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TRADITIONAL HOUSING DESIGNS */

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HUMAN SETTLEMENTS

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CONTENTS

INTRODUCTION

Owing to the appalling housing situation in the world today, the poor and disadvantaged continue to exist in spite of the fact that governments have realised that there is a crisis in human settlements, leading to extremely unhealthy conditions in poor rural settlements as well as in slums and squatter areas. The housing shortages for especially the lower income population tend to increase every year and the building materials and construction industries cannot cope with the demand.

According to the latest projections, the world's population, currently estimated to be approximately 4,842 million people, will grow to 6.1 billion in the year 2000 and to 8.177 billion in 2025. Estimates also indicate that there will be more people in the poor countries of the world, and this population will live in overcrowded conditions and in higher concentrations than ever before. During the last two decades of this century, an estimated 1.1 billion people will have been added to the already teeming urban centres of the developing world. In most parts of Latin America, Asia and Africa, urban growth up to the end of the century will be equal to or in excess of the current levels, showing greater concentrations of people in urban centres and a rapid increase in the number of large cities in the developing countries. The most current urbanization forecasts estimate that by the year 2000 the number of cities in the Third World with more than 1 million inhabitants will approach 300 and will have a combined population of more than 1 billion. Moreover, the urbanization process in developing countries is taking place at a much lower per capita income level than in the developed countries. This means that decision-makers and planners in developing countries are faced with more financial constraints than those in developed countries at a time when a serious housing deficit is created by an increasing number of urban dwellers.

Building materials are the most important input to the construction sector. Surveys in a number of developing countries show that the intermediate consumption of materials and supplies range from 37 per cent to 55 per cent of the total value of construction output. Thus, the building materials industry constitutes a critical prerequisite to the development of construction activities and of development in general. Experience in developing countries over the last few decades has shown that the lack of adequate development of this sector can lead to considerable delays in the implementation of development projects. Moreoever, foreign exchange constraints, owing to high foreign indebtedness and slack exports, impose severe external limitations to the development prospects of a great number of developing countries. In this context, owing to its potential for import substitution, and its role in development, this sector constitutes a priority target for any national policy aimed at satisfying the needs of the population and decreasing import dependency. The construction sector in a majority of countries is not using available resources optimally. Appropriate measures should be adopted to improve overall efficiency and productivity in the sector, especially in the development of locally produced building materials and components.

Timber is one of the locally available building materials in many countries in the world. However, there is a great lack of knowledge in technologies that use wood as a building material. The lack of information and the influence of technologies implanted without proper adaptation from industrialized countries have not been helpful in the use of proper designs and the treatment of timber as a material that could serve low-cost building. In many developing countries which possess tropical timbers, the housing situation can be ameliorated by the use of timber and its products in housing. However, one factor that prevents the extensive use of tropical forests is the wide diversity of species. Many secondary species have been ignored as building materials, although they are suitable to be used for this purpose. Poorly finished unseasoned, untreated and ungraded products hinder the use of timber as a building material. Proper treatment and design can improve its resistance to fire, water, fungi and termites.

I. TIMBER FOR HOUSING

Although the general decline in the use of wood per dwelling unit can be attributed to many factors, there is little doubt that in the final analysis only the most rational application of wood in building- having regard both to technical suitability and to competitiveness in cost - will make worthwhile contributions to a solution to the problem. The impact of urban planning considerations and, in particular, of residential densities and site coverage allowances on the use of wood construction for low-cost housing can be far-reaching. In many parts of the world, where forest products are abundant, timber housing has been and remains today a living tradition. It was developed initially as a craft-based method of construction for rural housing. Its subsequent development for urban housing is still carried out in the main by conventional techniques, and even the most industrialized wooden house systems cater mostly for detached single family houses and to a limited extent for low-rise multi-dwelling houses.

Height of Residential Buildings and its effect on the use of wood in elements of structure

Extensive use of wood with safety and economy dictates low and medium-rise housing. Building codes, with fire risk in mind, vary in the severity of their restrictions on the use of wood for residential construction. Almost invariably, however, limitations increase with the height of buildings. Other functional considerations and long experience also tend to favour low construction. A point in relation to house design which needs to be borne in mind is the inflexibility of multifamily housing with regard to future extensions. Single-family houses can be expanded by an additional storey or rear extension, even if houses are attached in rows or in cluster arrangements. With the prevailing large families in developing countries, combined with small incomes, such flexibility will inevitably commend itself to planners. Wood construction is ideally suited to permit future extensions at little or no extra initial cost. In medium-density development, with row or cluster housing, separating walls of non-wood materials or preferably, of wood-wool cement slabs, probably provide the simplest solution.

House plans and planning principles

The planning of dwelling, both as relates to the general configuration and the internal arrangement of rooms and services, has an important bearing on the economy of building, whatever materials are used. Climate and mode of living are the prime factors, but the type of structure and the characteristics and limitations imposed by available building materials also play their part. There is little factual information about the comparative economy of different house plans offering similar accommodation. Nevertheless, it is possible to indicate a few guidelines which are of particular relevance to the economic use of timber.

As a general rule, rectangular plans are the most economical, particularly for the use of wood and wood-based panels, which are generally rectilinear and rectangular. Such plans lend themselves best to standardization of elements and components, and the dimensional coordination of plans with available materials can do much to avoid unnecessary labour and waste. Encouragement of the adoption of standards in general and modular standards in particular can be given by their enforcement in the public sector.

In detached houses, plans nearest to the square in overall shape provide most space for minimum enclosure, but this consideration is secondary to that of using available standard sections and lengths and the plan shapes dictated by them. In row houses, narrow frontages are usually more economical in general development costs and in building costs (e.g. reduction of spans for wood members in floors and roofs when spanning between party walls). In general, projections from the plain rectangle add to cost and should be avoided unless dictated by climatic or similar considerations. L-shape plans may be justified in attached houses arranged in patio formation, but the additional hips and valleys (in the case of pitched roofs) add to cost. Internally, wide spans should be avoided wherever possible by making partitions load-bearing (at little or no extra cost). In two-storey houses, partitions should be superimposed wherever possible to avoid high bending moments on the intermediate floor joists.

In many countries, government ministries or agencies concerned with housing have not only laid down minimum standards of accommodation and equipment for low-cost housing, but have issued many standard plans for adoption by builders, housing associations and individuals. The best solutions in each country or region are likely to be found in the adaptation of traditional house plans to suit the requirements of modern materials and services. Prototype plans should be carefully prepared with an eye to the limitations imposed by available forest products and production techniques. The involvement of experts from the forest and building industries at an early stage is therefore essential.

Dwellings have to satisfy many diverse requirements according to climate, living habits, and standards which can be afforded. Some of these requirements have little or no bearing on methods of construction and materials, but others affect them profoundly. Durability and maintenance considerations affect especially the choice and treatment of wood materials. Other functional requirements can be met with ease in wood construction, often by the addition of other materials which can be readily tied or fixed to the structure.

Design procedures

Where an extensive use of wood in a housing project is desired, the designer and investor should consider the choice of house types and arrangement of site layout with an eye to possible inherent or statutory limitations, and modify the concepts or obtain necessary relaxations. The preliminary choice of structural forms will be followed by the systematic review of functional requirements, and the way to deal with them before proceeding to detailed structural design. As to the method of structural design, there are three recognized procedures, and some codes will accept any of them as valid (a) the conventional (traditional or rule-of-thumb) (b) structural analysis and (c) prototype testing.

As a rule, these procedures are economical in materials in the order listed. They each have their advantages and limitations. The first method, based on past experience and intuition, takes little account of technological advances and improvements in quality of materials. Its systems often contain structurally redundant parts These may be oversized, due to inefficient jointing, or ignorance of the strength properties of the materials used. Cutting down on member sizes or traditionally accepted minima in jointing methods (e.g., by speculative builders) may result in inadequate structures.

The second method is based on the application to design of the fundamental laws of mechanics and on empirical knowledge of the behaviour of materials and structures under diverse loading conditions. The resistance of the structure and the applied loadings are then correlated to provide safe buildings. A prerequisite of the analytical method is a knowledge of the strength properties of the materials to be used and of the loadings to be assumed. Neither one nor the other, however, are easily evaluated constants, but are variables over wide ranges. Safety cannot be regarded as a simple factor by which all stresses are reduced or all loadings increased, but must take into account the type of risk involved and an acceptable probability of failure which is statistically determinable. Design codes generally make inadequate allowance for load-sharing between members and tend to be conservative in some other important respects as well. There is great need for an international pooling of experience and resources to obtain more economical design criteria everywhere.

Prototype testing of components or elements also assume a knowledge of loading conditions which have to be simulated with adequate safety factors. A consistency in quality of materials and workmanship in repetitions of the prototypes tested is also assumed. Repeat tests on a number of samples are also required in some codes.

II. FACTORS AFFECTING STRUCTURAL EFFICIENCY

Three main considerations govern the efficiency of wooden structures (a) the strength properties of the materials (b) the means of connection between members and parts (c) the forms selected (for member components or complete building structures). During the past few decades considerable progress has been made in many countries in establishing standards of sizes and qualities for sawnwood and various wood-based panel products, often including stress grades based on the limitation of strength-reducing characteristics (such as knots, wane, slope of grain, etc.). Such standards are a prerequisite both for analytical design and for prototype testing. Grade stresses have been laid down not only for practically all available softwood species but for many hardwoods as well. In some countries wood species of similar strength characteristics are assigned group working stresses in order to simplify analytical design procedure. This method would appear to have particular merit in the possible exploitation of mixed secondary species from tropical forests, whose strength classification into groups could be most readily determined by density considerations. The assignment of strength and elasticity values based on a limited range of preferred numbers has been widely advocated and is already applied in Malaysia and East Africa.

Grade stresses assigned to visually graded softwoods generally err on the side of caution by the nature of the methodology employed in establishing them. Electro mechanical grading, already introduced on a limited scale in several countries, including Australia, where it has been used for grading hardwoods, is likely to increase the strength rating of timbers of all species to which it is applied.

Whatever grading methods are adopted, there appears to be little doubt that a great many, species in tropical forests not at present exploited commercially have ample strength properties for structural uses in housing. P.A. Campbell [1] recommends a simple performance specification which divides sawnwoods into three grades: structural, constructional (but nonload-bearing) and joinery quality. By lowering the standard of requirement, especially for the two former grades, he estimates that a saving of 15 per cent in cost has been achieved in East African

[1] Campbell, P.A. Performance specifications for the quality control of timber for housing in developing countries. WCH/71/6/2.

countries where such a specification has been adopted. The simplicity of these grading rules contrasts with the greater sophistication and complexity of the standards which are now obtained in highly industrialized countries, in particular in North America.

The development of efficient means of connections has been a major factor in the advance of timber engineering in the past few decades, and has permitted progressive reductions in sizes of structure/components. J.D. Boyd 2/ gives a comprehensive review of available methods and the factors affecting them and influencing their choice. Particular attention is given to the problems of jointing relatively dense hardwoods and means of overcoming them. Nailing is the most common solution for jointing timbers in housing in the developing countries - as it is in the industrialized regions.

III. NON-STRUCTURAL COMPONENTS AND USES

The design of non-structural components and parts is governed by various functional requirements relevant to the particular end use, as well as by available materials and methods of production. Functional requirements affect in particular surfacing uses such as floors, wall claddings, internal linings of walls, partitions and ceilings. Economy in design dictates the use of single parts to perform dual or multiple functions. This is particularly true of finish surfaces in wood or wood-based panels, which can usually be exploited structurally in addition to their primary functions.

Joinery and wood trim constitute an important group of wood uses. Wooden doors, windows, shutters, cabinets, shelving, skirting, etc., are widely used in housing even in countries with scarce forest resources. The designs of some of these items are largely influenced by traditons and climatic conditions. Increasing attention is being given in many countries to design adjustment according to the needs of rationalized production techniques. As with structural components, the general trend in the design of joinery items is toward economy in material content - largely achieved by the use of wood-based panels, and simplification of details of construction to reduce the number of necessary operations.

2/ Boyd, J.D. Problems associated with the use of wood in construction. WCH/71/4a/2

In modern design, particularly of low-cost housing, many traditional wood trim items such as skirtings, picture rails, architraves, barge boards, eaves, fascias and soffits are reduced to minimal dimensions and often completely eliminated. However, details must be carefully studied to avoid detrimental effects on function or appearance.

Regarding ancillary uses, mention must be made of formwork and scaffolding for which sawnwood, poles and panel products are used on a large scale. Careful structural design and selection of material are essential to guarantee both economy in material and the safety of operatives. Multiple use and reduction of waste in shuttering can best be achieved by panelization, which in turn dictates a measure of dimentional standardization in building.

IV. PRODUCTION AND ERECTION TECHNIQUES

For the construction of houses, wood and wood-based panel products enjoy a number of advantages over most other materials from the point of view of production and erection techniques. They are light and strong, easy to work, assemble and fix with simple hand tools, and also relatively easy to transport and erect in large sections without the use of costly equipment. This extreme flexibility has enabled a wide variety of production and erection techniques to be developed, attuned to the technological levels of different sectors of the building and wood-working industries which co-exist in most countries, and to the characteristics of the housing markets in which they operate. The methods range from on-site preparation of materials and stick-by-stick assembly of the houses to the most advanced prefabrication and shop-finishing of complete dwelling units, or sections of dwellings, and their subsequent transport and placing on prepared foundations. Between these two extremes there are many intermediate stages, each with a different distribution of labour and skills between factory and site. The adoption of one method or another in a particular set of circumstances depends not only on technical feasibility but to an even greater extent on economic justification.

V. COST COMPARISONS BETWEEN TIMBER-FRAME AND OTHER HOUSES

Cost comparisons between houses built with different materials and techniques are not easy to establish for a number of reasons, which may be grouped as follows:

(a) It is difficult to equate comparability of performance and to assess the value to be placed, e.g., on better insulation, finish, durability, appearance, etc.;

(b) The wide range of variations in site labour requirements and building costs, even for the same method of construction, owing to differences in plan, house size, details of construction, site and weather conditions, size of contract and, in particular, efficiency of management and labour, in which specialization and continuity play a large role.

For these reasons (particularly those in the second group), estimates of cost based on designs or on prototype houses, or even on small numbers of houses of new types, can be misleading.

A study made in Rangoon, Burma, has shown comparative costs of timber houses constructed as alternatives of high-cost type of dwellings made of bricks, cement, and asbestos-cement roofing sheets. The low-cost timber houses constructed for this project consist of four basic timber frames assembled at a central workshop before all materials are transported to the site. At the site, the frames are assembled using bolts and nuts. This way semi-prefabrication techniques reduce the labour requirement to about 70 per cent of the traditional way of construction, as well as reducing the construction time. The cost per unit area of this system ranges from 40-60 kyats/sq. ft. as compared to 180-220 kyats/sq. ft. of masonry structures with load bearing walls; 200 - 280 kyats/sq. ft. of reinforced concrete structures with brick filling walls, and 150 - 200 kyats/ sq. ft. of timber frame structures with brick filling walls. Only bamboo structures or mixed timber and bamboo structures, with a price range from 6 to 10 kyats/sq. ft., can compete with timber frame structures with timber walling (see table).

Table. Cost per Unit Floor Area of Different Types of Structures in Rangoon, and Advantages and Disadvantages

No.	Type of Structure	Cost per Unit Area Kyats/sq. ft.	Advantages and Disadvantages
1.	Masonry structures with load bearing walls	180 - 220	Since the walls must be thick enough to carry loads, the walls absorb heat in day time and transmit it in the evening. Least earthquake resistant compared to other structures.
2.	Reinforced concrete frame structures with brick filling walls	200 - 280	Better thermal behaviour, good earthquake resistance, most expensive of all types.
3.	Timber frame structures with brick filling walls (Brick nogging structures)	150 - 200	Better thermal behaviour, good earthquake resistance. The durability can only be that of the timber.
4.	Timber frame structures with timber walling	40 - 60	Good thermal behaviour, good earthquake resistance. Shorter life compared to masonry structures, about 80 years, flammable:
5.	Bamboo structures or mixed timber and bamboo structures	6 - 10	Good thermal behavior, good earthquake resistance. Shortest life and highly flammable.

Source: Rangoon City and Regional Development Project, TCD, UNCHS (Habitat), 1985.

Component production and cost

Standardization and mass production of individual joinery and structural components lead to cost reduction through refined design with consequent economy in materials (e.g., through glueing and use of sheet materials in flush door production, or pressing inserted tooth plates in trussed rafter manufacture), and through reduction of albour requirements by mechanization and division of operations. Despite the progress achieved -particularly in industrialized countries- further rationalization in the design of components and their standardization can still be achieved to reduce costs further.