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**UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION**

Distr.
LIMITED
PPD.62
5 November 1987
Original: ENGLISH

**THE BUILDING MATERIALS INDUSTRY:
ITS ROLE IN LOW-COST SHELTER PROGRAMMES**

**Sectoral Studies Series
No.39**

**SECTORAL STUDIES BRANCH
STUDIES AND RESEARCH DIVISION**

C.O. Fa2cke

Main results of the study work on industrial sectors are presented in the Sectoral Studies Series. In addition a series of Sectoral Working Papers is issued.

This document presents major results of work under the element Building Materials Industries in UNIDO's programme of Industrial Studies 1986/87.

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Preface

This study follows earlier work in the same field such as UNIDO's contribution to the International Year of Shelter for the Homeless: "The building materials industry: its role in low-cost shelter programmes", PPD.25 (SPEC.); "The building materials industry in developing countries: an analytical appraisal", Sectoral Studies Series No. 15, Volume I, UNIDO/IS.512" and "The building materials industry: the sector in figures", Sectoral Studies Series No. 16, Volume II, UNIDO/IS.512/Add.1. The report was produced in the Sectoral Studies Branch by Mr. C.O. Falcke.

Considering that building materials account for at least one quarter if not one third of total building cost in most instances, it is clear that the industrial production of building materials - the focus of this report - can play an important role in alleviating the shelter problems in low and middle income nations.

Contents

	<u>Page</u>
1. RECOMMENDATIONS AND EXECUTIVE SUMMARY	1
1.1 Recommendations	1
1.2 Characteristics of the industry	4
1.3 Technological and economical considerations	4
1.4 Participation of women	7
1.5 Main features of UNIDO's technical assistance programme	8
2. AN OVERVIEW OF THE BUILDING MATERIALS SECTOR	9
3. TECHNOLOGICAL AND ECONOMIC CONSIDERATIONS IN THE LOW-COST BUILDING MATERIALS INDUSTRY	16
3.1 Conventional construction versus pre-fabricated housing	16
3.2 Possibilities of industrial technologies in reducing construction costs and increasing housing quality	17
3.3 Research and technical assistance	20
3.4 Site and services and other incremental housing schemes	24
3.5 The public sector	24
3.6 The scope for small-scale production of building materials	25
3.6.1 The question of raw materials	28
3.6.2 Factor and technology combinations	29
3.6.3 Labour-capital substitution	30
3.6.4 Mobility	32
3.6.5 Product mix	33
3.7 Characteristics of the informal production of building materials	34
4. THE PARTICIPATION OF WOMEN IN THE CONSTRUCTION AND PRODUCTION OF BUILDING MATERIALS	37
5. RECOMMENDATIONS TO ENHANCE THE UTILIZATION OF LOCALLY AVAILABLE AND PRODUCED MATERIALS	38
5.1 Prices	38
5.2 The role of the private sector	39
5.3 The role of the public sector	40
5.4 Resource utilization	42
5.5 Organization of production	43
5.6 Research and information	44
6. DIRECTION OF UNIDO'S POLICIES FOR BUILDING MATERIALS AND CONSTRUCTION	46
6.1 Main features of UNIDO's technical assistance programme	47
6.2 Dissemination of industrial and technological information	48
Annex 1: EXAMPLES OF UNIDO PROJECTS	49
References	54

Tables

	<u>Page</u>
1. World production of building materials by type, 1975, 1980 and estimated 1985	12
2. Developing country production of building materials by type, 1975, 1980 and estimated 1985	12
3. World exports of building materials by type, 1975, 1980 and estimated 1985	13
4. Developing country exports of building materials by type, 1975, 1980 and estimated 1985	13
5. Developing country imports of building materials by type, 1975, 1980 and estimated 1985	14
6. World consumption of building materials by type, 1975, 1980 and estimated 1985	14
7. Developing country consumption of building materials by type, 1975, 1980 and estimated 1985	15
8. Average number of employees per million \$US value added, 1980	15
9. Technological considerations for developing countries	31

Plates

1. Simple jig for the manufacture of window slats.	22
2. Use of prefabricated materials for low-cost housing	23

EXPLANATORY NOTES

References to dollars (\$) are to United States dollars, unless otherwise stated.

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

Billion equals a thousand millions (1,000,000,000).

A slash between dates (e.g., 1980/81) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

Metric tons have been used throughout.

The following forms have been used in tables:

Three dots (...) indicate that data are not available or are not separately reported.

A dash (-) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add up precisely because of rounding.

1. RECOMMENDATIONS AND EXECUTIVE SUMMARY

1.1 Recommendations

The single unifying conclusion to the analyses carried out in this report can be stated simply:

Any meaningful strategy for the provision of low-cost shelter must include a resolute shifting of present housing production methods to a more intensive use of indigenous resources and to a more labour intensive basis. This can be done through intensified participation of the beneficiaries themselves. It would require a significant public support programme in the form of technical assistance but also de-regulation policies and stimulation of private - small scale - entrepreneurship in the building materials and construction sectors.

The greatest impact on the supply of low-cost housing is achieved by having a concerted promotion of a full range of compatible building materials, construction techniques, appropriate public policies and regulations, and a vigorous involvement of self-help and private entrepreneurship. To demonstrate how this can be done, the report develops numerous specific recommendations. The most important ones are listed below. For further recommendations as well as for the underlying discussions, please refer to the full text.

Prices for alternative building materials govern the choice of material, frequently between that of an imported or a local product. Hence, market prices should be allowed to reflect freely the economic costs and benefits of a given building material in order to optimize resource allocations. In many developing countries this often implies that foreign exchange rates must be neither under- nor overvalued.

Tariffs and other trade barriers work against the interests of those in need of housing. The customary argument about the necessity of trade barriers to protect the domestic industry carries precious little weight in the case of building materials for low-cost housing. Most, if not all such materials can be competitively produced from local raw materials. Care, however, has to be taken that the domestic producers are not penalized through unduly high prices for their inputs.

In public sector construction, high priority should be given to shadow pricing to reflect social costs and benefits of different building materials and alternative construction technologies.

Especially in building materials, the private sector can and must play an active role in alleviating distressed housing markets. Some public programmes go as far as making it a condition that there is a certain amount of self-help enterprise in the form of the collection or production of building materials.

Site and services schemes and other incremental programmes to which family initiative and private entrepreneurship can contribute significantly are very effective means of providing low-cost housing. The proper role of outside assistance is mainly in securing adequate land and infrastructure, in particular water and sanitation.

The private sector can also assist by raising and channelling financing for the production of low-cost building materials and the construction of housing. This takes many forms. Most important is self-financing generated through small-scale entrepreneurship and employment, both at home and abroad.

Any increased housing construction programme will create an accelerated increase in the demand for construction labour and material. Training, therefore, is important to avoid local bottlenecks with ensuing shortages, increasing prices, and growing imports. Such programmes should be geared towards the mutual objectives of providing not only shelter but also income and employment opportunities in the local building materials and construction industries.

Typically the public sector is one of the largest builders in most any economy. Therefore, the public sector can have a large and very direct impact on the domestic building materials industry through its own construction activity.

Governments can provide a secure market for the products of the small-scale and informal sector. Where the viability of low-cost domestic building materials has been proven, the relevant clauses should be drafted for insertion in the specifications of construction contracts, requiring that such alternatives be examined and used where appropriate. Manuals should be prepared reviewing alternative techniques. Tender and contract documents must be easy to understand and answer. Governments should resist the insistence by external aid donor agencies on criteria favouring the choice of inappropriate techniques. Regarding unconventional building materials, once it is clear how they can be effectively used in government construction, consideration could be given to subsidized demonstration projects.

The competence and autonomy of provincial and other local administrations should be accentuated. Co-ordination among agencies operating public works programmes in rural areas should be intensified. Local people must be more deeply involved in deciding upon and carrying out their own community infrastructure and shelter works.

Support to existing industries goes hand in hand with the establishment of new ones based on indigenous product development. This might take place in a building material development centre, either public or private. Such a centre could be given the responsibility for testing new materials and finished products, setting quality standards to ensure acceptance by the construction sector of all products, including new ones. Prototype development for the appropriate application of new materials and products in low-cost housing could also be on the agenda of such a centre.

Building codes and regulations should be revised to suit low-cost housing programmes based on the use of indigenous materials and techniques. The demand for housing should be invigorated. This entails public policies to stimulate both private and public saving that, in many developing countries, are subnormal owing to a low interest rate policy combined with inflationary

expectations. At the same time, an endeavour should be made to foster - or create, as the case may be - a market for primary and secondary mortgages. The increased demand for housing would act as a desirable stimulant for local producers of building materials, builders and contractors.

Prohibitively high costs of land can easily be characterized as an important constraint upon low-cost urban housing. The problem is aggravated by land speculation. National and local government purchases of land, and the subsequent lease thereof in accordance with long term city and regional plans, should be used to counter such tendencies and to invigorate housing demand in urban areas. Land taxes, which will make land speculation less attractive, should also be used vigorously.

Indigenous resources for building materials are relatively little utilized in many regions of the world, often because they are presently less accepted by the trade. Here manufacturers' associations and trade organizations can do a great deal by promoting unconventional products through developing proper standards and recognized quality assurance schemes.

The production of building materials should be organized so that:

- (a) The scale of production units is appropriate to the size of the community, its resources and skills;
- (b) Product design and production engineering is integrated with business systems;
- (c) The technology is easily understood and managed by people with no previous training;
- (d) The manufacturing is flexible enough to meet varying demands;
- (e) The raw materials are, as far as possible, available locally;
- (f) The finished product can be afforded by those who need it;
- (g) Management and control of the production unit is locally based.

Whereas economies of scale in the production of simple building materials are not always predominant, they do play a role when it comes to repair and maintenance, marketing and other types of specialist services. Co-operation between enterprises or between countries is one way of making such services available and to reduce their unit costs. However, maximum division of labour may not yield optimum, system-wide results.

A first step in a programme to increase the use of indigenous, low-cost building materials and native designs is to validate the merits of any proposal with respect to cost and quality, production technology and organization, and raw material supply and markets for the product. A judicious, scientific approach to these matters is required if a lasting impact on the provision of low-cost shelter is to be achieved.

Extensive research results are available in institutes and other bodies in industrialized countries and in developing countries. This knowledge must be disseminated effectively to the interested parties in the developing countries, necessitating appropriate international co-operation programmes.

There is a need for making self-instruction materials available in the local vernacular, presented and illustrated clearly, and easily available to those who would benefit from them. In many instances the production of building materials is fairly simple but at the same time great increases in quality could be achieved by paying close attention to certain aspects of the design and production processes. MAC (Machine Aided Craftsman) technologies should be applied widely.

Increased use of wood in building and construction could play a significant role in enlarging local markets for wood and wood products. However, in some societies certain technical problems (e.g., relating to humidity and decay) as well as financial discrimination, social prejudice, lack of referral standards, and legal constraints must first be overcome.

1.2 Characteristics of the industry

The building materials and construction sectors play a significant role in the economic and social development process. Because of this, governments pay close attention to these activities and they receive a great deal of support in terms of funding and public policies. However, at present most of this support has only a marginal and/or indirect effect on low-cost housing.

Valuewise, some two per cent of the world's production originates in the building materials industry. The sector is relatively most important in Southern Europe, Japan, the oil producing regions, and in the quickly industrializing countries of East and Southeast Asia. In global trade, building materials account for approximately three per cent of the total value. The import shares of the developing countries are three to four times those of their exports of building materials. Imports account for roughly one fifth of the developing countries' consumption of building materials. However, the available evidence suggests that it is not materials for housing purposes that are the primary cause for the heavy dependency on imports. Indeed, locally available materials and suitable technologies have always existed especially for low-cost housing purposes.

1.3 Technological and economical considerations

Construction in the developing countries is getting more materials intensive. Therefore, there will be a continued temptation to import building materials. Low commodity prices and the tightening of world credit conditions, however, have rendered such a strategy unworkable for many developing countries. Hence, if construction activities are to be increased and structurally unwise skimping on material is to be avoided, domestic capabilities must be enhanced. In particular, the further provision of shelter in many developing countries will depend on the sector's ability to shift housing production methods to a more indigenous resource and labour intensive basis. By the same token, the basic advantages of trade, especially regional trade in the case of building materials, must not be forsaken.

There is little difference between conventional and prefabricated housing in terms of building materials as a proportion of total cost. However, transportation and other logistics problems limit the geographical area which can be served by large, pre-fabricated building elements. Furthermore, such construction is neither typically cheaper nor of better quality than custom-built low-cost houses.

While in large cities construction cost, including those of building materials, may be brought down through prefabrication, low-cost shelter programmes could falter because the total cost of housing is also determined by the cost of land and infrastructure, and the cost of financing. Thus, from a building materials point of view, pre-fabricated housing does not offer many advantages in the developing countries, especially for low-cost shelter programmes.

Through the appropriate utilization of industrial technologies, the (economic as well as financial) cost of conventional, custom-built housing can be lowered to be better suited to low-cost shelter purposes. At the same time, quality can be improved compared to self-constructed units assembled from a haphazard collection of surplus materials. But the technological possibilities alone will not lead to low-cost shelter on a massive scale. Public policies and instruments must simultaneously be directed towards the other components of total housing cost, namely land, infrastructure and financing. Five, mutually reinforcing avenues are discussed in this report:

- Appropriate design of the housing unit;
- Light-weight, labour intensive construction technology;
- Greater utilization of indigenous building materials;
- Technical assistance to the industries producing building materials; and
- Design of building material standards and building codes appropriate to low-cost shelter.

The world's reserves of certain building materials, notably forest resources, are continuously declining. Present trends indicate accelerating depletion during coming decades. This is caused by growing populations and urbanization, shifting agriculture, grazing, natural disasters and, yes, plain mismanagement. Further technological development and increased industrial processing is one way of getting higher returns from limited resources. In many instances, substitution by other materials is also possible. Thus, industrial production of building materials can play a role in alleviating the shelter problems of the poor.

Technical assistance to the industries that produce building materials can obviously play a significant role in overcoming shortages in skills and appropriate tools for new building materials. Such assistance can, and does, range from the very simple construction of a jig to ensure that parts that will have to fit together, actually do so to the more complex design of prefabricated materials for a low-cost housing unit.

Experience shows that the building process of a low income urban house might take up to 20 years, in the course of which the house gradually evolves from a shanty to a dwelling unit that meets regular local housing standards. Given adequate access to appropriate building materials, this process, if properly managed, could easily evolve into socially acceptable housing. Bulldozing away squatter communities could destroy capital and the foundations for productive living by substantial numbers of families.

So-called site and services and other incremental housing schemes capitalize on the inherent capability of people to construct their own housing. They are respectful of the inhabitants in that they allow them to expand and improve their housing according to their demands and means. The provision of basic services such as water, sewage and roads, in addition to a

small plot of land ensures that at least minimum health and safety standards are met. With the ready availability of properly designed and fabricated building materials for at least the foundation and the frame, the families can then erect dwellings that suit their own particular priorities and incomes.

Such incremental schemes that capitalize on people's own capabilities and utilize a maximum of indigenous techniques and materials may be the most practical way of housing people on a massive scale. Normative, needs-based housing programmes typically not only vastly exceed the effective demand for housing, but would also tax an economy's total resources to such an extent that little if any would be available for capital investments.

Governments play an important role in shelter schemes. However, government programmes which simply build housing without involving the specific families that will use them are typically the most costly and least satisfactory. Furthermore, grandiose housing schemes conceived on the basis of need rather than productive capacity may ultimately wind up providing less housing than would a modest programme based on the active participation of the beneficiaries themselves.

Regulations, standards and building codes are essential to the orderly development of urban settlements, that is clear. But these edicts ought to reflect the reality of low-cost housing and the continuous evolution of new building materials and the improvement of old ones. The crucial difference between temporary and permanent final structures must be recognized and accommodated in the codes to optimize the use of inexpensive building materials and construction technologies, in particular in self-help shelter construction. The public sector in its own construction can be a leader rather than a laggard in adopting new techniques and materials.

The report notes that very large scale operations have never accounted for the majority of manufacturing operations in advanced countries. And the tendency in manufacturing today is towards the smaller rather than the larger scale. The construction and building materials industries are no exceptions in this regard; rather the opposite. In fact, many manufacturing processes in the building materials industry operate at constant returns to scale over a range that includes fairly small plants. Furthermore, varying degrees of technological complexity and labour intensity are possible because building materials resources are usually widely available, and the technologies associated with the industry are flexible enough.

Semistructural and auxiliary building components and secondary goods fabricated from basic structural materials offer many opportunities for small-scale operations. The informal construction industry in developing nations already possesses a vast pool of relevant knowledge, experience and manpower.

Small-scale plants seem especially appealing for non-metallic mineral-based building materials such as bricks or tiles. In the developed countries, the costs of making, firing and drying bricks and other heavy clay products decrease only very slowly with increasing capacity. In a developing nation, per unit costs may be significantly higher in large-scale plants.

Wood-related industries show essentially no economies of scale with regard to the amount of raw material or number of workers. Although production of medium density fibreboard, oriented strandboard, hardboard and

comply requires large, capital intensive plants, the production of sawn wood can be a very small-scale operation. Plywood and cement or gypsum fibreboard can be produced with medium scale, labour intensive methods. Similarly, small cement plants have proven to be feasible and steel minimills have flourished.

Regarding the organization of production, the report notes that most building materials can be manufactured using a wide variety of processes, from quite capital intensive to very labour intensive. The richness of potential production methods increases the potential for entrepreneurial activities in the sector and enables producers to innovate in ways which make the best use of the resources, viz. technology, labour, natural resources and capital. In the building materials industry, labour intensity is especially high in the informal sector. Estimates performed across the building materials industries of many developed and developing nations and within various countries across wide time spans provide convincing evidence that labour and capital are highly interchangeable in the face of differentials in factor prices.

Where the formal sector is less well-entrenched, the informal production of building materials is more widespread. Entry into the informal market is relatively easy. The average firm employs two people and is small enough that the owner's managerial instincts are sufficient to run it. Training is acquired through on-the-job training, apprenticeship and skills passed down from older relatives; and methods are adapted from traditional practices.

Informal production requires low capital investment and it is labour intensive. Land for workshops may be obtained by squatting rather than purchase, or a plant may be located in a house or a backyard. Financing is more likely to come from moneylenders or family donations than from banks. Machinery is likely to be manufactured locally and repaired with ingenuity and scavenged parts. Transportation of raw materials and finished products is by low-cost vehicles, such as animal drawn carts. Informal sector producers use virtually no foreign exchange in their inputs.

1.4 Participation of women

Throughout history, in all cultures women have played a central role in matters concerning housing. This entails the supplying of professional, skilled and unskilled labour for construction and the production of various materials for construction, woven panels, thatched roofs, brickmaking etc. Carpentry is increasingly done by women. In some countries, the majority of the construction workers are women.

Especially the small-scale production of building materials offers equal opportunities to men and women. This is particularly so when the activity takes place in or near the home, allowing other essential functions to be carried out at the same time. Similarly, the incremental adding-on or improvement of a housing unit is well suited to family members that have other main household chore responsibilities.

With a few exceptions, governments do not deal adequately with women in shelter projects. A specific focus on women is missing and there is insufficient conceptualization of women's issues in the context of housing development. Furthermore, the theme of women and shelter is not a popular research topic with scholars, institutes and universities.

1.5 Main features of UNIDO's technical assistance programme

It is a long-standing tradition in UNIDO's technical assistance programme to regard the building materials industry not only as a manufacturing sector in its own right but also as one of the essential inputs to the construction sector and, particularly, to the part of that sector concerned with low-cost housing, which in most developing countries ranks high among government priorities. Today, UNIDO's assistance to the building materials and construction industries sector constitutes approximately ten per cent of the Organization's total portfolio.

Building materials for (low-cost) housing purposes are usually produced by industries that also produce materials and products for other types of construction and non-construction purposes. It is therefore of paramount importance to view the production of (low-cost) building materials in its proper industrial context, that is as part of a product line. Similarly, when arranging the production of building materials for a given shelter project, one should also consider the continued viability of the production once the housing project is finished. This is UNIDO's practice and the organization stands ready to provide appropriate technical assistance to the building materials and construction industries within a comprehensive industrial strategy that considers both alternative uses of available raw materials and the full range of end uses. In that way we not only contribute to the provision of housing but also create an industrial base on which communities and nations can build. Therefore, in its policy and programme with respect to low-cost housing, UNIDO is emphasizing the following:

- (a) Production of a full range of construction materials, mostly from local materials;
- (b) Decentralization of production plants in order to promote small town and rural development;
- (c) Utilization of local resources and wastes for the production of building materials;
- (d) Efficient use of local manpower;
- (e) Adaptation of technologies for minimizing energy consumption; and
- (f) Enhancing traditional technologies by means of industrializing them.

In the construction related industries UNIDO is focusing on earthquake engineering and construction for seismic conditions through:

- (a) Strengthening design and construction capacities in countries lying in seismic zones;
- (b) Enhanced capabilities to repair and strengthen buildings damaged by earthquakes;
- (c) Application and demonstration of new advanced technologies for aseismic construction; and
- (d) Promoting close regional co-operation among countries lying in seismic zones in the exchange of scientific information and technology transfer.

2. AN OVERVIEW OF THE BUILDING MATERIALS SECTOR

Building materials are produced by a number of industry branches, the unifying element being that they constitute inputs to the construction sector. However, the products from these industries are also used for non-construction purposes, steel for example. Thus, while it is perfectly possible to speak about the production of building materials, it becomes much more difficult to define in operational terms a building materials industry. Similarly, it is equally difficult to define in operational terms a building-materials-for-shelter industry. Therefore, in presenting a statistical overview of the building materials sector, a certain amount of estimates and judgement with respect to available, published data is necessary.^{1/} Also, the following overview refers to building materials for all construction purposes. In rough terms, the construction of housing probably accounts for 30 to 50 per cent of all building materials.

A little more than a year ago, UNIDO's Sectoral Studies Branch undertook a basic investigation of the building materials industry.^{2/} Based on data for 1980 from that study, it can be said that some two per cent of the world's gross Domestic Product (GDP) originates in the building materials industry.

In the regional economies of the industrialized countries, the production of building materials in terms of value added are relatively most important in Southern Europe and Japan, and least important in North America. In the developing world, building materials are relatively most important in the oil producing regions and in the quickly industrializing countries of East and South-East Asia. Compared to other economic activities, the sector is of relatively little importance in Tropical Africa.

Building materials play a fairly large role in total external trade. In 1980, valuewise 3.3 per cent of the world's imports, and 3.0 per cent of the world's exports were building materials. In 1975, the corresponding figures were 3.0 and 2.8, and in 1983 they were 2.6 and 2.4, respectively. The relative importance of trade varies from one region to another more than does production. Whereas exports are somewhat more important than imports in the developed market economies, the import shares are three to four times those of the exports of building materials in the developing countries and in the centrally planned economies. Imports of building materials are relatively most important in the North African and West Asian regions, reflecting the importance of oil production in their economies. Correspondingly, the export of building materials from these regions is very modest. In the world, building materials play the relatively largest role in the exports of Europe and Japan, mirroring their importance in the production of these regions. Conversely, imports of building materials is most significant where domestic production is relatively least important, Tropical Africa and North America for example, or where domestic consumption is very high, North Africa and West Asia as stated above.

1/ For a methodology, see "The building materials industry: the sector in figures", Sectoral Studies Series No. 16, Volume II, UNIDO/IS.512/Add.1, 3 October 1985.

2/ "The building materials industry in developing countries: an analytical appraisal", Sectoral Studies Series No. 16, Volume I, UNIDO/IS.512, 29 January 1985.

The world production of building materials in real terms increased at an annual rate of 3.3 per cent between 1975 and 1980, from \$US 277.1 billion to \$US 326.3 billion at constant 1975 prices. In 1985, UNIDO estimated that the world production had increased to \$US 394.1 billion, representing an annual growth of 3.8 per cent since 1980. Compared to many other industrial sectors, the building materials sector has thus grown at a respectable and even increasing pace. The growth of external trade in building materials, however, has slowed down. World imports increased from \$US 26.3 billion in 1975 to \$US 37.1 billion five years later, representing a real annual growth rate of 7.0 per cent. But for the first half of the 1980s, UNIDO estimates that total world imports grew at the rate of only 4.3 per cent, reaching \$US 45.8 billion by 1985. The growth rates for exports are, of course, similar.

World exports of building materials were \$US 24.5 billion in 1975, and \$US 35.5 billion and \$US 42.8 billion in 1980 and 1985, respectively, at 1975 constant prices.^{3/} Regionwise, it was the developing countries that posted the largest export growth, mainly due to the strong performance of the newly industrializing countries of Asia. Their share in world exports is now of the order of ten per cent whereas only a decade ago it was between six and seven per cent. But despite this encouraging trend, the developing countries have also increased their already substantial share of world imports, from 28.5 per cent in 1975 to 30.3 per cent by 1985.

The developing countries have managed to increase steadily their share of the world's production of building materials. In 1975, they produced \$US 34.6 billion worth of such goods, representing 12.4 per cent of the world production. Five years later, this had increased to \$US 52.3 billion (at 1975 constant prices), yielding a 16 per cent share.

Then in 1985, according to UNIDO estimates, the production in the developing countries increased to \$US 66.1 billion or 16.7 per cent of total world production. At the same time the centrally planned economies, both in Europe and Asia, maintained their one fifth share of world production. Correspondingly then, despite a sizeable absolute increase in the production in the developed market economies, their share in the world production decreased from 68.8 per cent in 1975 to 63.8 per cent ten years later.

In its study of the sector, UNIDO differentiated between six main types of building materials:

- (1) Non-metallic building materials (such as cement, lime, asbestos, clay, glass, bricks, electrical insulation, and sanitary and plumbing fixtures);
- (2) Primary metal building materials (such as metal bars, rods, sections, tubes, pipes, and nails, screws, etc.);
- (3) Finished metal products (such as finished metal structural parts, hard tools, boilers, stoves, locks, hinges, valves, fixtures and fittings);

^{3/} The difference in world total imports and exports is mainly due to the fact that imports are usually valued at CIF (cost, insurance and freight included) whereas exports are recorded as FOB (free on board).

- (4) Wooden building materials (such as lumber, veneers, wood-based panels, and builders' woodwork);
- (5) Chemical building materials (such as pitch, tar, bitumen, paints, varnishes, plastics, and glues); and
- (6) Minimally processed mineral building materials (such as stone, sand, gravel, and aggregates).

The production of these various types of building materials in the world as a whole and in the developing countries is shown in tables 1 and 2 respectively. As can be seen, the largest relative gains by the developing countries is in the primary metal building materials. This is mainly due to strong growth in these materials in West Asia and in East and South East Asia. The absolutely largest gains are in the largest group of building materials, namely the non-metallic mineral products. In the developed countries, the relatively biggest gain in production has been in finished metal and in chemical building materials.

Tables 3, 4 and 5 show the external trade in building materials by type.^{4/} While the non-metallic products are the most extensively produced building materials, it is the primary metal products that are most widely traded. Owing to their low value to weight ratio and their universal availability, the minimally processed materials are hardly traded at all. The developing countries export primarily wooden and primary metal building materials but their imports are spread more evenly over all categories of building materials (except, of course, wooden and minimally processed materials). Clearly their balance of trade in all types of building materials except wood is lopsidedly negative. At least as far as building materials for shelter is concerned, this represents an unnecessary state of affair since locally available materials and suitable technologies have always existed for housing purposes.

Tables 6 and 7 show that there has been a substantial increase in the consumption of building materials, especially in the developing countries where it nearly doubled over the past 10 years. In fact, the growth in the consumption of building materials in the developing countries was faster than in either construction or population, indicating a trend towards more construction per capita and increasing materials intensity. As separate figures are not available, it cannot be ascertained whether this trend applies to the low-cost housing sector as well. However, we do know that there was a big boom in commercial and industrial construction during the period which would tend to support a conclusion that low-cost housing did not share in the tendency towards higher material intensity. In the developed countries the annual growth in population, construction and building materials kept pace with each other.

A comparison between tables 7 and 5 shows that the share of imports in the developing countries' consumption of building materials is on the whole approximately one fifth. However, there are considerable differences between the various types of materials: the import content is by far the highest

^{4/} A table of world imports is not shown since it is different from the export table only to the extent of the difference between FOB and CIF prices. Regional details of the trade can be found in the source document UNIDO/IS.512./Add.1, op.cit.

among chemical materials (nearly one half) and lowest in wood (and minimally processed materials, of course). The import content is also relatively low in the non-metallic building materials. Since it is primarily these latter types of materials that go into shelter construction in the developing countries, we may conclude, tentatively at least, that it is not the provision of housing that is the primary cause for the relatively large imports of building materials by these countries.

In the developed market economies the situation may be just the opposite. There the import content of the consumption of especially chemical building materials had risen to nearly one half by 1985. These materials include products such as paints and plastics in various forms that are used in buildings, including those for housing purposes.

Table 8 shows the labour intensity in the production of four types of building materials, based on statistics from some 15 developing and 10 developed countries. Clearly, the production in the developing countries is, appropriately, far more labour intensive than in the developed countries. This is especially so in the wooden building materials that are of great importance to the construction of shelter. Small-scale non-metallic mineral building materials operations can be very labour intensive as well.

Table 1. World production of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	83.5	99.2	120.6
Primary metal	42.8	52.6	63.1
Finished metal	73.0	83.9	101.0
Wood	47.6	54.9	66.6
Chemical	13.9	16.3	19.4
Minimally processed	16.3	19.5	23.4
All	277.1	326.3	394.1

Source: UNIDO/IS.512/Add.1, op.cit., section A.

Table 2. Developing country production of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	14.1	20.5	25.4
Primary metal	5.2	9.4	12.3
Finished metal	4.5	6.7	8.6
Wood	6.3	9.0	11.7
Chemical	1.4	2.1	2.4
Minimally processed	3.0	4.55	5.7
All	34.6	52.3	66.1

Source: UNIDO/IS.512/Add.1, op.cit., section A.

Table 3. World exports of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	3.2	4.8	6.5
Primary metal	8.5	10.7	13.0
Finished metal	5.5	7.5	8.6
Wood	3.2	4.8	6.1
Chemical	3.9	6.4	8.2
Minimally processed	0.2	0.3	0.4
All	24.5	34.5	42.8

Source: UNIDO/IS.512/Add.1, op.cit., Section A.

Table 4. Developing country exports of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	0.3	0.5	0.8
Primary metal	0.3	0.6	1.3
Finished metal	0.2	0.4	0.6
Wood	0.6	1.0	1.35
Chemical	0.1	0.3	0.4
Minimally processed	0.03	0.06	0.09
All	1.6	2.8	4.5

Source: UNIDO/IS.512/Add.1, op.cit., section A.

Table 5. Developing country imports of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	1.5	2.7	3.7
Primary metal	2.9	3.0	3.9
Finished metal	1.5	2.3	2.8
Wood	0.5	1.0	1.0
Chemical	1.0	1.6	2.3
Minimally processed	0.07	0.08	0.1
All	7.5	10.7	13.9

Source: UNIDO/IS.512/Add.1, op.cit., section A.

Table 6. World consumption of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	83.6	100.1	121.1
Primary metal	43.7	52.8	64.0
Finished metal	73.3	84.2	101.6
Wood	47.7	55.5	67.1
Chemical	14.2	16.6	19.9
Minimally processed	16.3	19.5	23.4
All	278.9	328.8	397.1

Source: UNIDO/IS.512/Add.1, op.cit., section F.

Table 7. Developing country consumption of building materials by type, 1975, 1980 and estimated 1985 (in constant 1975 billion US dollars)

Type of building material	1975	1980	1985
Non-metallic mineral	15.3	22.6	28.4
Primary metal	7.8	11.9	15.0
Finished metal	5.8	8.7	10.8
Wood	6.15	9.0	11.4
Chemical	2.35	3.5	4.3
Minimally processed	3.1	4.6	5.7
All	40.5	60.2	75.5

Source: UNIDO/IS.512/Add.1, op.cit., section F.

Table 8. Average number of employees per million \$US value added, 1980

Type of building material	Developing countries	Developed countries
Non-metallic mineral	118.7	52.7
Primary metal	85.6	47.9
Finished metal	129.7	58.6
Wood	227.6	89.3

Source: UNIDO/IS.512/Add.1, op.cit., section B.

3. TECHNOLOGICAL AND ECONOMIC CONSIDERATIONS IN THE LOW-COST BUILDING MATERIALS INDUSTRY

In the previous section we saw that building materials have played a perhaps surprisingly large role in global trade. Among the many reasons for this one might mention the large scale construction projects that were initiated during the generally favourable economic conditions that prevailed for much of the 1970s. As domestic capacities became fully utilized, bottlenecks quickly developed in the local markets and the buyers turned to foreign suppliers. In many developing countries the tendency towards imported building materials was further strengthened by relatively easily obtainable credit and by favourable commodity prices. Even where building materials were available locally, the use of imported substitutes increased. In Egypt, for example, the volume of imported cement increased from 700,000 metric tons in 1970 to 7.9 million tons in 1976.

Now, however, low commodity prices and a very large debt burden have rendered a construction activity that is largely reliant on imported materials and technologies no longer viable in many developing countries. In fact, the lack of foreign exchange to import building materials and construction equipment has become a principal obstacle to the expansion of housing. Moreover, the tightening of world credit conditions has resulted in capital scarcity in the majority of the developing countries. What imported material is available has become, in effect, very expensive. This, in turn, has led to structurally unwise skimping on material in the form of under-sized components and too widely spaced studs, for example. The long run effects could be very serious indeed.

The further provision of shelter in many developing countries will, therefore, depend on the sector's ability to shift housing production methods to a more indigenous resource and labour intensive basis. In addition to labour, suitable resources that often exist in relative abundance include wood, limestone, and various types of clays and vegetal materials. Each country's circumstances are somewhat unique to its endowment of natural resources. However, the advantage of trade, in particular regional trade in the case of building materials, must not be forsaken.^{5/} The basic principle of comparative advantage cannot be overthrown by fiat, and attempts by relatively small economies to achieve self-sufficiency across the board of basic industries have not often worked. Furthermore, the lack of basic domestic raw materials need not in every instance constitute a serious obstacle to the production of a related building material. During the 1960s and 1970s the Republic of Korea developed a significant wood products sector (also for exports) based on imported timber.

3.1 Conventional construction versus pre-fabricated housing

Conventional construction in the developing countries is characterized by the predominance of on-site activities and the fabrication of building materials using manual labour and simple hand tools. In contrast, the

^{5/} UNIDO's study of the building materials sector discussed two different strategies employed by Mexico and the Democratic People's Republic of Korea, op.cit., pp. 80,....,85.

building process of pre-fabricated houses consists mainly of the mass fabrication of materials and components and the assembly of the house. Nevertheless, there is little difference between conventional and prefabricated housing in terms of building materials as a proportion of total cost.^{6/} It has been estimated that the proportions of labour and material costs in total cost, excluding land cost in conventional urban construction by contractors in a developing country is approximately 30 per cent and 70 per cent, respectively.^{7/} In a developed economy, materials typically account for a smaller share of total construction costs, from 50 to 60 per cent.^{8/} Especially in the developing countries, the labour content of rural construction tends to be higher than that in the urban areas, and the share of materials correspondingly lower - perhaps as low as 50 per cent of total cost, excluding land cost.^{9/} Perhaps more significantly, virtually all building material in rural housing is domestically produced.

From a building materials point of view, pre-fabricated housing does not offer many advantages in the developing countries, especially for low-cost shelter programmes. Furthermore, such construction is neither typically cheaper nor of higher quality than custom-built low-cost houses.^{10/} In developed countries it has been found that pre-fabrication on a national level is advantageous only when some 80-90 per cent of total housing construction is done with standardized pre-fabricated elements, quite obviously not a desirable proportion of total housing to be devoted to low-cost shelter in most any country. Moreover, transportation and other logistics problems limit the geographical area which can be served by large, pre-fabricated building elements. While in large cities construction cost, including those of building materials may be brought down through pre-fabrication, low-cost shelter programmes could falter because the total cost of housing is also determined by the cost of land and infrastructure, and the cost of financing.

3.2 Possibilities of industrial technologies in reducing construction costs and increasing housing quality

Through the appropriate utilization of industrial technologies, the (economic as well as financial) cost of conventional, custom-built housing can be lowered to suit better low-cost shelter purposes. At the same time quality can be improved compared to self-constructed units assembled from a haphazard collection of surplus materials. Five, not mutually exclusive avenues present themselves:

6/ Sharing in development - A programme of employment, equity and growth for the Philippines, International Labour Office, Geneva, 1974, p. 221.

7/ Ibid., p. 220

8/ A Study of the Impacts of Alternative Land Use Plans for the Lake Tahoe Basin, By David M. Dornbusch & Co., Inc., San Francisco, Calif. 94133, 1978, Appendices, p. P-3.

9/ Sharing in development, op.cit., p. 221.

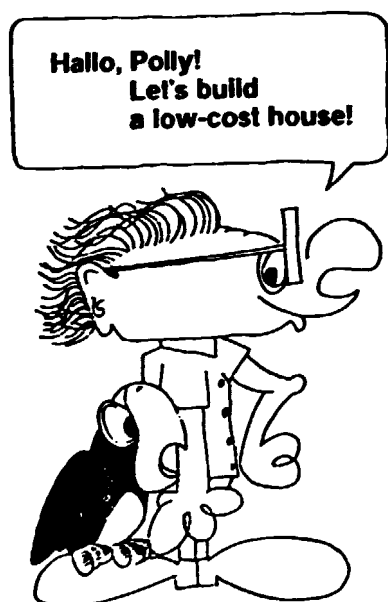
10/ Ibid., p. 220.

- Appropriate design of the housing unit;
- Light-weight, labour intensive construction technology;
- Greater utilization of indigenous building materials;
- Technical assistance to the industries producing building materials; and
- Design of building material standards and building codes appropriate for low-cost shelter.

Note that technological possibilities alone will not lead to low-cost shelter on a massive scale. Public policies and instruments must simultaneously be directed towards the other components of total housing cost, namely land, infrastructure and financing.

As an example of appropriate design, and also simple construction technology, one can mention UNIDO's cartoon-style guide on how to build a low-cost housing unit.^{11/}

Featuring Tony and his diminutive parrot friend, Polly, the Manual was originally prepared by the Instituto de Pesquisas Tecnológicas (IPT) of Sao Paulo, Brazil, for a self-help community building project.



The Manual provides direct and simple assistance to people and communities that want to build their own houses, either individually or on a co-operative basis. Complicated design calculations have been omitted and instructions are straightforward and easy to follow. Any deviations from the plans or types of wood used should be checked with a technical expert.

The Manual is based on an experimental group of 40 houses. The average cost was \$US 49.70 to \$US 59.50 per square metre (as of March 1982), depending on the area, which averaged 40 square metres, and the type of foundation used (stone or ceramic blocks and a cement or wooden floor). All houses were equipped with bathroom built with concrete blocks. The cost included the materials delivered to the construction site and the labour for manufacture and assembly and for masonry, electrical and pipe work. It did not include materials and labour for

painting; electrical, water and sewerage installations; nails and tools; and land acquisition and infrastructure.

The Manual presents a construction system aimed at helping low-income families solve their housing needs in regions that have ample timber. It is divided into two parts. The first part covers the design of the house; quantities of material needed; pre-fabrication and pre-cutting of components; construction; finishing; and adaptations and modifications. The second, and

^{11/} "Popular manual for wooden house construction", UNIDO/ID.330.

major, part is devoted to the actual construction. This includes the layout; erecting piles; laying of the floor frame and boards; erecting the panels; erecting the roof frame; and putting on the roof, and windows and doors.

Although the construction system was conceived and implemented in the Amazon region of Brazil, information on wood species found in Africa and Asia is also included, as are data on the required physical and mechanical characteristics of the wood used in various parts of the house. The Manual should therefore be of use in many regions of Africa, Asia and Latin America.

At present, the Manual is available only in English. However, a Spanish edition is in preparation, and a French version may be issued later. The uniqueness of the cartoon approach is that the format used enables seriously interested parties to reproduce the Manual in their own language by translating the captions and inserting them in the appropriate places. UNIDO is willing to make good originals available to Governments, national bodies or bona fide groups for this purpose.^{12/}

As an example of greater utilization of indigenous building materials one can mention the rather recent recognition that coconut palm wood can be used for light framed structures on a large scale. With this in mind, a recent UNIDO project has worked out several designs for low- and medium-cost housing utilizing coconut palm wood.^{13/} These houses are primarily intended for rural areas, villages and small country towns in the tropical regions. But there is no inherent reason why selected coconut palm wood could not be used for structural or decorative components in higher quality houses or industrial and commercial buildings as well.

Coconut palm wood, as well as other wood and agricultural residues can of course also serve as a source of fuel for the firing of clay bricks and lime for which the mineral raw materials often are readily available. Saw dust or other fibres may be mixed with brick clay, thus facilitating the firing and yielding a better product.

The greater utilization of coconut palm wood has an incidental benefit in that in nearly all coconut growing countries, existing plantations are approaching an over-mature (sterile) stage evidenced by reduced fruit production. The ensuing replantation programmes will result in a large quantity of old palm trees being available for lumber and fuel wood.

The situation is generally similar with the generation of certain wastes that on the one hand represent a cost (namely that of disposal), and on the other hand a potential opportunity in that they could be used beneficially in

12/ Copies of the Manual or of the blank cartoons are available on request, quoting title and document number, from the Editor, UNIDO Newsletter. The decision to supply blank cartoons, however, will rest with the substantive office responsible for the Manual.

13/ See Technical Report: Utilization of coconut palm sawn wood as a light framing structural material. Regional Coconut Wood Training Programme, UNIDO/DP/ID/SER.A/695, May 1986; and Coconut Wood Building in the Asia and Pacific Region, Agro-Industries Branch, UNIDO/IO.628, May 1986. For the utilization of bamboo, soil, ferrocement and other unconventional materials, see Seminario materiales no convencionales para construcciones rurales, Medellin, 12-14 November 1986, Comité de Investigación y Desarrollo Científico, CINDEC, Colombia.

the production of building materials. An example is fly ash available as an industrial waste from coal. This can be used in the production of fly ash cement blocks using patterns familiar from making traditional soil cement blocks. The mix of Portland cement and water with fly ash does not have to be in exact, standardized proportions, compaction is manual, and the wet blocks may be dried in the open sun. The sizes of the blocks can easily be made to conform to traditional block dimensions so that locally produced moulds are easily adapted to the production of the fly ash cement blocks.

In the production of pozzolana cement, fly ash may be replaced by rice husk ash which is easily available where rice is grown. Research has been carried out in a number of centres with the aim of developing the optimum technologies for the preparation of the rice husks and for the subsequent rice husk ash cement production. A UNIDO publication on this subject is available to interested institutions and individuals.^{14/}

Other by-products and wastes usable in construction result in the mining sector, in the production of phosphate, aluminium, cement, and sulfate,^{15/} as well as in agriculture. Brown mud resulting from aluminium production can be used in lieu of clay to yield bricks, wall blocks and glazed floor and wall tiles of acceptable quality.^{16/} Straw has multiple uses as fillers, reinforcers, and material for weaving panels. Branches, chips, mill residues, etc., can be used in various composite panels. Rejects from the timber export business can be used to good effect for small-scale local construction purposes. The possibilities are limited more by imagination and tradition than by technology or economics as countless innovative projects to increase the utilization of by-products and waste around the world has shown.

3.3 Research and technical assistance

The world's reserves of certain building materials, notably forest resources, are continuously declining. Present trends indicate accelerating depletion caused by growing populations and urbanization, shifting agriculture, grazing, natural disasters and, yes, plain mismanagement. Improved and extended management has a central role in achieving increased yield as well as efficiency in the utilization of natural resources without detrimental ecological consequences. Further technological development and increased industrial processing could achieve higher returns from limited resources. In many instances, substitution by other materials is also possible.

Technological research and experimentation have led to numerous local substitutes for imported and/or otherwise costly building materials. A recent innovation is the production of sisal cement roofing sheets as substitutes for galvanized iron sheets or asbestos cement roofing. Although the process is

^{14/} Rice Husk Ash Cement: Their development and applications, November 1984, no symbol.

^{15/} James R. Clifton, Paul W. Brown and Geoffrey Frohndorff, Survey of Uses of Waste Materials in Construction in the United States, NBSIR 77-1244, National Bureau of Standards, Washington, D.C., 20234, July 1977.

^{16/} Feasibility study for the utilization of brown mud of Shandong Aluminum Works as building material; Project No. SI/CPR/84/803; Report to UNIDO, 1985.

simple in principle, it requires care and the use of appropriate tools in order to achieve a desired quality. In particular, the thickness of the final product must be kept within fine tolerances so that the sheets do not place an excessive burden on the bearing structures and thereby ruin the economies of cement roofing. Equally important is keeping the proportions of fibre, portland cement, sand and water correct in order to avoid a product that is brittle and structurally weak.^{17/}

Technical assistance in MAC (Machine Aided Craftsman) technologies to the industries that produce building materials can obviously play a significant role in overcoming shortages in skills and appropriate tools for new building materials. Such assistance can, and does, range from the very simple construction of a jig to ensure that parts that will have to fit together, actually do so (see plate 1) to the more complex design of prefabricated materials for a low-cost housing unit (see plate 2).

Other areas for the technical assistance programme lie in the dissemination and further improvement of new technologies. For example, it would be advantageous to improve the quality of the above mentioned sisal cement product in order to be able to reduce the thickness of the sheets with the consequent reduction in cement and in the load on the roof trusses. In Bhutan a prototype house designed by a UNCHS project (BHU/80/002) has achieved a saving of approximately 57 per cent in the consumption of timber compared to a traditional Bhutan house. Such prudence, without loss of loadbearing strength, also makes the use of relatively heavy roofing materials more economical. In Bhutan, UNIDO has assisted in the traditional production of slate for this purpose and introduced improved mining, transportation and processing methods.

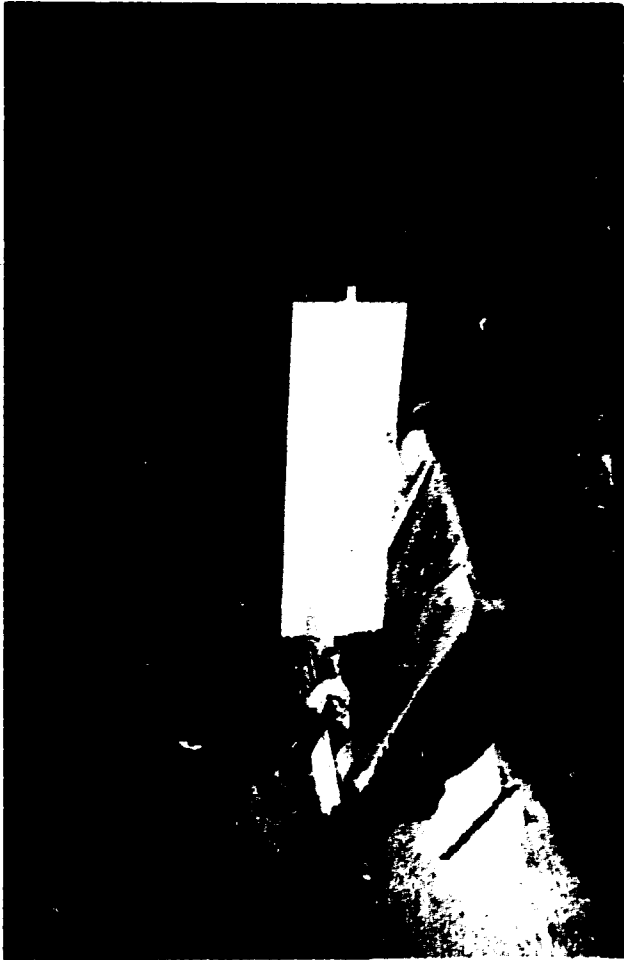
Dissemination of information does not have to do only with new or improved products and technologies. Often it is social prejudices and values that need to be changed to conform better to today's realities.^{18/} For example, in some developing countries the use of timber for residential housing is unnecessarily frowned upon because wooden houses have traditionally been associated with poor people.^{19/} The questions of grading and standardization of building materials are very important for the wider use of certain materials in construction. Present specifications, especially in developing countries, are totally out of keeping with current technology. Local and national building codes are also often outdated and constitute significant obstacles to the greater use of new or non-traditional building materials. Some of these codes and standards are clearly protective of an existing industry and product.^{20/} Clearly, this is not in the interest of low-cost shelter.

^{17/} United Nations Centre for Human Settlements (Habitat), Innovative Building Materials Production and Utilization in Lusaka, Zambia. Project monograph, produced for the International Year of Shelter for the Homeless, January 1986.

^{18/} See, for example, "First world-wide study of the wood and wood-processing industries", Sectoral Studies Series No. 2, UNIDO/IS.398, August 1983, p. 163.

^{19/} This may have had a real justification at some time but with modern preservation techniques, wooden structures can be very durable, indeed.

^{20/} UNIDO/IS.398, op.cit., p. 166.



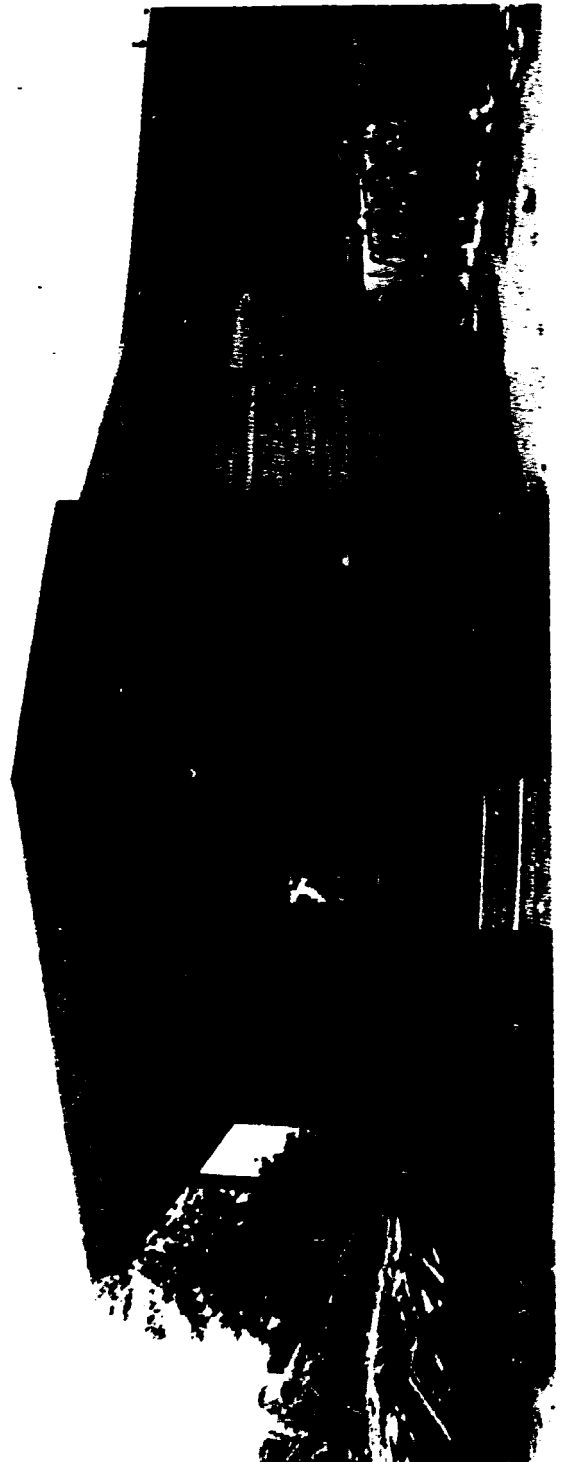


Plate No. 2

3.4 Site and services and other incremental housing schemes

The industrial production of building materials can play a role in alleviating the shelter problems of the poor. Experience shows that the building process of a low income urban house might take up to 20 years, in the course of which the house gradually evolves from a shanty to a dwelling unit that meets regular local housing standards.^{21/} Given adequate access to appropriate building materials, this process if properly managed, could easily evolve into socially acceptable housing. Bulldozing away squatter communities could destroy capital and the foundations for productive living by substantial numbers of families.

So-called site and services and other incremental housing schemes capitalize on the inherent capability of people to construct their own housing. They are respectful of the inhabitants in that they allow them to expand and improve their housing according to their demands and means. The provision of basic services such as water, sewage and roads, in addition to a small plot of land ensures that at least minimum health and safety standards are met. With the ready availability of properly designed and fabricated building materials for at least the foundation and the frame, the families can then erect dwellings that suit their own particular priorities and incomes. Wall panels can be woven and roofs thatched, later perhaps to be replaced by more substantial materials. Demonstration projects and training schemes in the making of simple building materials and in basic construction techniques would be appropriate means for the society and/or international aid organization to assist the low-income people to construct their own dwellings in such a way that they also meet the rightful requirements of the society with respect to community health and fire risks.

Such incremental schemes that capitalize on people's own capabilities and utilize a maximum of indigenous techniques and materials may be the most practical way of housing people on a massive scale. This viewpoint is now gaining wide acceptance both within national schemes (e.g. the Honduran slum upgrading programme) and international contexts (such as the International Year of Shelter for the Homeless). Normative, needs-based housing programmes typically not only vastly exceed the effective demand for housing, but would also tax an economy's total resources to such an extent that little if any would be available for capital investments.

3.5 The public sector

Governments play an important role in shelter schemes. However, government programmes which simply build housing without involving the specific families that will use them are typically the most costly and least satisfactory. Among the problems associated with government programmes which build housing without substantial involvement on the part of the users are: (i) design and construction often fail to reflect users' tastes; (ii) costs per unit of living space tend to be higher; and (iii) it is very easy for such programmes to lead to housing being distributed strictly on the basis of political patronage. Furthermore, grandiose housing schemes conceived on the

21/ Sharing in development, op.cit., p. 217.

basis of need rather than productive capacity may ultimately wind up providing less housing than would a modest programme-based on the active participation of the beneficiaries themselves.^{22/}

One of the most obvious ways for a government to encourage the development of low-cost building materials and appropriate construction technologies is to favour the use of such materials and methods in public sector construction. But there appears to be a number of factors that militate against the adoption of such strategies and policies in many countries. Among these are: (a) a constrained or under-developed domestic supply of building materials based on locally available low-cost raw materials; (b) construction technologies and building standards that favour or require the use of imported, higher technology materials and equipment; (c) inappropriate building codes that favour the status quo; (d) attitudes of architects, engineers, government and other officials, consultants and donor agency representatives who tend to consider the use of indigenous materials and local designs a regressive step, even damaging to national prestige; (e) shortcomings in quality control and lack of standards on part of local materials with a consequent tendency by contractors as well as financiers to specify advanced techniques and elements as a form of assurance; (f) reluctance by donor agencies and central governments to finance local cost, preferring to bias construction projects towards an import and capital-intensive direction; and (g) lack of reliable data on costs and qualities as a basis for economically sound evaluation of local or innovative materials versus more advanced or traditional materials.

These are conditions that are both internal and external to the building materials industry. Some are of a technological nature, some are economic, and some have more to do with the way business is, or has been conducted than anything else. Common to them all is that they all represent real obstacles that need to be removed before the building materials and construction industries can unleash their full potential in contributing to the provision of decent, low-cost shelter for the people of the world.

Regulations, standards and building codes are essential to the orderly development of urban settlements, that is clear. But these edicts ought to reflect the reality of low-cost housing and the continuous evolution of new building materials and the improvement of old ones. The crucial difference between temporary and permanent final structures must be recognized and accommodated in the codes to optimize the use of inexpensive building materials and construction technologies, in particular in self-help shelter construction. The public sector by adopting new techniques and materials in its own construction can be a leader rather than a laggard in this respect.

3.6 The scope for small-scale production of building materials

Very large scale operations have never accounted for the majority of manufacturing operations in advanced countries.^{23/} And the tendency in

22/ See Foreword by Dr. Arcot Ramacharadan, USG, Executive Director, UNCHS (HABITAT), to Shelter for Low Income Communities: Sri Lanka Demonstration Project, Case Study - Part I, UNCHS (HABITAT), 1987.

23/ Optimum scale production in developing countries: a preliminary review of prospects and potentialities in industrial sectors, Sectoral Studies Series No. 12, UNIDO/IS.471, June 1984.

manufacturing today is towards the smaller rather than the larger scale. The construction and building materials industries are no exceptions in this regard; rather the opposite.

A main reason for the recent reduction in enthusiasm for very large scale facilities is that they are generally only efficient when operated at or near design capacity. For a variety of reasons, this is often not the case, especially in developing countries. Furthermore, certain technological developments such as flexible, computer assisted manufacturing allow small and medium scale operations to gain the advantages of automation without the costs and rigidities of large scale production systems. However, far more important in the case of building materials for low-cost shelter, is the recent positive change in the attitude and corresponding policies of governments and donor agencies towards small-scale private entrepreneurship. Combined with the very good potential for creating MAC technologies suitable for small-scale enterprises in the building materials industry, the sector is poised for a major role in raising the living standards of low income groups all over the world, not only through the provision of shelter but also through offering good employment and income opportunities. In many cases the small-scale production of relatively simple building materials like bricks, window frames etc., is particularly well suited for family enterprises, presenting job opportunities for women and men, for adults and youth alike.

Many manufacturing processes in the building materials industry operate at constant returns to scale over a range that includes fairly small plants.^{24/} Building materials resources are usually widely available, and the technologies associated with the industry are flexible enough to allow varying degrees of technological complexity and labour intensity.^{25/}

Semistructural and auxiliary building components and secondary goods fabricated from basic structural materials offer many opportunities for small-scale operations. The informal construction industry in developing nations already possesses a vast pool of relevant knowledge, experience and manpower. Small-scale plants seem especially appealing for non-metallic mineral based building materials such as bricks or tiles. In the developed countries, the costs of making, firing and drying bricks and other heavy clay products decreases only very slowly with increasing capacity.^{26/} In a developing nation, per unit costs may be significantly higher in large scale plants.^{27/}

"Techniques with a high labour content or improved or mechanized techniques for preparing, forming and drying the clay are in some cases more efficient than such highly mechanized or automatic techniques as tunnel kilns and drying".^{28/} Moreover, the costs of mining and transporting the increased

24/ UNIDO/IS.471, op.cit.

25/ For more details see UNIDO/IS.512, pp. 107, ..., 154.

26/ Brickmaking plant: industry profile, Development and Transfer of Technology Series, No. 10 (ID/212), 1978, p. 31.

27/ Sid Boubekeur, Outline of a policy for expertise and technological selection in capital goods for cement and brick manufacturing (ID/WG.425/4), prepared for UNIDO, Vienna, 27 August 1984, p. 47.

28/ Ibid., p. 50.

quantities of clay necessary for the larger plants, and the costs of the fuel and power for the larger kilns, may rise disproportionately with the increase in output; in developing countries especially, the increase in transportation and energy costs could outweigh any savings from productive efficiency even if these existed.

Wood-related industries show essentially no scale economies with regard to the amount of raw material or number of workers. Although production of medium density fibreboard, oriented strandboard, hardboard and comply requires large, capital intensive plants, the production of sawn wood can be a very small-scale operation. Plywood and cement or gypsum fibreboard can be produced with medium scale, labour intensive methods.^{29/} Small cement plants have proven to be feasible and steel minimills have flourished. Since the latter items account for the great majority of wood products used in construction, a small to medium scale wood industry is possible in most developing countries. (In Brazil, for example, only 145 of the nation's 15,058 producers of wood products are large firms, while 994 are medium sized or small firms and 13,919 are very small.)^{30/}

The notion that small cement plants are not feasible may be rooted in the vague idea that only a large plant could produce the major ingredient of massive concrete based construction projects, but the success of small cement plants throughout the world belies this notion. Even with capacities as low as 20,000 metric tons per year, plants have proved economically efficient.

Mini cement plants can be brought on-line in 1 to 1.5 years, as against 4 to 6 years for large scale plants. Upkeep costs for mini plants are low, and much of their equipment (i.e. kilns, silos, sheds and conveyor belts) can be produced locally, stimulating the rural economy.^{31/}

The experience at a pilot limework at Moshaneng, Botswana has shown that with careful planning a low technology option can be used successfully to produce sufficient quality lime at a comparatively low-cost. The advantages of the process are: (a) low capital cost; (b) high return on investment; (c) easy to construct (using locally available materials!), maintain and operate; (d) limestone deposits of insufficient size for large scale production can be utilized economically; (e) no risk of mechanical or electrical breakdown, especially important in remote areas; (f) labour intensive operation; and (g) flexible output that can easily adapt to market conditions.^{32/}

29/ A review of technology and technological development in the wood and wood-processing industry and its implications for developing countries, prepared by the Sectoral Studies Branch, Division for Industrial Studies, Sectoral Working Paper Series No. 8 (UNIDO/IS.413), November 1983, p. 115.

30/ Luiz C.M. Bonilha, The building materials industry in Brazil, a background paper prepared for UNIDO, July 1984, p. 32.

31/ Op.cit. ID/WG.425/4, p. 40.

32/ For details, see "Lime in industrial developments: a UNIDO guide to its uses and manufacture in developing countries", Sectoral Studies Series No. 18, UNIDO/IS.555, August 1985, pp. 51,....,66.

Scale economies in the manufacture of steel bore their fruit during the period of long economic growth when installations were operating at 90 to 100 per cent of capacity. The world crisis in steel made these levels fall consistently until they were below 80 per cent, and in certain European mills below 60 per cent. Since 1977, the ten American "Big Steel" companies have closed, idled, transferred or sold 20 plants or parts of plants.^{33/} Against this background, minimills, which melt scrap in electric furnaces and roll the hot steel into a relatively few products, have flourished. In Italy alone, there are 120 minimills, accounting for more than half the country's output of steel. In 1980, minimills accounted for 46 per cent of the total steel output of Spain, 32 per cent for the United Kingdom, 29 per cent for the Democratic People's Republic of Korea, and 23 per cent for Japan.^{34/} Small rolling mills for concrete reinforcing rods are operating successfully in Tunisia.

Minimills are not a marginal phenomenon, but an important and lasting development in the iron and steel industry. In America, their number has increased from the 10 or 12 minimills sharing 2 per cent of the steel market in 1960, to the 50 minimills which accounted for 15-18 per cent of the market at the start of 1984, and experts predict this market share will rise to 24 per cent by 1990 as innovations in minimill technology bring down production costs and improve product quality.^{35/}

3.6.1 The question of raw materials

The distribution of natural resources necessary for the building materials industry is widespread enough to allow for a system of small-scale plants. Clays suitable for brickmaking can be readily found nearly everywhere in the world. The ingredients of cement are available at low-cost in nearly all regions, and where the ingredients of Portland cement are scarce, blended cements based on industrial and agricultural wastes may be substituted in many construction projects - at lower cost. Deposits of gypsum are scattered throughout the world; recently, it is being made available as a byproduct of fertilizer manufacture in many parts of the world. For wood based building materials, small-scale logging and processing operations are feasible in many developing countries.

For the manufacture of a range of building materials the availability of economical fuel resources is essential. In areas where neither conventional fuels nor agricultural wastes are at the disposal of the industry, bricks, for instance, will have to be replaced by unfired materials including stabilized soil blocks. It is also in such areas that a material like marble, which normally is regarded as a luxury material can play the role of a low-cost building material in the form of wall blocks and floor tiles, provided it is efficiently quarried and processed. The same applies to sand stone and tuff which lend themselves well to block cutting by mechanical as well as manual means. These materials have been successfully promoted by various UNIDO projects.

^{33/} Robert J. Miller, "Steel minimills", Scientific American, May 1984, p. 33.

^{34/} Op.cit., UNIDO/IS.471, p. 21.

^{35/} Op.cit., UNIDO/IS.512, p. 114.

The resources necessary for the production of steel are not as easily found as those for other building materials. Only 30 per cent of the world's known deposits of iron ore are in developing countries and only 5.2 per cent of the world's supply of high-quality coking coal. But even without domestic supplies of the most common raw materials, a country can develop a steel industry, as long as it does not view large, integrated mills with coke fuelled blast furnaces as its only option. The discussion on mini mills has opened up entirely new perspectives in this respect.^{36/}

3.6.2 Factor and technology combinations

The building materials industry adopts to a wide range of raw materials and technologies. This not only allows plants to exist within a wide range of sizes, levels of technological complexity and ratios of labour to capital, but also to remain profitable by adapting to changes in the economy. In many instances a continuum of choices for the pairing of plant size and technological complexity is possible.

At the small-scale, simple technology end of the spectrum, the extent and success of the informal sector of the construction industry proves that untrained, self employed builders relying on indigenous materials, traditional methods and ingenuity can provide housing for a large number of people. This sector is believed to be responsible for a large share of housing in developing countries - perhaps half the homes in urban Egypt, perhaps 90 per cent in Honduras.^{37/} The further development and deployment of MAC (Machine Aided Craftsman) technologies where machines and tools are specifically designed for and around the skilled craftsman, can improve immensely productivity and quality in the manufacturing of appropriate building materials. This would also require only minimal capital.^{38/}

A single worker with a good supply of clay can handcraft, fire and market enough bricks for a small business to be viable. Firing can be done in a hollow mound by lighting a fire inside, using wood or agricultural waste as fuel. At slightly more elaborate levels, a brickmaker might build a more permanent kiln, or stove, with outer walls of mud covered bricks. In villages and towns with rudimentary industrial facilities, these or slightly more complex methods might be sufficient. In cities, large and dense markets might justify investment in a modern factory with a tunnel kiln costing hundreds of thousands of dollars but able to produce 60 tons of bricks per day.

36/ See e.g. Mini-mills: the way ahead. Proceedings of the Metal Bulletin's Second International Mini Mills Conference, Vienna, 1982 and Techno-economic considerations for the establishment of a steel industry based on the direct reduction technology for sponge-iron production, prepared by UNIDO (ECE document STEEL/SEM.9/R.31), 1983.

37/ International Labour Office, Informal sector employment in Egypt, prepared by Mahmoud Abdel-Fadil, Geneva, 1980, p. 31.

38/ Thus, for example, a HABITAT project in Malawi has developed an alternative to iron sheets for roofing called sand-cement tiles. These can be manufactured as a cottage industry using a craftsman's tool kit obtainable for \$US 300. See report in IYSH-1987 Bulletin, Number 8, February 1987, p. 11.

In the past 20 years, new tools, such as integrated multiband saws and chippers and new cutting knives have led to greater yields from raw wood. New methods that can break down the wood into strands, scrim and wafers have made products such as processed boards possible. Microcomputers have allowed for the increased automation of processing plants and the scanning and sorting of diverse species of trees to allocate them more efficiently to end uses. Small sawmills producing lumber for local consumption are also widely used. Researchers in Australia have recently developed two types of kilns which are transportable, inexpensive and designed to suit the needs and limitations of small-scale sawmills in developing nations. Both kilns run on cheap, locally available fuels.^{39/} Small-scale production of processed boards is possible, with only a few workers needed to cast the boards on flat concrete tables and roll in vegetable fibres during setting. Although such cement and gypsum based boards are too heavy for cheap transport, they can be ideal for local use as internal and external linings and flooring. The quality of their finish can be high, and the inert matrix makes them resistant to fire, decay and biological attack. Between technological extremes are processes such as the production of wood wool, wood-cement particle boards and wood-fibre cement, which use a mixture of simple and more complex technologies. Table 9 is a summary of the technological considerations a developing country might take into account when deciding which domestic wood industries to encourage.

The manufacture of steel is inherently more complex than that of other building materials, but more leeway is possible than is commonly believed. A mill that uses scrap as its raw material can ignore the difficulties of ore reduction and the creation of intermediate products such as pig iron, while a mill that limits its mix of final products to rods and bars can eliminate the need for elaborate casting and shaping machinery. But this doesn't mean that minimills must limit themselves to simple or old-fashioned methods. Free of the need to spend vast amounts of money to build and maintain the facilities of an integrated plant, a minimill can more easily invest in modern equipment for the steps of steel manufacture within its domain.^{40/}

3.6.3 Labour-capital substitution

Most building materials can be manufactured using a wide variety of processes, from quite capital intensive to very labour intensive. The richness of potential production methods increases the potential for entrepreneurial activities in the sector and enables producers to innovate in ways which make the best use of the resources, viz. technology, labour, natural resources, and capital. In the building materials industry, labour intensity is especially high in the informal sector. Estimates performed across the building materials industries of many developed and developing nations and within various countries across wide time spans provide convincing evidence that labour and capital are highly interchangeable in the face of differentials in factor prices.^{41/}

39/ UNIDO/IS.413, op.cit., p. 26-27.

40/ Robert J. Miller, op.cit., p. 34.

41/ David Wheeler, The economics of the building materials industry in developing countries, Center for Construction Research and Education, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1982, p. 72.

Table 9. Technological considerations for developing countries

Aspect	Sawn wood Sawmill	Plywood	Fibre board hardboard	Medium density fibre board	Particle board	Wafer board	Strand board	Cement particle board	Cement fibre board	Gypsum fibre board	Kiln dryer for sec processing
Wood raw material yield	40-50%	30-50%	85%	90%	90%	85%	85%	90%	90%	90%	
Suitability for developing countries	Simple	Simple	Wet batch. Simple Wet cont. Inter dry-advanced	Advanced	Suitable most developing countries	Suitable most developing countries	Advanced	Suitable most	Simple all	Simple all	Yes
Maintainability of plant	Simple	Simple	Medium-sophisticated	Sophisticated	Medium	Medium	Sophisticated	Medium	Very simple	Very simple	Simple
Industrial infrastructure required	Simple	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Very simple	Very simple	Simple
Operation of process	One shift possible	One shift possible	Continuous except batch	Continuous	Continuous	Continuous	Continuous	Continuous	One shift simple	One shift simple	One shift or continuous
Min. econom capacity	Varies	m ³ /day	m ³ /day	m ³ /day	m ³ /day	m ³ /day	High	m ³ /day	Low	Low	m ³ /day 5-10 or less
Local market Export		20 120	15-20 70	75-100 200	30-40 200	30-40 200		20-30 50			
Energy Fuel (heating)	Low None	Medium Medium	High High	Higher High	Medium Medium	Medium Medium	Medium Medium	Medium Medium	V. low	V. low	High
Water		Small	Wet high Dry small	Small	Small	Small	Small	Medium	Low	Low	
Ecological considerations	Small	Medium problem	Wet serious dry medium	Medium	Medium	Medium	Medium	Low	Nil	Nil	Small

Source: A review of technology and technological development in the wood and wood-processing industry and its implications for developing countries, Sectoral Working Paper Series No. 8, UNIDO/IS.413, 1983.

For instance, casting from ingots is much more labour intensive than continuous casting, and so may be economically preferable for steel plants in developing nations. Separate melting and rolling facilities also may help steel mills weather market fluctuations more efficiently by allowing them to use their full melting capacities during slack times to create stockpiles of ingots, which can be rolled during times of peak demand.^{42/}

Brickmaking may be accomplished almost entirely by hand. In developed countries, winning clay through manual labour is profitable for outputs up to 14,000 bricks per day. In developing countries, it would be profitable at much higher levels. Evidence shows that teaching workers to use their shovels more efficiently and offering financial incentives for increased productivity may be more cost-effective than investing in clay-winning machines.^{43/}

Arguments have been presented, that uncertainties as to the quality of handmade cement may lead engineers to prescribe more concrete in building projects or reinforce it with more costly materials.^{44/} Yet high-grade cement may be superfluous for many local building projects, and a study of the Mexican cement industry showed that the effectiveness of quality control can be independent of production technology.^{45/} India and several other developing nations have been exploring alternatives to costly on-line instrumentation controls of quality.^{46/} Though the manpower per ton of output is two to three times greater in mini cement plants than in large plants, the quality of cement produced in India's mini plants rivals that produced in its giant rotary kiln plants. The single unit design and compact size of the vertical kiln plant at Dalmiapuram has facilitated production efficiency and quality control; a single superintendent in an elevated office can supervise nearly all the operations in the factory.

3.6.4 Mobility

Mobile plants may allow factory owners to remain competitive by moving their plants when sources of raw materials are depleted or the construction needs of a small market are met. Workers with cranes can dismantle a complete vertical kiln cement plant, which weighs less than 200 tons, reconstruct it at

42/ UNIDO/IS.471, op.cit., p. 21.

43/ Brickmaking plant: Industry profile, Development and Transfer of Technology Series No. 10 (ID/212), 1978, p. 7, and René Urien, "Alternative strategies for building material industries in developing countries", ECO No. 83-16, Centre Scientifique et Technique du Bâtiment, Paris, 4 May 1983, p. 39-40.

44/ The building materials industry in the ESCAP region, Economic and Social Commission for Asia and the Pacific (ESCAP), Working Paper prepared for UNIDO, Bangkok, 1984, p. 9.

45/ Ruth Pearson, The Mexican cement industry: technology market structure and growth, Working paper No. 11, prepared for ECLAC, Buenos Aires, September 1977.

46/ Fred Moavenzadeh, "Global prospects for concrete production", Concrete International, February 1984, p. 30.

another site and have it ready to resume production within a month.^{47/} Field plants to produce concrete precastings on-site and then be relocated when a construction project is finished are now available; manufacturers have sold several in the Middle East.^{48/} Engineers have developed a mobile lime-burner which combines the advantages of shaft and rotary kilns and is able to process limestone of many grain sizes into 20 tons of high-quality lime per day.^{49/} Mobile sawmills have long been available and have been used successfully in both developed and developing countries.

For regions where a dispersed population would make a permanent brick-making plant unprofitable, a mobile forming plant has been invented which can produce a respectable 1,000-15,000 bricks per hour.^{50/} With respect to Africa, special initiatives have been taken by UNIDO. The population living in rural areas has only very limited access to load bearing bricks. The mere cost of transporting bricks to the point of use would raise the end price to an unacceptable level and the local market is still not sufficient to justify a production on the spot. A UNIDO project initiated in 1984 has introduced a mobile mechanized brickmaking plant. The production unit is composed of traditional brickmaking equipment and has a capacity of 1,000-1,500 bricks per hour. It is mounted on a trailer which makes it possible to tow it from one place to the other depending on the demand. The project will allow a realistic assessment of the potential role of this type of unit in satisfying the requirements of rural areas for high quality bricks.

3.6.5 Product mix

Entrants into the building materials industry also should have little trouble finding a product mix compatible with their resources and the needs of the local market, or altering this mix as conditions change. There exists a wide range of possible wood products. Although wafer boards, strandboards and medium-density fibreboards may now be beyond the technological capabilities of many developing nations, as supplies of common species of trees decline and a familiarity with more modern wood production methods and equipment grows, these products may become more attractive to manufacturers in developing countries. Even bricks can come in a surprising assortment of sizes, strengths, compositions, perforation patterns and shapes, suited to a variety of construction needs. And, with minimum additional investment, the production can be extended to the making of roofing tiles, floor tiles, drainage pipes and so on. Ferrocement, a highly versatile form of reinforced concrete made of wire mesh, water and cement, is a building material with great promise for houses, boats, barns and factory components. Relatively easy to make and light to transport, ferrocement panels nonetheless are strong, mouldable, inexpensive, and resistant to corrosion, compression, tension, bending, stresses and water. Not only are ferrocement panels valuable as the basic

47/ N. Ramachandran, "World's smallest cement plant", Rock Products, May 1967, p. 76.

48/ Fred Moavenzadeh, op.cit., February 1984, p. 31.

49/ Hungarian building and production technologies for transfer to developing countries, prepared by G. Kunszt and T. Mezos, 1983 (Microfiche), p. 23.

50/ Op.cit., ID/WG.425/4.

components of housing, but especially in hot, dry climates, they may alleviate the shortage of roofing material. The lack of low-cost, durable roofing is the single greatest obstacle to building low-cost housing in developing countries where roofing can represent 50 per cent of the total cost of a simple home. Yet the raw materials of ferrocement are available in most countries, its production is labour intensive, and the skills involved are easily acquired and include many methods already common in the informal sector.^{51/}

An interesting and often economically attractive way of expanding the product range of a given production of building materials is to utilize its waste material. A good example is the marble industry where the often substantial quantities of waste marble, after appropriate crushing and grading, can serve as aggregate in terrazzo products (marble chips in a (white) cement matrix). This is an ideal low-cost material for floor tiles and for sanitary ware.

3.7 Characteristics of the informal production of building materials

The importance of the informal construction sector in providing shelter and commercial structures for the urban poor has been recognized for more than a decade. The urbanization of the developing world brought many traditional industries to the cities. Since the formal construction sector was hard-pressed to provide shelter for so many new inhabitants, the migrants continued to rely on the methods of the village. Were these methods still to be called traditional? Or could they now be defined as informal, in contrast to the methods of the formal urban market? As the inhabitants of squatters' settlements adapted traditional techniques to urban conditions, improving them with materials and methods from the formal urban sector, the lines of distinction blurred further.

If the definition of the informal construction industry is murky, the outlines of its subsector, the informal building materials industry, are even fuzzier. In theoretical discussions and studies, this subsector is rarely treated apart from its parent sector.^{52/}

The relationship between the informal building materials industry and other sectors of the economy is not simple. The informal construction industry, for example, does not rely solely on building materials produced in the informal sector; builders may buy, scavenge or steal materials produced by formal manufacturers. Similarly, construction firms in the formal sector may buy materials from informal producers to save money, to obtain products for which no formal substitutes exist, or to evade taxes or labour regulations.

The relationship between the formal and informal building materials industries is also somewhat arbitrary. Firms in both sectors may use the same production factors, and these inputs may come from either the formal or informal market. Both sectors may labour under similar constraints, and both may claim similar linkages to the rest of the economy. Nonetheless, a broad

51/ Roofing in developing countries: research for new technologies, National Academy of Sciences (NAS), Washington, D.C., 1974, p. 45.

52/ Small-scale building materials production in the context of the informal economy, United Nations Centre for Human Settlements (UNCHS), Nairobi, Kenya, 1984.

distinction in terms of final products has been proposed,^{53/} with the manufacture of glass, cement, nails, asphalt, steel and plastics limited to the formal sector, and the manufacture of lime, pozzolana, bricks, tiles, concrete blocks, thatch roofing, stone and fibercement relegated to the informal sector. But this is confusing, since the formal sector may also produce items from the second set. Nor is it accurate to classify the informal sector by the number of employees in each firm: though the average firm in this sector employs few people, a formal, capital-intensive operation may employ even fewer. Again, most researchers have resorted to an operational definition in the form of a list of traits typical of informal producers: small number of employees, small volume of output, low capital investment, reliance on locally available raw materials, and local markets whose conditions fluctuate widely.^{54/}

Irrespective of its exact definition, or lack thereof, the informal construction sector is not an anomaly of developing countries. It is pervasive in even the most industrial nations, though its nature may vary with national income. Few houses in developed nations are built entirely by workers from the informal sector; instead, most informal activity is confined to maintenance or home improvement.

In developing countries, where the formal sector is less well-entrenched, the informal production of building materials is more widespread. Studies reveal that entry into the informal market is relatively easy. The average firm employs two people and is small enough that the owner's managerial instincts are sufficient to run it. Training is acquired through on-the-job training, apprenticeship and skills passed down from older relatives; and methods are adapted from traditional practices.

Wages for employees in the informal building materials sector are generally lower than the national minimum wage, but higher than the average wage for agricultural labourers. Owners tend to earn more than the minimum wage, and since many employees are members of the owner's family, they may be receiving greater returns from their work than their wages would indicate.^{55/}

Informal production requires low capital investment and it is labour intensive. Land for workshops may be obtained by squatting rather than purchase. or a plant may be located in a house or a backyard. Financing is more likely to come from moneylenders or family donations than from banks.

53/ Ibid., p. 7.

54/ Ibid., p. 6.

55/ Small-scale building materials production in the context of the informal economy, United Nations Centre for Human Settlements (UNCHS), Nairobi, Kenya, 1984; Caroline Moser and Judith Marsie-Hazen, A survey of empirical studies in industrial and manufacturing activities in the informal sector in the developing countries (UNIDO/IS.470), prepared for the Global and Conceptual Studies Branch, Division for Industrial Studies, 23 May 1984; and Mahmoud Abdel-Fadil, Informal sector employment in Egypt, International Labour Office, Geneva, 1980.

Machinery is likely to be manufactured locally and repaired with ingenuity and scavenged parts. Transportation of raw materials and finished products is by low-cost vehicles, such as animal drawn carts. Informal sector producers use virtually no foreign exchange in their inputs, as opposed to the 10 per cent of inputs in modern, medium scale units and the 40-80 per cent in plants that make asbestos-cement and galvanized iron.^{56/}

The combination of factors in the informal sector results in a lower productivity per worker than in the formal sector but a typically higher ratio of output to capital. Statistics specifically related to the productivity of the informal building materials sectors are rare, but it has been estimated that one million Kenyan shillings invested in the informal manufacturing sector of Nairobi would create jobs for 5,500 workers and produce 2,250,000 shillings of output, while the same amount invested in the formal sector would employ 500 people and produce only 744,000 shillings of output.^{57/}

56/ UNIDO/IS.470, op.cit., p. 127.

57/ UNCHS, op.cit., p. 15.

4. THE PARTICIPATION OF WOMEN IN THE CONSTRUCTION AND PRODUCTION OF BUILDING MATERIALS

Throughout history, in all cultures women have played a central role in matters concerning housing. Among other things this entails the supplying of professional, skilled and unskilled labour for construction and the production of various materials for construction, woven panels, thatched roofs, brickmaking etc. Carpentry is increasingly done by women. In some countries, the majority of the construction workers are women.

It was noted in the previous section that especially the small-scale production of building materials offers equal opportunities to men and women. This is particularly so when the activity takes place in or near the home, allowing other essential functions to be carried out at the same time. Similarly, the incremental adding-on or improvement of a housing unit is well suited to family members that have other main household chore responsibilities.

An advisory seminar on women and shelter, sponsored by the Centre for Social Development and Humanitarian Affairs and Habitat, held in Vienna in December 1985 noted that, with a few exceptions, governments do not deal adequately with women in shelter projects. A specific focus on women is missing and there is insufficient conceptualization of women's issues in the context of housing development. Finally, it was noted, that the theme of women and shelter is not a popular research topic with scholars, institutes and universities.

Measures that governments can take to increase the participation of women in the production of building materials include:

- (a) Making sure that contracting for public works do not discriminate against small-scale operators, or women led/owned enterprises;
- (b) Securing women's access to guaranteed loans and other financing to small businesses;
- (c) Offering guidelines for obtaining financing from commercial sources, and for running a business;
- (d) Offering assistance in the selection of equipment and production methods, especially for the provision of shelter;
- (e) Conducting research and development of building materials suited for small-scale production, and based on local raw materials;
- (f) Conducting specific training in building trade occupations and making sure that women, too, get access to such training;
- (g) Keeping building codes and other regulations up-to-date; and
- (h) Understanding the dynamics of the informal sector, squatting, and incremental housing in order to channel the energy into socially beneficial development of individuals and families.

5. RECOMMENDATIONS TO ENHANCE THE UTILIZATION OF LOCALLY AVAILABLE AND PRODUCED MATERIALS

The single unifying conclusion to the analyses carried out in this paper can be stated simply:

Any meaningful strategy for the provision of low-cost shelter must include a resolute shifting of present housing production methods to a more intensive use of indigenous resources and to a more labour intensive basis.

Supporting only one of several manufactures which together make up the total building materials industry in a country has only limited effect on the low-cost housing sector. The coordinated promotion of a full range of compatible materials to be produced in the required quantities is the ideal way of assisting a national building materials industry. Likewise, to support only the construction of housing units (and infrastructure) without due attention to the adequate supply of appropriate building materials cannot lead to optimal results.

5.1 Prices

Any builder will choose his materials in such a way that the ratio of value to price will be optimal. Especially in low-cost shelter construction, the cheapest material to fulfil a given function will be chosen. Prices for alternative building materials therefore govern or even determine the choice of material, frequently between that of an imported or a local product. Hence, market prices should be allowed to reflect freely the economic costs and benefits of a given building material in order to optimize resource allocations. In many developing countries this often implies that foreign exchange rates must be neither under- nor overvalued. Undervaluation will lead to prices for imported materials that are unduly low in comparison to domestic products. Overvaluation again leads to the export markets being too lucrative and eventually to price increases and possibly shortages on the domestic markets. Neither situation is desirable from the point of view of providing low-cost shelter for the homeless.

Tariffs and other trade barriers work against the interests of those in need of housing. A 50 per cent tariff on imported bricks, for example, means that a domestic producer may without undue fear of price competition charge for his products up to 49 per cent more than what the imported bricks would cost without the tariff. This, in turn, will have both income and substitution effects on the domestic consumer of bricks - the homeless among others. The customary argument about the necessity of trade barriers to protect the domestic industry carries precious little weight in the case of building materials for low-cost housing. Most, if not all such materials can be competitively produced from local raw materials. Care, however, has to be taken that the domestic producers are not penalized through unduly high prices for their inputs.

In public sector construction, high priority should be given to shadow pricing to reflect social costs and benefits of different building materials and alternative construction technologies. For investments within the public sector there should be no real problems in enforcing choices for which the social benefit is greater than market profitability.

5.2 The role of the private sector

In most societies, the great majority of all housing has always been provided through the private sector, either in the form of owned or rented units.^{58/} Few countries could, or would, change this at least as far as middle and upper income housing is concerned.^{59/} Often the problem with low income shelter, however, is that the incomes of these people simply do not suffice for housing units of a socially acceptable standard on the private market. Nevertheless, and especially in building materials, the private sector can and must play an active role in alleviating distressed housing markets.^{60/} Some public programmes go as far as making it a condition that there is a certain amount of self-help enterprise in the form of the collection or production of building materials.^{61/}

Site and services schemes and other incremental programmes to which family initiative and private entrepreneurship can contribute significantly are very effective. This approach is very flexible, adjusting itself readily to each individual family's income and demands. It also offers a viable opportunity for self-help, allowing variable participation by unskilled family members, small contractors and jobbers.^{62/} The proper role of outside assistance is mainly in securing adequate land and infrastructure, in particular water and sanitation.^{63/} Of course, in so doing preference should be given to domestic building materials and local producers, unless there are compelling technical and/or economic reasons to utilize other materials.

The private sector can also assist by raising and channelling financing for the production of low-cost building materials and the construction of housing. This takes many forms. Most important is self-financing generated through small-scale entrepreneurship and employment, both at home and abroad.^{64/} Other significant forms are assistance programmes by NGO's, charity drives, and short term financing through village money lenders. Longer term, private source lending may be available through donor agencies, directly or indirectly through the government. For example, under the Housing

^{58/} See, e.g. Robson, D.G., Aided self-help housing in Sri Lanka 1977 to 1982. A report prepared for the Overseas Development Administration of the United Kingdom (undated), p. 27.

^{59/} Sri Lanka, Urban Sector Report, World Bank, 1984, p. 52.

^{60/} NHDA/MIT, Reading the village: Kanhidigama builds under the Million Houses Programme (Rodrigo Brana and Caroline Clarke, NHDA/MIT Joint Research Programme), 1984, p.1.

^{61/} Housing in Sri Lanka, Murga Research Institute, 1976, p. 167.

^{62/} Sharing in Development, op.cit. p. 223, and Marni Pigott, The Formulation and Implementation of Housing Policy in Sri Lanka: The origin and implications of the "Million Houses Programme", ILO Sectoral Activities Programme Working Paper, Geneva, 1986, p. 68; also see section 3.6 above.

^{63/} See Shelter for low income communities, op.cit., especially p. 21.

^{64/} Marni Pigott, op.cit. pps. 68 and 69.

Guarantee Loan Programme of the US AID, the US Government underwrites long term financing (30 years) for low income housing programmes by private sector lenders in the USA.^{65/} Technical assistance and training is provided to support the programme. Such programmes should be geared towards the mutual objectives of providing, not only shelter but also income and employment opportunities in the local building materials and construction industries.

Any increased housing construction programme will create an accelerated increase in the demand for construction labour and material. Training, therefore, is important to avoid local bottlenecks with ensuing shortages, increasing prices, and growing imports. A particularly interesting practice for the private sector in this context is the tradition in Sri Lanka whereby "the builder family employs a master craftsman with the family providing the unskilled labour in the building process. Very often one of the family members works as an "understudy" to the master craftsman. This method of imparting skills is traditional, and the skills acquired in the process vary from village to village, depending on indigenous techniques."^{66/} The value of this process should be internationally recognized and institutionalized in many places.

5.3 The role of the public sector

Typically central and local government and their various agencies - collectively referred to as the public sector - is one of the largest builders in most any economy. Therefore, the public sector can have a large and very direct impact on the domestic building materials industry through its own construction activity. However, recent experience shows that best results are achieved when the government assumes a supportive rather than participatory or direct role in the provision of housing.^{67/}

Governments can provide a secure market for the products of the small-scale and informal sector. This could be done especially easily in rural areas where much of non-governmental construction is carried out with unconventional building materials typically supplied by the informal sector. It should be stressed that such a scheme needs to closely match price with value. There is no particular reason to expect that it would be in the over-all interest of economic development to pay a value in excess of what the materials are worth. The main advantage to the particular producers who win such contracts would be the opportunity to concentrate on improving production techniques and upgrading equipment. This would be facilitated by eliminating from the investment decision the uncertainty of marketing the anticipated increase in output which the investment would be expected to bring about. Such a reduction in uncertainty would also assist in obtaining financing.^{68/}

^{65/} In 1981 the Government of Sri Lanka and US AID agreed to a multi-year \$US 100 million housing guaranty programme. Marni Pigott, op.cit. p. 70.

^{66/} Ibid. p.74, 75.

^{67/} See Shelter for low income communities, op.cit., p. 21.

^{68/} UNIDO/IS.512, op.cit. p. 165.

Where the viability of low-cost domestic building materials has been proven, the relevant clauses should be drafted for insertion in the specifications of construction contracts, requiring that such alternatives be examined and used where appropriate. Manuals should be prepared reviewing alternative techniques. Tender and contract documents must be easy to understand and answer.^{69/}

Governments should resist the insistence by external aid donor agencies on criteria favouring the choice of inappropriate techniques. Included in the terms of reference for expatriate and local consultant firms in civil engineering and public works should be directives requiring feasibility studies and work specifications to consider domestic, locally produced building materials.

The competence and autonomy of provincial and other local administrations should be accentuated. Co-ordination among agencies operating public works programmes in rural areas and small towns should be intensified. Local people must be more deeply involved in deciding upon and carrying out their own community infrastructure and shelter works. Groups of villages and towns or urban districts could consider larger projects; when approved, they could be financed partly through central government support and partly by voluntary contributions from the communities in the form of cash, labour or materials.^{70/}

Regarding unconventional building materials, once it is clear how they can be effectively used in government construction, consideration could be given to subsidized demonstration projects. However, such projects are appropriate only in non-experimental situations. Demonstration projects are not the same as prototypes and have a different role to play. While the simple fact that the government is regularly using certain materials for its own construction tends to improve the standing of the materials in the opinion of many potential customers, there are instances where such use has been premature and in fact produced the opposite of the intended effects.^{71/}

Support to existing industries goes hand in hand with the establishment of new ones based on indigenous product development. This might take place in a building materials development centre, either public or private. Such a centre could be given the responsibility for testing new materials and finished products, setting quality standards to ensure acceptance by the construction sector of all products, including new ones. Prototype development for the appropriate application of new materials and products in low-cost housing could also be on the agenda of such a centre. The focus should be on the production of structural elements, windows and doors, water and sanitation equipment, and electrical installations.

Building codes and regulations determine the choice of materials and construction techniques. They should be revised to suit low-cost housing programmes based on the use of indigenous materials and techniques.

69/ First Consultation on the Building Materials Industry, Athens, Greece, March 1985. Report, UNIDO/ID.335, p. 12.

70/ For very similar recommendations vis-a-vis labour intensive construction techniques, see *Sharing in Development*, *op.cit.* pp. 223-224.

71/ UNIDO/IS.512, *op.cit.*, p. 166.

The demand for housing should be invigorated. This entails public policies to stimulate both private and public saving that, in many developing countries, are subnormal owing to a low rate interest policy combined with inflationary expectations. Allowing interest rates to increase, undoubtedly raises the availability of institutional credit for housing purposes,^{72/} albeit at somewhat higher rates to borrowers than presently. At the same time, an endeavour should be made to foster - or create, as the case may be - a market for primary and secondary mortgages. The increased demand for housing would act as a desirable stimulant for local producers of building materials, builders and contractors.

Prohibitively high costs of land can easily be characterized as an important constraint upon low-cost urban housing.^{73/} The problem is aggravated by land speculation. National and local government purchases of land, and the subsequent lease thereof in accordance with long term city and regional plans, should be used to counter such tendencies and to invigorate housing demand in urban areas. Land taxes, which will make land speculation less attractive, should also be used vigorously. In many central cities, the situation is perhaps not so bad since the Government owns land in the city itself which is either vacant or can be made available for housing through the relocation of some activities in the suburbs or in the regions. This alternative is preferable to the relocation of squatters. In general, it can be said that in order to relocate and economically upgrade existing poor urban shelter developments, and to prevent further concentration in the big urban centres which would inevitably provoke further growth of squatter communities, a dispersion of economic opportunities is needed.

5.4 Resource utilization

Indigenous resources for building materials are relatively little utilized in many regions of the world. Or where the use is high, it is mainly for non-industrial use. Thus, UNIDO's strategy for promoting an indigenous building materials industry is in most cases based on the local availability of raw materials such as clay, limestone, laterite, wood, stone and so on.

Many resources are under-utilized mainly because they are presently commercially less accepted. This is, for instance, the case of clay for bricks and adobe blocks where concrete is presently used. Wood provides another example. Where the reason for the low utilization is mainly low product quality or inappropriate technology, the remedy lies in developing proper standards and quality controls. Here manufacturers' associations and trade organizations can do a great deal by promoting unconventional products through recognized quality assurance schemes. In disseminating information about indigenous timber, particular attention must be paid to terminology and names of materials as they can vary significantly for the same material or species, from one part of a country to another. Illustrated, simple manuals and booklets together with actual demonstrations can be especially important in this context.^{74/}

72/ Ibid, p. 13.

73/ See also Shelter for low income communities, op.cit., p. 23.

74/ UNIDO/IS.512, op.cit., p. 13.

Only a limited part of the world's forest resources is under active forest management. Improved and extended forest management has a central role in achieving increased yield as well as efficiency in the utilization of forest resources.^{75/} National geological surveys are important in ensuring that domestic non-metallic mineral resource endowments are effectively utilized.

5.5 Organization of production

The ninth session of the Commission on Human Settlements, held last year in Istanbul, made the following statement (summary):^{76/}

- (1) The scale of production units for the manufacture of building materials should be appropriate to the size of the community, its resources and skills.
- (2) The technology should be easily understood and managed by people with no previous training.
- (3) The raw materials should, as far as possible, be available locally.
- (4) The finished product can be afforded by those who need it.
- (5) Management and control of the production unit should be locally based.

A rather similar conclusion had been reached by UNIDO a few years earlier:

"The constraints in developing the wood and wood processing industry in the developing countries are mainly related to the availability of skilled labour, operators and supervisors, availability of equipment adapted to local conditions, poor quality of products produced, low productivity, trade barriers, and difficulties in gaining acceptance for secondary or commercially less accepted species.", and

"Developing countries need technical assistance for the evaluation and selection of appropriate technology. The level of technology must be appropriate not only to the type and scale of production, but also to the local resource endowments, infrastructure, capital, labour and management skills and maintenance possibilities."^{77/}

To the above list of organizational dictates, one should add

- (6) Product design and production engineering is integrated through information flows with business systems such as sales planning, production planning and control.

^{75/} UNIDO/IS.398, op.cit., p. 172.

^{76/} NGO News on human settlements No.2, 1986, p.2.

^{77/} UNIDO/IS.398, op.cit., p. 174 and 176.

- (7) The manufacturing should be flexible enough to meet varying demands which, in the developing countries, typically means more skills than machines. MAC (Machine Aided Craftsman) technologies should receive wider attention and application in the building materials (and construction) industries.

Many necessary improvements have been identified. In the wood sector, material handling, standardization, grading, machining, glueing and finishing technology, drying, preservation and industrial engineering can be mentioned.^{78/} In the non-metallic mineral based industries a similar set of problems is prevailing. For manual small-scale brickmakers, centralized extraneous service and support in areas such as clay exploration and testing, product diversification, energy management and training is essential to maintain competitiveness. Co-operative clay winning, fuel procurement and firing may also consolidate the position of small-scale brick yards, introduced in an effort to decentralize the manufacture of building materials.

Whereas economies of scale in the production of simple building materials are not always predominant, they do play a role when it comes to repair and maintenance, marketing and other types of specialist services. Co-operation between enterprises or between countries is one way of making such services available and to reduce their unit costs. However, maximum division of labour may not lead to the most optimum allocation of resources under realistic conditions in the developing countries.

5.6 Research and information

A first step in a programme to increase the use of indigenous, low-cost building materials and native designs is to validate the merits of any proposal with respect to cost and quality, production technology and organization, and raw material supply and markets for the product. A judicious, scientific approach to these matters is required if a lasting impact on the provision of low-cost shelter is to be achieved.

The small-scale sector is particularly dependent on research and development activities undertaken by the local or national government. While, in many instances, the results of research accrue more strongly to those located near the research facility there is typically a significant spillover effect that is national and so to a certain extent funding should be national rather than local. Also, in connection with the preceding proposal regarding government purchasing, there could be a programme for evaluating the applicability of unconventional materials in government funded construction. This type of research could be very beneficial, not only to small-scale building materials producers but to the overall effectiveness of the construction sector.^{79/}

Extensive research results are available in institutes and other bodies in industrialized countries and in developing countries. This knowledge must be disseminated effectively to the interested parties in the developing countries, necessitating appropriate international co-operation programmes.

78/ Ibid. p. 176.

79/ UNIDO/IS.512, op.cit., p. 165.

There is a need for making self-instruction materials available in the local vernacular, presented and illustrated clearly, and easily available to those who would benefit from them. In many instances the production of building materials is fairly simple but at the same time great increases in quality could be achieved by paying close attention to certain aspects of the design and production processes.^{80/}

Small-scale operations are generally dependent on economic and technical information supplied by equipment and materials suppliers or by governmental organizations. It would be useful, however, to increase the availability of technical and economic information on a local basis. This might be accomplished through an organization also concerned with training or research and development, or both. Such advisers could help to disseminate economic information, especially concerning the availability of markets and the supply of tools and raw materials. A government programme for purchasing building materials from the small-scale/informal sector could be administered in the first instance through such local technical advisers.^{81/} The establishment of local technology adaptation centres as vehicles for technology transfer could also be considered.^{82/}

Increased use of wood in building and construction could play a significant role in enlarging local markets for wood and wood products. However, in some societies certain technical problems (e.g., relating to humidity and decay) as well as financial discrimination, social prejudice, lack of referral standards, and legal constraints must first be overcome.^{83/}

Technologies for the use of commercially less accepted species need additional development and dissemination, especially relating to the grouping and processing of mixed species. End-use oriented research and a species grouping classification system related to end-use applications are required.^{84/}

80/ UNIDO/IS.512, op.cit., p. 166.

81/ Ibid., p. 166.

82/ UNIDO/ID.335, op.cit. p. 13.

83/ UNIDO/IS.398, op.cit., p. 174.

84/ Ibid., p. 176.

6. DIRECTION OF UNIDO'S POLICIES FOR BUILDING MATERIALS AND CONSTRUCTION

Building materials manufacture and construction are closely interlinked and in the context of technical assistance very difficult if not impossible to consider separately. It is therefore a long-standing tradition in UNIDO's technical assistance programme to regard the building materials industry not only as a manufacturing branch in its own right but also as one providing essential inputs to the construction sector and, particularly, to the part of that sector concerned with low-cost housing.

In most cases the resources for the manufacture of building materials are local, the jobs created surpass those in other manufacturing sectors many-fold and the end result is improvement of housing and thus of living standards for the largest possible segment of the population. Viewed in this light, the promotion of the building materials industry is an important factor in any country's socio-economic development.

Today, UNIDO's assistance to the building materials and construction industries sector constitutes approximately ten per cent of the Organization's total portfolio thus reflecting the importance which the recipient government attaches to this key industry. The assistance to the building materials industry can range from very short consultancy missions aimed at a solution to a specific technical or economic problem to integrated programmes of assistance over several years. These aim at the promotion of a range of new industries and rehabilitation of old ones via the creation of an institutional infrastructure capable of providing testing and quality control services as well as technology development, extension service, training and trouble shooting.

Typically, however, a UNIDO project will aim at the promotion of one or more related industries using locally available raw materials and producing building materials required for consumption in the vicinity of the factories. A combination of a brickmaking plant with a small-scale lime kiln constitutes a typical example of a practical building materials manufacturing complex suitable for satisfying the material needs in a larger city or a well populated rural district. (The high weight-to-value ratio of the products make it imperative to reduce the size of individual production units for the purpose of facilitating decentralized manufacture and reducing transport requirements.)

In selecting the technology for such manufacturing units, guiding principles have been the optimum utilization of locally available raw materials and energy resources, and the reduction of mechanization to the optimal minimum in order to improve the labour-to-investment ratio and facilitate operation and maintenance. Equally important is the emphasis on the manufacture of products for traditional type construction employing self-help techniques. In the past, a certain reluctance on behalf of recipient governments to accept so-called "appropriate" or "intermediate" technologies was obvious, but during the last five to ten years the trend has significantly turned in the direction of techniques specifically adapted to the needs, capabilities and resource endowments of individual developing countries.

A great variety of such manufacturing technologies are either traditional or developed through technical assistance efforts in developing countries around the world and are in confined locations being applied with considerable success. It should therefore seem a simple task to accelerate the promotion of such technologies everywhere but experience unfortunately shows that this is not the case. The existing mechanisms for transferring technologies from one country to another or just from one part of a country to another are simply not sufficient either due to lack of contacts between the holders of technology and those in need of it or due to the lack of the human and financial resources required to implement such a transfer. Within the limitations of its means, UNIDO is attempting to perform a catalytic role in this process, but again it is only in the context of specific technical co-operation projects or the supporting activities carried out in this sector that real progress is made towards dissemination of simple technologies going beyond on the one hand traditional manufacturing methods and on the other hand conventional industrial manufacturing technologies as applied in industrialized countries.

6.1 Main features of UNIDO's technical assistance programme

Building materials for housing or other construction purposes are usually produced by industries that also produce materials and products for non-construction purposes. Metal products, glass, and plastics are good examples. It is therefore of paramount importance to view the production of low-cost building materials in its proper industrial context, that is as part of a product line. The enterprise in question simply may not be an economically viable entity if it were to produce only for the construction industry.

Similarly, when arranging for the production of building materials for a single project, no matter how large, one must also consider the continuing viability of the production once the initial project is finished. Gearing up for a single project can be very questionable from an investment point of view. Perhaps even more important: no continuing, long term impact on industrialization, employment skills, and income generation is left behind.

UNIDO's practice is to view the production of building materials, and to provide technical assistance accordingly, within a comprehensive industrial strategy that considers both alternative uses of available raw materials and the full range of end uses. In that, the Organization not only contributes to the provision of housing but also creates an industrial infrastructure on which communities and nations can build.

In its policy and programme with respect to low-cost shelter, UNIDO is emphasizing the following:

- (a) Production of a full range of construction materials, mostly from local material;
- (b) Decentralization of production plants in order to promote small town and rural development;
- (c) Utilization of local resources and wastes for the production of building materials;

- (d) Efficient use of local manpower;
- (e) Adaptation of technologies for minimizing energy consumption; and
- (f) Enhancing traditional technologies by means of industrializing them.

In the construction related industries UNIDO is focusing on earthquake engineering and construction for seismic conditions through:

- (a) Strengthening design and construction capacities in countries laying in seismic zones;
- (b) Enhanced capabilities to repair and strengthening buildings damaged by earthquakes;
- (c) Application and demonstration of new advanced technologies for aseismic construction; and
- (d) Promoting close regional co-operation among countries lying in seismic zones in the exchange of scientific information and technology transfer.

6.2 Dissemination of industrial and technological information

UNIDO's Industrial and Technological Information Bank (INTIB) activities fall under one of two main categories, viz. industrial inquiry services, and positive dissemination of industrial information.

(1) Industrial inquiry services

Industrial inquiry services has been operational since 1968, representing a major line of communication and transfer of information regarding industrial matters, including low-cost building materials.

The number of substantive inquiries received averages about 1,300 per year, of which ten per cent are related to building materials.

(2) Positive dissemination of information

(a) Technology information profiles: These provide industrial and technological information on technological alternatives in priority sectors such as mini cement plants and mini lime plants;

(b) Technical memoranda: These are joint publications with small and medium industries in the choice of most appropriate technologies, for example in small-scale brickmaking; and

(c) How to start manufacturing industries series: These are 2-4 page profiles giving brief descriptions of manufacturing processes, machinery and equipment as well as labour, investment and production costs. They are intended to stimulate project promoters and sponsors in developing countries and to help them identify suitable products for local manufacture, including building materials.

Annex 1

EXAMPLES OF UNIDO PROJECTS

Non-fired clay bricks

A project recently completed in Niger provides an example of UNIDO technical assistance focusing on the development and promotion of small-scale building materials technology based on existing traditional methods. To make effective use of an old mechanized brick plant rendered obsolete by the construction of a large and more modern plant, the project carried out a series of technological trials aiming at optimizing the quality of non-fired clay bricks extruded in the original production line.

Using the well-known concept of laterite stabilization, different mixtures were investigated and it was found that two parts of laterite mixed with one part of clay and stabilized with 4 per cent of cement not only was easy to process but also yielded bricks of excellent quality. This mixture compared favourably to others tested when processed in a hand press. Before the end of the project, several organizations including FAO, USAID and UNCHS used this technology for brick manufacture serving low-cost housing projects.

It was also demonstrated that simple whitewash with lime slurry of the walls constructed with this material made the bricks resistant to rain, thus achieving a desirable wall structure through the use of locally produced and inexpensive materials based entirely on locally available resources.

Regional network on low cost housing

In 1983 UNIDO initiated a regional project for the Asia and the Pacific Region on low-cost building materials, technologies and construction systems. The project will finalize its operation in late 1987. It provides opportunities for technology transfer and exchange of experience and application of technologies suitable for low-cost housing. UNIDO has gained considerable experience through this project and such technical assistance programmes could be developed in other regions as well.

The Regional Network in Asia and the Pacific for low-cost building materials technologies and construction systems was established to ensure a continuous flow of information and a systematic programme of exchange of technologies. The Network was entrusted with the following major tasks:

- (1) Collection and dissemination of information which includes publication of a quarterly Network Monitor, annual reports, directories, technology manuals, and bibliographies of literature on low-cost building materials, technologies, and appropriate construction systems and design;
- (2) The co-ordination of research programmes;
- (3) The arrangement of consultancy/advisory services; and
- (4) The operation of a training programme which includes study tours, workshops, seminars, individual fellowships and on-the-job training.

Today the Network comprises a total of thirteen countries which have endorsed the project document. These countries are Afghanistan, Bangladesh, China, Indonesia, the Democratic People's Republic of Korea, Malaysia, Nepal, Pakistan, the Philippines, Sri-Lanka, Thailand, Tonga and Tuvalu.

Under the management/monitoring of UNIDO, this UNDP funded project is being co-ordinated by a regional secretariat based in Manila. The regional secretariat is publishing the quarterly Network Monitor and also other related publications. The Network has so far accomplished the following:

(a) Six technology manuals (presently in printing) on claybricks, concrete hollow-blocks, pre-stressed concrete, bamboo and rice-husk-ash cement;

(b) A directory of housing experts in the Philippines, presently being compiled;

(c) Three feasibility studies on production of various low-cost housing materials and building technologies;

(d) Five seminar-workshops on pre-stressed concrete, building materials from agro-residues, building materials from industrial residues, concrete hollow-blocks, and on inter-locking blocks;

(e) Six tours to study various low-cost housing technologies available in member countries;

(f) Seven on-the-job trainings to familiarize participants from member countries with the production and application processes of various low-cost housing technologies;

(g) Seven fellowship grants to participants from member countries for visits to research and academic institutes in industrialized countries; and

(h) A monograph on building materials from agro-residues; a second monograph on the state of research and development on low-cost housing is ready to be published.

The member countries have gained new and up-dated knowledge from their participation in the project's training component, and from information provided by reports, manuals, monographs, newsletters, and other sources for on-going research and development programmes. So far the project has organized a total of 32 activities wherein more than 130 nationals from different member countries have participated. The project's activities have been found relevant and in accordance to the needs of the region. Therefore, UNDP increased the budget of the project by some 70 per cent in 1985.

Building construction under seismic conditions in the Balkan region

In this regional project six countries, namely Bulgaria, Greece, Hungary, Romania, Turkey and Yugoslavia are participating. The aim of this project is to reduce seismic risk to human life and property in the areas of the Balkan region and increase economic efficiency in building activities through the organization of a joint effort between the participating Governments and the specialized institutions in the countries of the region. The project is achieving these objectives by ensuring (a) continued co-operation in research and development, training and exchange of information in the field of building

construction under seismic conditions; and (b) the development of materials, components, structural and building systems, model designs, building technologies, and organization for construction under seismic conditions.

Assistance in the development of building materials and supplies industry for low cost housing in Indonesia

The project assists in (a) the establishment of an operational/roving planning team located in Jakarta, up to three regional operation/planning teams, and up to five model programmes for the implementation of selected construction projects for demonstration and (b) the identification of new business opportunities for the production and supply of required materials and equipment in co-operation with national research and development institutes and respective Government programmes.

Assistance to boost the production of building materials in Chad

The purpose of this larger scale project is to contribute to the reconstruction of Chad's capital N'Djamena and especially of its public buildings and, through substitution of traditional materials (adobe, etc.) by more durable building materials, to permit even the poorer layers of the population to construct homes of adequate standard.

These objectives are to be achieved through the promotion of local manufacture of good quality materials such as fired clay bricks, stabilized soil blocks, lime, etc., based on optimal utilization of local natural resources.

Furthermore, the project will support the establishment of a building materials development centre and laboratory capable of supporting a self-sustained growth of the sector in the years to come.

Introduction of mobile brickmaking technology in Tanzania

The project addresses itself to the problems faced by the rural construction sector due to the non-availability of durable building materials in an acceptable price range. It aims at an upgrading of rural housing standards through the promotion of decentralized production of such materials.

It also aims at developing and proving the appropriateness of a mobile brick manufacturing unit capable of producing quality facing bricks for short term construction requirements in areas not justifying a permanent mechanized brick plant.

Research and development centre for light building materials, China

This project is executed by the Government. The work to be performed by the associated agency, UNIDO, will be to provide a staff member mission which will assist the project authority in the following tasks: identification of training needs and fields of training; determination of equipment and estimation of prices; determination of duties, duration and modality of experts services; drafting of a detailed work plan; and identification of host institutions for study tours, trainers and sources of expertise. In addition, the specialist shall advise the Centre on the manufacturing processes of glass fibre reinforced cement products and decorative materials, and their utilization in the building industry.

Upgrading and development of indigenous building materials manufacturers, Bangladesh

The development objective of the project is to achieve more efficient management and use of the country's scarce indigenous resources such as minerals, agro-products and wastes, for the production of building materials. The immediate objective of the project is to strengthen, diversify and rationalize the manufacture of heavy clay products.

Heat-insulation systems for external parts of buildings, Yugoslavia

The objective of the project is to determine the optimum heat insulation of buildings taking into account the prevailing climatic conditions in the Socialist Republic of Slovenia. Besides technical, design and economic factors, present regulations will be evaluated and new ones, if necessary, proposed.

Energy conservation in the operation of buildings, Hungary

It is of primary importance for Hungary to keep the annual growth rate of energy consumption under control. This project is intended to contribute to the realization of this goal in the field of construction and operation of buildings.

Promotion of local building materials, Madagascar

In an overall effort to increase the pace of low-cost housing construction of decent standard, the project will promote the production of local building materials that from both a price and a quality point of view satisfy the requirements of the construction sector.

Direct assistance in the development of appropriate technologies and support to the manufacturing sector will be supplemented by, on the one hand, the creation of a central co-ordinating structure assuring optimum utilization of the available resources including know-how and information and, on the other hand, a determined promotional effort in the construction sector aimed at demonstrating the best way of applying the materials promoted by the project.

Establishment of a small-scale brickmaking plant in Gambia

The aim of the project is to establish a small-scale brickmaking plant for the manufacture of burnt building bricks, perforated bricks and hollow bricks.

Advisory mission on using rubber base isolation technique in aseismic construction, Mexico

The project provides advice to the Government on the application of the specialized knowledge of the use of rubber isolation techniques in construction of earthquake resistant buildings.

Technical advise in aseismic construction strengthening and repair of buildings, Mexico

The project assists the Government and industry in strengthening their capacity and capability in the design and construction of earthquake resistant buildings.

Construction and formulation of a specific programme of assistance in the development of the local building industry and of energy sources in rural areas, Cameroon

The Government has become increasingly aware of the problems of inadequate housing and the need for improvement of local building materials. This project aims at promoting increased manufacturing and use of local building materials that could eventually improve low-cost housing standards. It also promotes the effective utilization of non-conventional energy sources, particularly in rural areas.

References

- Mahmoud Abdel-Fadil, Informal sector employment in Egypt, International Labour Office, Geneva, 1980.
- Luiz C.M. Bonilha, The building materials industry in Brazil, background paper prepared for UNIDO, July 1984.
- Sid Boubekeur, Outline of a policy for expertise and technological selection in capital goods for cement and brick manufacturing (ID/WG.425/4), prepared for UNIDO, 27 August 1984.
- James R. Clifton, Paul W. Brown and Geoffrey Frohndorff, Survey of Uses of Waste Materials in Construction in the United States, NBSIR 77-1244, National Bureau of Standards, Washington, D.C., 20234, July 1977.
- Robert J. Miller, "Steel minimills", Scientific American, May 1984.
- Fred Moavenzadeh, "Global prospects for concrete production", Concrete International, February 1984.
- Caroline Moser and Judith Marsie-Hazen, A survey of empirical studies in industrial and manufacturing activities in the informal sector in the developing countries (UNIDO/IS.470), 23 May 1984.
- Ruth Pearson, The Mexican cement industry: Technology market structure and growth, Working paper No. 11, prepared for ECLAC, Buenos Aires, September 1977.
- Marni Pigott, The Formulation and Implementation of Housing Policy in Sri Lanka: The origin and implications of the "Million Houses Programme", ILO Sectoral Activities Programme Working Paper, Geneva, 1986.
- René Urien, "Alternative strategies for building material industries in developing countries", ECO No. 83-16, Centre Scientifique et Technique du Bâtiment, Paris, 4 May 1983.
- David Wheeler, The economics of the building materials industry in developing countries, Center for Construction Research and Education, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1982.
- The building materials industry: the sector in figures, Sectoral Studies Series No. 16, Volume 2, UNIDO/IS.512/Add.1, 3 October 1985.
- The building materials industry in developing countries: an analytic appraisal, Sectoral Studies Series No. 16, Volume 1, UNIDO/IS.512, 29 January 1985.
- Sharing in development - A programme of employment, equity and growth for the Philippines, International Labour Office, Geneva, 1974.
- A Study of the Impacts of Alternative Land Use Plans for the Lake Tahoe Basin, by David M. Durnbusch & Co., Inc., San Francisco, Calif. 94133, 1978, Appendices.

Popular Manual for Wooden House Construction, UNIDO/ID.330.

Technical Report: Utilization of coconut palm sawn wood as a light framing structural material. Regional Coconut Wood Training Programme, UNIDO/DP/ID/SER.A/695, May 1986

Coconut Wood Building in the Asia and Pacific Region, Agro-Industries Branch, UNIDO/IO.628, May 1986.

Seminario materiales no convencionales para construcciones rurales, Medellin, 12-14 November 1986, Comité de Investigación y Desarrollo Científico, CINDEC, Colombia.

Rice Husk Ash Cements: Their Development and Applications, November 1984, no symbol.

Feasibility study for the utilization of brown mud of Shandong Aluminum Works as building material; Project No. SI CPR 84 803; Report to UNIDO, 1985.

United Nations Centre for Human Settlements (Habitat), Innovative Building Materials Production and Utilization in Lusaka, Zambia. Project monograph, produced for the International Year of Shelter for the Homeless, January 1986.

First world-wide study of the wood and wood-processing industries, Sectoral Studies Series No. 2, UNIDO/IS.398, August 1983.

Optimum scale production in developing countries: a preliminary review of prospects and potentialities in industrial sectors, Sectoral Studies Series No. 12, UNIDO/IS.471, June 1984.

Brickmaking plant: Industry profile, Development and Transfer of Technology Series, No. 10 (ID/212), 1978.

A review of technology and technological development in the wood and wood-processing industry and its implications for developing countries, Sectoral Working Paper Series No. 8, UNIDO/IS.413, November 1983.

Lime in industrial developments: a UNIDO guide to its uses and manufacture in developing countries, Sectoral Studies Series No. 18, UNIDO/IS.555, August 1985.

Mini-mills: the way ahead. Proceedings of the Metal Bulletin's Second International Mini Mills Conference, Vienna, 1982

Techno-economic considerations for the establishment of a steel industry based on the direct reduction technology for sponge-iron production, prepared by UNIDO (ECE document STEEL/SEM.9/R.31), 1983.

International Labour Office, Informal sector employment in Egypt, prepared by Mahmoud Abdel-Fadil, Geneva, 1980.

Brickmaking plant: Industry profile. Development and Transfer of Technology Series No. 10 (ID/212), 1978.

The building materials industry in the ESCAP region, Economic and Social Commission for Asia and the Pacific (ESCAP), Working Paper prepared for UNIDO, Bangkok, 1984.

Hungarian building and production technologies for transfer to developing countries, prepared by G. Kunszt and T. Mezos, 1983 (Microfiche).

Roofing in developing countries: Research for new technologies, National Academy of Sciences (NAS), Washington, D.C., 1974.

Small-scale building materials production in the context of the informal economy, United Nations Centre for Human Settlements (UNCHS), Nairobi, Kenya, 1984.

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The building materials industry: its role in low-cost shelter programmes

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