because of their corrosion-resistance and their extreme durability, offer the most economical way to cover any roof in the tropics, that is. The initial investment, however, is generally considered too costly for that purpose.
Roofing felt (and similar fibrous materials) being too short-lived and corrugated asbestos-cement sheets being too heavy, this only leaves the simple, conventional corrugated galvanised iron sheet as a practical and generally accepted roofing material, a convenient compromise between durability and economics.

Galvanised iron, however, is a very poor insulator and it therefore is virtually impossible to build a so covered house without a ceiling underneath.

General experience in Suriname is, that even a 4-6 inch thick glasswool blanket on top of the ceiling, though costly, is inferior to a sufficiently thick cushion of stationary air between roofing and ceiling. By far the majority of houses are therefore built with a doublepitched roof of some construction and a horizontal ceiling, mostly of 4mm-plywood, at exterior wall level, which in Suriname is fixed by the local Building Code at not less than 2.75 m (9') above the floorsurface.

Only a minority of houses has a sloping ceiling directly beneath the rafters. Bruynzeel Suriname only very recently introduced two types of upper-middleclass houses with curved roofs of long-span aluminium sheets, running from gutter to gutter, with their ceilings following the slope of the rafters at a distance of only 10".

The problem of maximum ventilation, in order to obtain maximum coolness, can - contrary to the protection against radiant heat - hardly be solved on the drawing-board.
Of course, some precautions can be taken so as not to obstruct a free flow of wind across the entire house, but the mere question of existance or non-existance of the flow itself greatly depends on circumstances beyond the control of the designer.

In Suriname, most low-cost houses have partitions of only 8' high (except those surrounding bath and toilet), which leaves an opening of approx. 1' immediately below the ceiling, permitting an excellent removal of hot air, but at the cost of the soundproofing of the individual rooms. The more expensive houses usually have no such ventilation, though there is a slight tendency towards leaving louvred openings over the interior doors.

Older types of houses usually have louvred wooden shutters securely closing the (paneless) window-openings against burglary during the night. The slits between the louvres are wide enough to allow - in combination with the vents over the partitions - for a sufficient flow of air to prevent closeness and stuffiness.

More modern houses, among which all Bruynzeel houses, have glass-louvred aluminium full-frame windows of local make, screened if so desired, giving an excellent adjustable ventilation, without seriously affecting the security of the houses.
Windows and doors under the eaves of the roof usually have a screened upper part for permanent ventilation, protected against the rain by the large overhang.

On the other hand, however ingenious the ventilation provisions in the house itself, they are of no use whatsoever if, for lack of pressure on one and suction on the other side, the air fails to move across the house.
Given a certain geographical location, with a fixed climatological situation, this motivation for the air to flow through the house can only originate from the location of the house with regard to the prevailing wind, if any.

It goes without saying that the need for ventilation provisions in the design of the house is inversely proportionate to the force of that wind.
Though Suriname and the Caribbean area (its natural market) have the same N.E.-trade winds all year round, the forests of Suriname soon die it down to a weak breeze, whereas the Caribbean islands (leeward as well as windward) have a constant wind of considerable force. Therefore, the ventilation precautions in Suriname are much more important than they are on these islands.

An extreme consequence of this need for ventilation is the typical custom of the Surinamese of building their houses on stilts in order to catch as much of the breeze as possible. That this method doubles the habitable floor surface at almost no cost, is secondary; primary is the necessity of ventilation.

The ideal orientation of any house, in relation to the wind, is with all rooms facing the wind. For big mansions and expensive villas, this may be right, but for economic mass-produced houses, this, of course, is Utopia. Rooms of minor importance: kitchen, bathroom, toilet, utility room etc. can very well be placed on the leeward side of the house, whereas the terrace or balcony, livingroom and bedrooms, preferably should be on the windward side. The suction, caused by the wind, on the leeward side, very nicely sucks away all unpleasant odours.

If identical houses have to be built along both sides of a street or road, the problem always is, that what is good on one side, is absolutely wrong on the opposite side. By "mirroring" the houses on the "wrong"side of the street, which constructionally is very easy, some improvement is obtained, though it never is absolutely satisfactory.

As already stated in the introduction, Suriname is virtually free from hurricanes. The circumstances, however, that many of the Bruynzeel precut houses are exported to the Caribbean area, where hurricanes regularly do occur, necessitates the design of these houses to comply with regional regulations on that point. Good-sized anchor-bolts and/or (galvanised) metal reinforcement strips over all connections will usually do the trick.

Some areas, however, object to the generously sized overhangs of the Bruynzeel houses and order them to be reduced to some 15 cm (6") instead of the original 1m (40"). Nevertheless, Bruynzeel houses with standard overhangs of 1m, are known to have withstood notorious hurricanes without any damage except some loose roofing sheets or similarly slight damage.
In the above, especially on the subject of heat-insulation, the starting point was that mass-produced houses will always be wooden houses. This of course, is not an absolute necessity.

Mass-produced houses of other building materials than wood, are very well imaginable and have actually been built very successfully in various parts of the world.

Working on the assumption, however, that the economy of any country, but especially of a developing country, is best served if its building industry makes maximum use of the building materials which are indigenous, it is only natural to think of wood as the most obvious and most economic building material for a developing country like Suriname.

Lacking many natural resources, except bauxite and lumber, lacking all major industries, except the aluminium and lumber industry, Suriname has only one home-grown building material: timber, and it would attest of poor economic insight not to make optimal use of this given situation by importing more foreign materials than absolutely necessary.

But apart from the above economical features, wood also has some additional favourable aspects in its aspect of technical applications.
Its excellent thermal insulating properties already having been mentioned, one of its major further advantages is the almost unlimited flexibility of a wooden house.

Contrary to a house built of bricks or concrete blocks, the wooden house, even if built on stilts as is customary in Suriname, can very easily be enlarged if the composition of the owner's family so desires, an operation which, with any other building material, would be substantially more radical and expensive.

The standard construction of almost all Bruynzeel houses, with their non load-bearing partitions and their wall to wall hardwood strip floors which are put in before the partitions are put up, gives additional internal flexibility in the groundplan of the houses, unequaled by any other construction method and/or material.

This automatically leads to a more detailed discussion of the construction of precut Bruynzeel houses.

D. Constructional aspects.

At Bruynzeel's the idea of producing precut houses, was conceived, some 15 years ago, mainly from the necessity to open up wider markets for the products of its fast-growing lumber industry. A minor consideration was of course (but nevertheless a consideration) that when conceiving precut houses, an outlet for short lengths of lumber of various species and sizes (always a problem for a saw-mill) could be created.

In Suriname, the standard procedure for a contractor to build a wooden house was to go to a sawmill and buy the required quantity of lumber in lengths of 20' and longer and then cut it up - on the site - to the lengths he really needed, leaving the mill with the very same short lengths he (the contractor) made on the site.

In the long run, this was a highly undesirable situation, which supposedly only could be altered by offering the customer the service of preparing for him a complete break-down into the required lengths for the specific house he had in mind.

Because the bulk of the houses are built from simple drawings showing little more than a plan and some elevations, this not only would require a staff of draughtsmen, but also a number of skilled technicians for the preparation of the lists-of-materials.

It was for these reasons that Bruynzeel undertook to design a series of houses of varying dimensions and to prepare the accessory lists-of-materials, broken down to exact sizes and quantities. For the customer, the most spectacular advantages were the absolute avoidance, on the site, of waste and unnecessary labour, plus the savings on freight-charges, whereas, at the same time, the company found a use for its short timber.

After having outgrown its growing pains, the system became very popular, especially in Government circles (The Department of Public Works), because of their need for houses in the interior, where the freight-saving factor is of major importance.

Some years later, however, the lack of unity in the subsequent incoherent designs made itself felt, particularly in the warehouses, where a great variety of sizes had to be kept in stock.

The logical decision then to be made was to standardize the various components of the diverging types of houses, in order to reduce this multitude of lengths to a manageable number.

This was done some 5 or 6 years ago, by introducing a 4' module (M) for all horizontal dimensions of all houses and by standardizing on a height of approx. 9'.

By further introducing a standard depth of 28' (7M) for all types and standard widths of 2.5M and 1M for balconies and terraces, not only the floor-joists were limited to one or two standard lengths, but also all rooftrusses were reduced to one single standard size, composed of only a few different components.

On top of all this, the diversification of the lengths of the houses was restricted to three standard lengths: 6M, 9M and 12M, by introducing a "macro-module" of 3M, corresponding with the c.t.c. distance of the stilts of the substructure, so popular in these regions.

Consequently, this macro-module is at the same time the standard length of the girders of all three types.

Of course, the choice of the 4' module was not accidental, but prompted by the standard width of the sheet material, plywood [illegible] or particleboard, used for the lining of ceilings and walls. The only constructional disadvantage of this 4' module is that it is a little unpractical for windows and doors. The standard full-frame aluminium louvred windows (Stanley, model M16) [illegible], has a maximum width of 36" + 2", so all windows need an extra stud between their top- and bottom-rails. Moreover, the siding adjacent to one side of a window opening varies from a multiple of 4'. Though doors can be made of any width, a 4' door is not practical either, so the doors require an extra stud as well. On the other hand, the advantages of the 4' module are so predominant that the above disadvantages are gladly accepted. The alternative, a 3' module, acceptable for windows and doors, would necessitate all sheets to be cut to that width, rendering it doubtful if all cuttings could be put to good use.

The combination of the 4' module with the already described [illegible]ection system, in which the partitions are only put up after completion of the ceiling and floor of the entire house, results in an almost ideal flexibility of the floorplan. Alternations adapting the incidental composition of the customer's family can very easily be made, at almost no costs.

Though the modular system apparently only had advantages in the constructional and economical field, productionwise there is a small disadvantage:

Fixing the depth of all houses at 7M and the determination of the macro-module at 3M, inevitably leads to extremely monotonous lengths of joists, rafters and girders, of which the production-department has to produce sizable quantities.

With the unreliability of the logs from the Surinamese forests, this sometimes presents a problem, minor for the small-sized [illegible]s, more substantial for the girders and joists, because of their heavier sizes.

In fact, when the houses are built on 8' stilts (which is customary in Suriname) or on 2' precast footings (which is less and less popular), they of course need girders and a layer of joists.

With a c.t.c. distance of 3M (12') in both directions, between stilts or footings, the girders have to be 3"x8" whereas the joists at 2' intervals, are 2"x6". But because the production of 3"x8"'s is too unpredictable, the girders are composed of two 2"x8"'s, nailed together with short pieces of 2"x8" in between at the junctions, through which pieces the anchor-bolts are drilled.

To safeguard against possible insufficient production of 2"x8"'s and 2"x6"'s tests are presently being conducted to staple two 1"x8"'s (and 1"x6"-s) together to 2"x8"'s (and 2"x6"'s). The initial results of these tests are very promising indeed.

The bulk of the remaining constructional components of the present Bruynzeel houses are 2"x4" for the rafters and the studs etc, of the loadbearing outer walls, and 2"x3" for the non bearing partitions. Not because of their unavailibility, but in this case only to carry the utilization of short lengths to the extreme, the above stapling-tests also include the composition of 2"x4" and 2"x3" from 1"x4" and 1"x3" shorter than 4' and the results of these tests also are very satisfactory.

Bruynzeel houses, though mostly built on stilts, can also be built directly on a concrete slab. This does not require any special provisions, except the omission of girders, joists, flooring, stairs, handrails, etc. etc.

The bottom sills or sole plates of all exterior walls then have to be secured safely to the concrete slab by means of anchor bolts at no more than 4' distances, especially if the house is built in a country or on an island within the cyclone area.

The roofstrusses of all Bruynzeel houses are placed at 4' intervals corresponding with the c.t.c. distance of the studs in the bearing walls. This may seem rather wasteful, but has the advantage of 1"x3" purlins being sufficiently strong.

The redesigning of the original types of houses to comply with the modular system and the advantage of reducing the initial number of components by approx. 50%, which resulted in a corresponding increase of stocking capacity of the stores.

Apart from this greater stocking capacity, the extreme standardization of sizes achieved by the introduction of the modular system had an even more advantageous effect on the production of the various components.

The streamlining of the production process, the ease of handling and sorting the reduced number of sizes, together with the simplified packaging and transportation, probably turned out even more profitable than the gain in storing capacity.

Another important aspect of the production of good quality houses, is the correct choice of the species which is most suitable for that specific function of that specific component in the total construction.

The decision to use a certain species to fulfil a certain function, requires a thorough knowledge of the specific properties of most of the available species.

On the whole, the knowledge of the various species which has usually been acquired through the experience of many generations is the best guide to the most suitable application of each species.

Modern conservation techniques however, together with the excellent qualities of contemporary paints, have opened up wide horizons of new applications of species which formerly were considered absolutely useless.

Strong species, with a Modulus of Elasticity of over 120,000 kg/cm2 are, of course, preferably to be used for joist and girders and all other load- bearing components; studs, braces, sills, rafters, etc. can be made of any middle-class species with a M.O.E. of 100 - 120,000 kg/cm2, provided they have good nail-holding properties and a good resistance against attack by insects.

The critical property for siding is its resistance against climatic conditions, whereas resistance against wear is a desirable property of floors in general, supplemented by good moisture constancy for balcony floors. Doors, windows, etc. should also have good weathering-properties as well as stability and excellent working-properties.

In its details, the construction of the standard Bruynzeel houses is conventional, timeless and simple; girders, joists (butt-jointed on the centre girders), sole plates, studs, wall plates, rafters, tie plates, barge boards, fascia boards, ceiling laths, flooring, siding, ceiling, interior lining, etc. etc., they are all there as in most conventional houses.

The only aspects wherein the Bruynzeel houses differ visually from traditional houses, is in the siding: it is divided into three horizontal bands, around the entire house; the centre one, restricted to the areas between doors and windows, made up of horizontal drop-siding, and the top- and bottom ones of vertical V- grooved (or otherwise profiled) narrow strips. The horizontal and vertical areas are separated by a horizontal "water-sill" of a watershedding design.

Because of the tropical climate in practically all countries where Bruynzeel houses have been and are built, the contractor is always advised to use galvanized nails. Some of the Suriname species of wood being rather splitty, it is advisable to blunt the point of the nail by hitting it with the hammer before driving it in, especially if the nail is to be placed close to the butt end of the member. Of course pre-drilling of nail holes is even better, but usually too costly because of the unavailability of electric current on the site.

The floor of the bathroom is a concrete slab, simply poured on top of the wooden floor after red-leading the latter very thoroughly and putting a sheet of kraftpaper in between. This concrete slab has an elevated rim, on which the sole plate of the surrounding walls is anchored by simple means.

The surrounding walls are lined with narrow slats (of any quality lumber), covered with brick-netting, on which the tiles are placed in the usual way.

Formerly, the stilts on which the wooden structure of the house is based, were built up of concrete blocks, but experience has since taught the contractors that solid concrete, monolithically poured around a mesh of reinforcing rods, is not only more economical but also stronger.

In cyclone- or earthquake-prone areas, these solid concrete stilts are compulsory.

The most widely-spread objection against wooden houses is that their maintenance allegedly is so much more expensive than that of bricks or concrete houses.

To a small extent, this may be true, but on the other hand there is much truth in the thesis, that "maintenance-prevention begins on the drawing-board".

Generally-speaking, getting wet incidentally will not be harmful to the wood, but a prolonged contact with water or moisture should at any price be prevented.

Apart from the necessity of a reliably watertight finish of roof and exterior walls, care should be taken to guarantee optimal measures to prevent moisture-absorption by the butt-ends of all members closest to the ground.

With houses on stilts, these precautions are restricted to the lower ends of the stair-beams, which preferably should be fastened to their concrete footings by means of metalstuds, keeping the beams separated from the concrete.

This danger zone is much more extensive with houses on concrete slabs. Here, care should be taken to keep the lower (vertical) siding-strips dry, not only by keeping them sufficiently away from the ground, but also by preventing the strips from touching the concrete itself.

In addition to the physical precautions mentioned above, the lumber can also be protected against decay by chemical treatment with one of the many materials on the market. Maximum protection is undoubtedly achieved by pressure-treating the lumber, which gives a much deeper penetration of the chemicals than ever will be effected by dipping or brushing methods. The latter system are much less expensive, though. One of the renowned chemicals is sodium-pentachlorophenol, which is not too expensive, relatively easy to dissolve and only slightly harmful to human beings.

Because not all species of lumber are equally susceptible to decay and insect attack and because Bruynzeel houses are for the greater part made of species with a sufficient innate resistance against pest-attack, they are not treated as a routine.

Bruynzeel plywood and particleboard have been treated against termite attack already and if the customer is still afraid that his house will decay prematurely, the treatment can yet be applied during construction by the brushing or spraying methods, both of which offer adequate protection against attack by common pests.

C. Production aspects.

As already stated under "Constructional aspects", the idea of producing complete precut lumber-packages for the construction of standard houses of a rational design, though springing from the search for wider markets for the lumber, was also prompted in some small degree by the factual necessity to create an outlet for the short lengths coming from the production line.

Generally the motives for a lumber company to start producing houses, can be either negative (passive), i.e. a surplus production capacity or a surplus-stock in certain species and sizes, or positive (active), i.e. an existing demand for relatively inexpensive houses.

Inthe situation Bruynzeel was confronted with, the positive arguments were dominating, because of a growing demand for low-cost houses, which undoubtedly could be stimulated.

However, because not all species are equally suitable for constructional purposes, there had to be a very close co-operation and co-ordination between the production department and the design department, in order not to make mistakes, either in the choice of species, or in the domain of constructional monstrosities.

The following items had to be considered very carefully:

1. The "lumber-balance".
2. The quality of the stand of the forests.
3. The demand for specific species and sizes by the regular (local and export) customers of sawn-lumber.
4. The submission to standard dimensions.
5. The average specification of the surplus stock.

Ad 1) With "lumber-balance" is meant the mutual proportions in which the various saleable species and sizes are available at the output-end of the sawmill.
This lumber-balance preferably should not be upset or disturbed. The design of a house namely is much easier if the designer has to reckon with one species only, instead of many with diverging properties.
The forests of Suriname, however, being so heterogenous, the design-department is anyhow forced to adapt its designs to the properties and availability of the various species and consequently it constantly has to keep a watchful eye on the strict observance of its instructions and directions.

ad 2) The forests of Suriname generally contain trees of a relatively small trunk-diameter only, in a tremendous variety of species, mostly with a deplorable amount of internal (heart) defects.
For the replenishment of a large sawmill like Bruynzeel's, daily consuming large quantities of logs, this means that logging operations for practical and economical reasons

cannot be too selective, so the average log-diameter in the mill is hardly any larger than the average trunk-diameter in the forest. For the production of the mill this means that it will compromise an above average percentage of not too heavy dimensions and only few heavy sizes.

ad 3) Because regular customers will always order general purpose species, instead of the species only suitable for a limited number of applications, the designer of precut houses will always have to do with the less-known, the less-current species (which is not always a disadvantage), but also with the less-suitable species. This latter circumstance always carries the danger of degrading the quality of the lumber-package and hence of the house, and should therefore be avoided by all possible means.

ad 4) The production programme of Bruynzeel's sawmill - self-evidently aiming at maximum efficiency - hardly comprises any large sizes at all. The maximum thickness in only one species is 3", in most other species only 2". Supply of heavier sizes is therefore left to the competition. For the design-department, this means that all load-bearing members necessarily have to be of rather small dimensions, which in turn means that the c.t.c.-distances of these bearing members have to be adapted to the max. thickness in which they are sawn. At any cost, deviations from the standard production-programme should be prevented, because non compliance with that programme only creates new stocks of different unmarketable sizes.

ad 5) Because of the small diameter of the average log from the Suriname forest, its crookedness, its defects and its relatively high percentage of sapwood, the lengths-specification of the average production of the sawmill for most species is rather unfavourable. As a contractor will always order long lengths, the mill usually is left with the remainder, the perfectly sound but shorter lengths for which there is no ready market, unless made into ready-made products, among which complete lumber packages for houses of a special standard design.

As for these designs, it can be said, that, on condition of the above restrictions being strictly adhered to, production-wise the design as such is relatively uninteresting.

If, on the other hand, the sales department, in cooperation with the design department decides on the introduction of one or several new types of houses, in order to cover a wider range of income groups, this decision always implies the disadvantage of reducing the size of the production series of each individual design, rendering the production and stocking thereof less economical.

This latter disadvantage can be met with nicely - up to a certain extent - if the design department strictly adheres to the use of standard components, applicable to all designs, deriving, as it were, one design from the other.

This in turn carries the danger that (especially with houses on stilts or footings, so popular in this region) all joists are of exactly the same length, and even the girders are exactly the same after introduction of a "macro-module" as described on page 1[illegible].

This endless repetition of standard-components very easily leads to a deadly monotony in the production process, particularly in the heaviest sizes, which anyway are appreciably more difficult to produce, even in small quantities.

D. Precut or Prefab

1. General aspects

Once having decided upon the industrial production of houses, it is illogical to stop halfway by thinking only of the delivery of precut components for these houses.

The most obvious and logical continuation of this idea, is to finish these precut components to ready-cut ones and assemble them - in the factory - to ready-made units, ready for transportation to the building-site.

The ultimate would be to assemble all necessary components to a complete house and to take it to the site in one piece.

The thus obtained absolute substitution of manual field. labour by mechanised industrial labour in the factory, would be almost ideal for the building-economy.

Of course, everybody agrees that this prefabrication of ready-made houses is absolutely infeasible for lack of transportation equipment, in the factory as well as on the site.

This impracticability being agreed upon, the next question is to determine the limit of practicability, which means that somewhere, there is a limit, where the size of the prefabricated components becomes prohibitive for transportation facilities and transportation cost.

The transportation conditions nowhere being exactly the same, particularly not in developing countries, this practical limit will vary from country to country, even from site to site. Though at Bruynzeel the conception of the idea of prefabrication of components self evidently almost co-incided with the birth of the plan to produce precut houses and though Bruynzeel is fully convinced of this prefabrication-idea to be sound and healthy, it nevertheless never was (and possibly never will be) carried out on a large scale, in this country, that is.

Only in some very special cases, where the circumstances happened to be extremely favourable, the prefabrication of small standard components in a very simple form was realised, and very successfully at that.

The three main objections to the prefab-system, in this or any developing country are:

a. The sizable investments in the factory (machinery, jigs, buildings) are prohibitively high for the relatively small series to be expected from the home- and export markets.

b. The transportation of the prefab-components to and on the site is very costly and nevertheless very damaging.

c. The stocking of the prefab units requires large and costly buildings, which are mostly inefficiently used.

It is the firm belief of Braynsel that the industrial prefabrication of houses or components of houses can only be effected economically, if the sale of really large series of identical or similar components is absolutely guaranteed during a number of consecutive years.

If on the other hand the series to be built, are of substantial quantities (let us say for instance one thousand units a year) then this situation could be inverse. This means that if in developing countries the very serious problem of low cost houses will be tackled on a large scale and for a number of years, then in that case a prefabrication set-up can favourably be considered.

2. <u>Practical aspects</u>
As already established under "general" while thinking of prefabrication of building components, the all-important question to be decided upon, is the size of the prefabricated units.

Because this size is decisive for the economic feasibility of all three major aspects of the prefab-building method, i.e.:

a. industrial fabrication

b transportation

c. assembly on the site,

the various pros en cons of the choice of this size have to be weighed very carefully, prior to taking a decision.

Ad a. The larger the prefab units, the heavier they are and the larger the jigs in which they are to be assembled. The weight of the unit also is determinant for the type and capacity of the lifting gear to be used, in the shop, as well as in the stores.
The size of this unit further is decisive as to the ease of the assembly of the component members in the jig; the larger the unit, the farther the carpenter has to reach out in order to reach the centre with hammer, saw, nails and what not.
On the other hand, the smaller the units, the more lumber-intensive they are.

Ad b. The larger the units, the heavier they are and therefore the larger the capacity of the transportation means for the transport from the factory to the building-site has to be. For smaller distances, or even sizable ones, over well-paved roads, this may not seem too important, but for upstream-transportation of components by river, over rapids etc., this weight factor is of extreme importance. Even with the transportation of small-sized units by sea to an island without port-facilities, where the ship lies anchored in the roads and the prefab-units are transhipped on to barges and from these barges on to trucks or donkey-carts, the weight and manageability of the units are not only important but can even be prohibitive for delivery.

Ad c. The same argumentation about weights as under a) applies for the lifting-gear on the site, with the extra negative argument of buildings on stilts, where the lifting of the prefab units by hand is almost unfeasible and by travelling crane is very expensive, even in series.

The above arguments about size and weight of the prefab units, together form a convincing plea for standardization of rather small-sized prefab components, or no prefabrication at all.

Particularly in developing countries, where the lack of transportation-facilities and the generally small production series anyway form a handicap in the striving for the most economical system, these size/weight arguments are the more convincing.

As argumented under "Constructional aspects", the choice of a 4'module for all standard designs proves to be a good workable compromise between the flexibility of the design, the waste prevention on the site, the interests of ~~the~~ production department, etc. etc. and could therefore very well be transposed to the standard width of all prefabricated building components.

Arguments like the above must have been decisive for the designers of the "Unicom-Method", the modular system introduced by the "National Lumber Manufacturers Association" in the U.S.A. which is also based on a 48" major module, subdivided into two 24" minor modules.

This method, however ingenious it may be, with its endless variety of panels, rooftrusses, doors, windows etc., actually is far too complex for any developing country, because of its overwhelming diversification of possibilities and combinations, only fitting a gigantic market like the U.S.A.

This complexity, however, does not imply that the choice of the 4' module would not be applicable for smaller markets which means that if Bruynzeel ever decides upon the prefabrication of building components, it in all probability will not choose the prefabrication of wall-sized units, but will decide upon 4' modular components.

3. Financial aspects.

In addition to the financial aspects already touched upon in the course of the general considerations, e.g. the massive investment in buildings, machinery, tools, jigs, (overhead) cranes, stores, special trucks, fork-lifttrucks, etc., there are the financial consequences of the inevitable bulkiness of all prefabbed components, which compared with the precut-system, works out in considerably higher freight-charges, especially if these components have to be shipped to overseas destinations.
Another aspect with a financial bearing is that the prefabricated elements arrive on the building-site at a given time and then have to be stocked for some length of time free from climatic influences, in some kind of shed or better building, which has to be of a certain spaciousness in order to allow for adequate freedom of internal transportation.

The substitution of manual field-labour by mechanical shop-labour, efficient as it may be in sum total, means for the manufacturer that, not only the investment in the necessary machinery is considerable, but also the writing-off of this investment and the maintenance and even the power-consumption are not to be neglected and all these factors increase the price of the prefabricated components.

Finally, there is the consideration of the insurance of the prefab elements against damage during transportation, which, particularly with shipment overseas, can results in considerable premiums.

4. Constructional aspects.

As to the construction of the house and its constructional components, it goes without saying that there are elements for which the prefabrication has little or no influence on their construction. Roof-trusses e.g. are virtually unaffected by their fabrication, either in the factory, or on the site; in the latter case, they usually are assembled on the ground before going up, anyway. The only factor which might cause a difference in their construction is, that being shop-assembled the construction has to be a little stronger, sturdier, in order to withstand the damaging influences of repeated handling and transportation.

Another constructional element which is an exception, is the floor, in combination with its joists and girders. As far as known, even in the most advanced prefabrication systems, this element is not prefabricated, probably because of the weight of the thus created units, which have to be of considerable length in connection with the economical span of the joists. An additonal argument for the non prefabrication of floor-panels may be the inevitable unsightly seams in the resulting floor surface.

Finally, there are the walls, the most apt elements for prefabrication.

If the design of the house is strictly made on a modular system the logical way to break it down into manageable prefab components is by adhering to this module for the width of the prefab panels. Up to this point, there seem to be no consequence but if the constructional details of the prefab elements are considered closely, there are some definite differences.

The most striking difference is the size of the studs. If a regular loadbearing stud of say 2"x4" has to be split up into two end studs of two adjacent panels, they can hardly be two 1"x4"'s but preferably have to be at least two 5/4"x4", if not 6/4".

This very definitely results in an increase of the lumber volume and hence in an increase in price.
Then, there are the rectangular connections between horizontal and vertical members. If, in the site-constructed house, these connections can be of a simple type, fastened together with some toe-nails, in the prefab construction, this very same connection becomes more complicated: preferably a mortise and tenonconstruction, for maximum sturdiness to withstand the tortures of repeated handling and lifting.

Glueing, screwing and/or doweling of these connections is generally a necessity.

The dimensional tolerances also have to be very close for a perfect fit on the site. This means that all lumber used in the prefab components must be very well seasoned, preferably by kiln-drying it to the average moisture content to be expected in the country where the house is to be constructed. Especially for the exterior siding, this correct moisture content is critical.

Another constructional problem is the tightening of the joints between the panels. If the panels are bolted together, it probably will be feasibel to place a resilient strip of foam-rubber or foam-plastic, preferably impregnated with a tar-product, between the panels before tightening the bolts. If the panels are nailed together, the injection of some permenent plastic compound into the seams, is probably the only feasible solution.

In both cases, however, it will be necessary to cover this seam with a wheather strip, covering all openings and not creating new ones.

Because all horizontal members, which normally span the entire length of the walls in the conventional construction method, now frequently are interrupted at the joints of the modular panels, the use of additional continuous sole- and wall-plates is necessary.

5. Transportation aspects.

Another all important decisive factor to be compared, is transportation cost. Any prefabrication in the factory is rendered absolutely useless if the transportation of the prefab-components from factory to building site is impossible or prohibitively costly or damaging.

Generally, the prefabricated element is much bulkier than the lumber of which it is composed, therefore an increase in freight charges has to be reckoned with.

Apart from this volume argument, however, there are some other factors of a different nature, but with the same cost-increasing effect.

Take, for instance, the transportation of the prefabricated roof-trusses and leave (for the moment) out the consideration that the volume of a roof-truss is a multiple of the volume of the composing lumber. The shape of a roof-truss, however, is so extremely unmanageable that the disadvantage of its volume is only small, compared to that of its shape.

The transportation of such roof-trusses upstream by canoe or even by small motor launches is all but unthinkable. Even transportation of these trusses by truck requires a special flatbed truck, and even then, the difficulties caused by the protruding ends of the rafters touching aerial wiring etc. are not to be neglected.

Shipping trusses overseas, which, in this area, frequently will occur, requires the utmost care of the operator of the ship's lifting gear and the trusses probably will have to be shipped as deck-cargo because of the impossibility to lower them through the hatches.

Of course these roof-trusses were chosen as an extreme example but on the other hand, if one would decide not to ship the trusses prefabricated because of their difficult transportation the whole idea of prefabrication would lose most of its attraction and part of its economy.

The transportation difficulties with wall-sized panels are pretty much the same as with roof-trusses, but with small modul. wallpanels they are of course much less extreme.

The importance and difficulties of a good transportation, even of these small-sized panels, should nevertheless not be underestimated. Their handling has to be done with utmost care, because, however strong they may be built, the danger of damaging them either in the ship's tackle or by knocking against each other or against any other obstacle, is very real. Even the danger of warping the panels and loosening all lumber-connections by uneven lifting by hand again should not be underestimated.

Under "Practical aspects", the possibility, or even probability, of the panels to be shipped to an island without port-facilities was already mentioned. The danger of damaging the panels in whichever way, during transshipment onto a barge - riding the waves - is not a probability, it is a certainty.

The insurance against the financial consequences of these damaging factors is undoubtedly costly, but even then, the certainty of being covered against financial losses hardly compensates for the trouble of claims etc. etc.

Even, when only thinking of local projects, the transportation of the prefab components can be costly, either because of the inadequate trucking facilities, or because of the poor state of the road surface, both of which can be very damaging to the panels.

Finally, the necessity of adequate lifting-gear at the site, is not to be forgotten, because of its price, which usually is high.

All these transport considerations again inevitably lead to the following statements:

a. that prefabrication of building components in a factory, more or less distant from the building site, should be weighed very thorougly before being decided upon, and

b. that the transportation difficulties with prefab components, in contrast to those with precut materials, play a very important part in this controversy and might very well turn the scale.

6. <u>Design aspects</u>.

In comparison with the modular <u>precut</u> system, the modular <u>prefab</u> system hardly has any disadvantageous aspect at all for the designer. In both cases, he is subjected to the same restrictions in his architectural freedom. In both cases the extent of these restrictions is proportionate to the size of the module.

The smaller the module, the less radical the restrictions.

In practice, this means that individual houses, sold in the open market, can best be made of small modular components of say 4', giving the house a greater flexibility in its groundplan, necessary to allow the individual customer to adapt it to his personal requirements.

Wider, even wall-sized, prefabricated units are generally suitable for large series of low-cost houses built together, the possibility of personal alterations being unfeasible altogether.

7. **Summary.**

In the foregoing six paragraphs, the various possibilities and impossibilities of the prefab component building method were contemplated, evaluated and compared with the precut system as it is practised by Bruynzeel in Suriname. For this latter system, most of the restrictions do not count.

Because Bruynzeel occasionally has had an unique opportunity to gain experience in the prefab system, with wall-sized panels as well as with modular ones, it feels qualified to judge the pros and contras of both systems.

Speaking from this experience and as has been stated before, it is this company's belief that industrial prefabrication of components for the construction of houses is only economically feasible if large orders for identical components come in regularly.

It is an absolute impossibility to establish and maintain a well-equiped factory for the production of prefabricated components if the massive investments required for this factory cannot be written off against very large quantities of components produced.

For the Caribbean market the probability of such a situation ever being realised, is very remote indeed. It is the company's belief, that for smaller orders, under favourable circumstances there nevertheless is a possibility to find a workable compromise between the size of the orders on the one side and the economy and evident advantages of the prefab method on the other hand.

If the design of the house in question is modular and the size of the order is not too small, the quantity of small modular components, necessary for the construction of the houses, may be sufficient to justify the use of simple jigs of such a construction that all types of panels can be assembled in it.

If, moreover, the transportation facilities are not too unfavourable so that the joints in the panels need not to be too complicated, an economical prefabrication, mostly by hand, looks feasible.

Finally, it is the conviction of Bruynzeel, that under all other circumstances, industrial prefabrication of components, modular or not, is impractical and uneconomical. Then the lumber had better be taken to the site in precut form and be assembled then and there, either to prefabricated elements in a provisional assembly shop, or directly into a house.

It is therefore that - up to now - Bruynzeel only ventured in the field of prefabrication in some incidental cases, in which the advantages of prefabrication were so evident and obvious that they overruled the extra cost that had to be met. The most spectacular cases were the shipment of large quantities of almost identical 3' wide panels, in one case deep into the interior of Surinam, in another case to an extremely remote spot on the coast of French Guyana, both absolutely uninhabited areas, for the construction of houses and barracks for a temporary labour camp.

Bruynzeel finally is convinced that under its own local and regional circumstances, the most efficient and practical solution for its problems lies in the precut-building method and that it is no use to risk the loss of large amounts of money by prematurely trying to introduce the prefab system.

Admitting its limited experience in the domain of prefabrication, but on the other hand having given it considerable thought, Bruynzeel feels entitled to draw up the following cost-comparison diagram:

	Precut		Prefab	
	Factory	Site	Factory	Site
Lumber	<	–	>	–
Additional materials	–	–	>	–
Wages	<	»	>	<
Depreciation	<	–	>	–
Maintenance	<	–	>	–
Energy	<	–	>	–
Transportation	<	>	>	<
Damage	<	<	<	>
Investments	–	«	»	»

< = less   « = much less
> = more   » = much more
– = equal

Provided that the labour-market in the country of destination is of sufficient size and quality, not to influence the situation, the above considerations again lead to the following generalization:

Under favourable transport conditions, guaranteed repeat orders for large series will justify the prefabrication method in any form, but incidental small orders under equally favourable transport conditions are a too risky basis for large investments.

If transport conditions are less favourable prefabrication will always be a risky business, even for large series, though with small modular components the critical point between acceptability and non acceptability of this risk lies elsewhere and is less distinct.

E. Training-needs.

As in most countries endowed with large forests, where for generations and generations the construction of wooden houses has been common practice, the local potential in craftmanship in Suriname is sufficiently large not to worry about when thinking of site-built houses of individual precut members.

Therefore, if a company in Suriname should decide upon either system, the engagement of skilled personnel to do the job, either in the factory or on the site, probably would not meet with serious difficulties.

In the various islands of the Caribbean area, however, the situation is exactly opposite. Because most of these islands have no forests, the experience in the construction of wooden houses mostly is almost nil.

Because the prefabrication system requires a certain amount of skilled labour in the factory, but only a good organisation and almost no special skill on the site, the combination of these two data should create a very fertile climate for the introduction of prefabricated houses from Suriname into these islands.

The small population of most of these islands, however, together with their manifest lack of funds needed to improve the living conditions of their lower income-groups, have up till now always prevented them from placing orders tall enough to undertake prefabrication.
These realistic arguments, together with the infrequent shipping conditions, lacking capacity for really large quantities, and with the very sizable distances between Suriname and most of these islands, make the idea of the Suriname lumber industry ever shipping large quantities of prefab elements to these islands highly unrealistic. Up till now, only the shipping of precut materials has proven to be feasible.

This basically means, that if ever, in these islands, there will be a need for training of personnel, it will be the training of skilled labour to put up individual houses, of pre<u>cut</u> components.

The idea of exporting large series of prefabricated components to these islands can, therefore, already be abandoned.

F. <u>Manuals</u>.

At the time of introducing precut standard houses on the Surinam market in 1954, Bruynzeel wrote an erection manual for their construction.

This manual, though printed in hundreds of copies, was only used in some 4 or 5 instances, where the layman-customer really put up his own house. It is Bruynzeel's experience that almost all buyers of precut houses have it put by local contractors, some of them have gained considerable experience in this field.

With prefab houses, this proportion may be quite different, though this is doubtful. The idea of large series simply does not agree with individual construction.

The local contractor ordering a series of precut or prefab houses will not need a manual if he knows his trade.

General experience is, that if a manual is necessary, it will have to be visual to a great extent, with little text and many drawings and exploded views and such.

The above, of course, is only a sketchy picture of the situation in and around Surinam and though it does not necessarily apply to all developing countries, it hardly is conceivable that the broad outlines of the above local account would not hold in most comparable regions.
The isolated location of Surinam, with its small population and its small home-market, its lacking transportation possibilities to neighbouring countries, its great distance to potential overseas markets, of course they all are serious handicaps for the development of a steady outlet for large-sized mass-produced articles as prefabricated building components.

Bruynzeel believes in the mass-production of semi-finished or even fully finished quality products and in its series of precut standardized houses it thinks to have found the optimal compromise between the existing need for lowcost economy houses and the limited possibilities dictated by its geographical location and the less favourable stand of its virgin forests.

CONVERSION-TABLE

26^{0} - 27^{0}	=	approx. 80^{0}F
a difference of 9^{0}C	=	" 16^{0}F
" " " 1.5^{0} - 2.2^{0}C	=	" 3^{0} - 5^{0}F
2300 mm	=	7' - 6 9/16"
300 mm	=	11 13/16"
60 mm	=	2 3/8"
100 Km	=	62.15 miles
400 Km	=	248.6 miles
300 Km	=	186.45 miles
10-15 m3	=	353-530 cubic feet
5 m3	=	176.5 " "
1 ha	=	2.47 acre
1 km2	=	0.386 square mile

[redacted]

74.IO .2