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BACKGROUND PAPER ON PRIORITIES IN DEVELOPING COUNTRIES IN THE FIELD OF INDUSTRIAL CONSTRUCTION 1/

by

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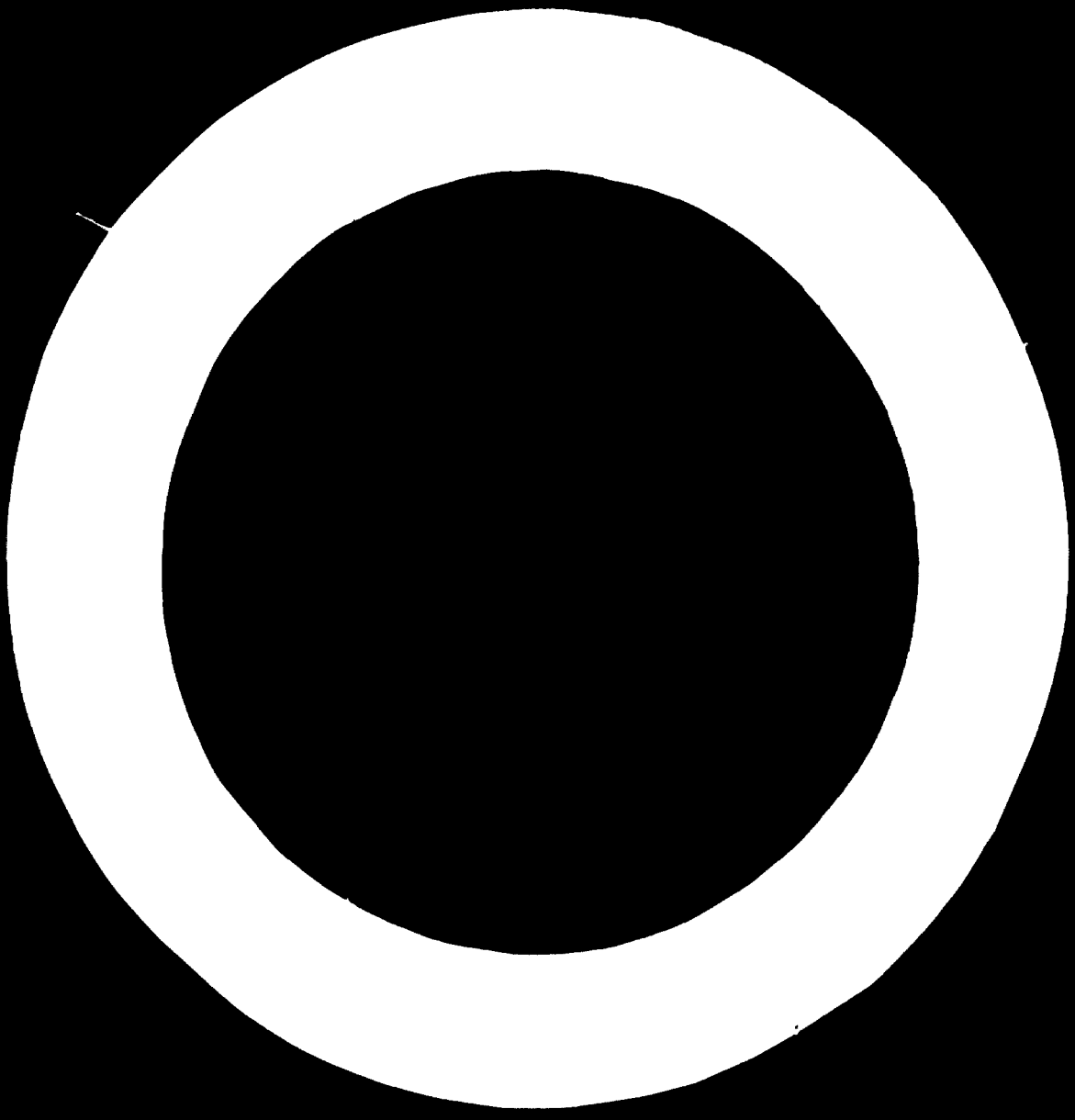

1 THE DEVELOPMENT OF THE INDUSTRIAL CONSTRUCTION SECTOR

The commencement of industrial construction as a distinct sector of a nation's building and civil engineering industry coincides with the beginning of the replacement of cottage industry by industrialised methods. However the sector only begins to provide a substantial market justifying the growth of specialised methods, materials, components and suppliers as industry becomes a major employer and economic force. Thus, although the construction of specialised industrial buildings can be traced back to, and beyond, the demand for factories and warehouses associated with the industrial revolution, the development of a substantial sector specialising in techniques such as prefabrication is very much more recent.

However, even prefabrication is by no means a new technique as by 1844 prefabricated iron warehouses were being shipped from England to Africa and in the 1850's E.T. Bollhouse of Manchester and a number of other manufacturers were shipping iron houses, churches and commercial buildings to California and Australia, where there were too few skilled workmen available and an urgent need for buildings of various kinds.

A further stimulus to the development of prefabrication techniques in the U.K. was provided by the Crimean War in 1854–6, where the intense cold and prevalent sickness led to a demand for instant barracks and hospitals. The standard barrack hut, to take sixteen men, was made of wood and iron and weighed only a ton. It folded into two flat packages for ease of transportation, and could be quickly taken to pieces and reassembled. Some specific needs stimulated an interesting early attempt at the integrated design of plumbing, drainage and ventilation services.

The condition of the military hospitals became a national scandal by January 1855, leading to the fall of the Government. The Permanent Under Secretary at the War Office, Sir Benjamin Hawes, wrote on February 16th, 1855 to his brother-in-law, Isambard Kingdom Brunel, asking the famous civil engineer to design an improved hospital of 1,000 beds which could be quickly built in England and then shipped out for assembly on some predetermined site. Brunel responded rapidly and, on March 5th, wrote to Hawes explaining the idea behind his design for the hospital.

This letter contained a cogent statement of the principal of prefabrication:

> 'the aggregate of the buildings should consist of such parts as might be conveniently united into one whole under great variations of conditions of the form and nature of the site. That the several parts must be capable of being formed into a whole united by covered passages, and that it should be capable of extension by the addition of parts to any size.'

He then went on to explain the layout in detail. Each standard unit would consist of two wards each for 24 patients and it would be completely self-contained with its own nurse's rooms, water closet, outhouses and other details:

> 'so that by no accident can any building arrive at its destination to be erected without having these essentials complete.'

Brunel was a master of detailed planning, still the key to successful prefabrication. There were fixed wash basins and invalid baths of his own design, while each unit was to be sent out with its own wooden trunk drainage system. Surgery, dispensary and offices' rooms consisted of the same standard timber units; only the kitchen, laundry and bakehouse were of metal to reduce the risk of fire.

By April 21st all the components had been prefabricated and the vessels left England, erection starting on the site a month later. The hospital was built by only 18 men who had been sent out from England, and it was ready to admit the first 300 patients by 12th July. This early case study of prefabrication shows the capacity of a relatively primitive building industry to respond to an urgent need, providing it is guided with energy and not impeded by restrictive administrative procedures. [2]

Unfortunately these qualities are rare and national building industries have often been slow to respond to and adopt improved technologies, techniques and procedures. There has been a tendency for the development

of the construction industry to lag behind social and economic changes, with the result that its response to national needs is sometimes inappropriate and belated. Another inhibiting factor in many countries is the piecemeal nature of demand, as individual clients seek particular architects or engineers to design structures on a 'one-off' basis, and the builder knows only that his next job will be very different from the last. In turn the building materials industry must provide a vast range of products to cater for the varying preferences and prejudices of client and their professional advisers. This diversity stems largely from what Bowley describes as the 'system' of a separation of the three phases which lead to the completion of a building. [3]

1. Working out the overall design in accordance with the client's requirements for accomodation and amenities.

2. Calculating the structural design to ensure that the building is durable, resists anticipated loadings and climatic conditions and that the services work.

3. Actually producing the building and making it ready for occupation.

In broad terms the first phase is the speciality of the architect, the second of the structural, civil or services engineer and the third the province of the building contractor who is only involved after the design phases are complete and tender documents prepared. Thus the contractor has no opportunity to apply his experience at the design stage or discuss with the client ways in which his objectives could be achieved more economically. On this watertight division of responsibilities, Bowley comments:

'In sum, the separation of design responsibilities from building responsibility enabled builders to neglect their own education in design, or avoid the employment of designers, and the architect to neglect his own education in building practice and the employment of building technicians. Equally the development of the system of independent quantity surveyors enabled designers to neglect proper study of estimating and avoid the employment of estimators.'

Another feature of this 'system' is the absence of competition in design. Although this does have some advantages for the client in that in a competitive situation, design contracts might be won by unscrupulous or inadequate firms, it does have the effect of insulating the designer from the effects of uneconomic design or inaccurate costings. In fact additional costs redound to the immediate financial benefit of the consultant as fees are usually calculated as a percentage of overall costs, although it does of course harm his reputation.

This 'system' of separation of responsibilities has begun to give way in some work areas within developed countries, particularly in the area of industrial construction, to the 'package deal' in which the contractor negotiates direct with the client for the design, preplanning and construction of a project. These 'package deals' can result in more rapid completions and lower overall project costs providing the contractor has a good reputation, is experienced and employs a qualified multi-disciplinary team of engineers, estimators and surveyors. It does however throw a heavy burden of responsibility onto the contractor and some clients prefer to employ independent consultants to ensure that they will receive unbiased advice on design, tender acceptance and site supervision. These objections apply with rather more force in many developing countries, where few indigenous contractors have expanded to the stage of employing qualified professional design staff.

A more severe constraint, in both developed and developing countries, is the 'feast and famine' nature of demand for building and civil engineering production, particularly in the industrial construction sector. Whether demand emanates from Government or private sources, potential clients react to periods of economic stringency by cutting down on plans for capital investment. Thus the construction industry, which has a particularly long time cycle from initiation, through design, tendering, planning to final execution, finds itself repeatedly used as a short-term economic regulator. The industry tends to react by under-investing, both in plant and training and maintaining a skilled labour force, with the result that it is poorly equipped to cope with the next expansion of demand.

The cyclical nature of demand for construction naturally reacts on the manufacturers and suppliers of building materials and compononts. With the prospect of substantial fluctuations of demand and a bulky product which is expensive to store, manufacturers are naturally reluctant to purchase expensive machinery or even to spend heavily on research and development of new products.

Even in a developed country such as the U.K. many companies have become disenchanted with system building. A number of proprietory systems were developed in the 1950's to meet the growing demand for houses, schools and factories. However the very large number of firms that were attracted to the market, including several shipbuilders who assumed that their skills could be readily adapted to industrialised building activity, resulted in a fragmented market in which only a few survivors were able to secure a reasonable foothold. It seems unlikely that, given the fact that industrial buildings are usually one - or at most two - storey structures, comprehensive system building techniques will become prevalent and a more promising approach would appear to be to concentrate on modular coordination and the prefabrication of components, wherever possible employing local materials.

One of the most serious problems facing a number of developing countries is the lack of local steel or cement manufacturing facilities. The fact that technological research and development has been concentrated on large, sophisticated and expensive plants, has narrowed the choice for many countries to either a vast and disproportionate investment in advanced technology or a continuing absence of local capacity. Yet structural steel and reinforced concrete are basic structural elements in industrial construction. There is an urgent need for effective study and research into ways of manufacturing steel and cement economically on a smaller scale. Although it is unlikely that steel production can be carried out economically on an intermediate scale it would be most advantageous for cement production to be decentralised to village plants in the rural areas. For most rural purposes, the quality standards imposed generally for portland cement production are excessive and a cheaper but slightly

more variable product would be welcomed. It would be well placed to encourage the construction of pilot plants to prove the feasibility of small scale lime and cement production, and this could make a vital contribution to lowering rural construction costs.

There is a need to view the relative merits of small and large scale plants for developing countries against a broader social and economic background. Conventional financial appraisal techniques tend to favour the unthinking transfer of the technologies that have grown up to meet the specialised needs, systems and pressures of the industrialised countries. These technologies are geared to the labour-saving creeds which are quite appropriate where unemployment is about 4-5 per cent (and employment is therefore 95-96 per cent), and are, consequently capital-intensive, large-scale and highly sophisticated. But the need of poor people in poor communities is generally for ways of doing things that are capital-saving, small-scale, and relatively simple to use and maintain.

In fact the overriding need of most poor countries is useful and productive employment for their people -in many cases millions rather than thousands of new jobs are needed. But the typical cost per workplace in industrialised countries is $ 5-10,000, so this kind of technology would permit only a fraction of the employable population to be put to work. If jobs are to be created on anything like the required scale, they must be cheap enough and simple enough to be used by rural and small-town populations without sophisticated technical and organisational skills and with very low incomes.

There is a further factor which affects the balance of advantage between small and large-scale production. This is the contribution to on-site costs of building materials made by transport costs, which is particularly onerous in the case of heavy building materials. The recent steep increases in fuel costs have added substantially to this contribution, and there would be considerable advantages in local production of materials in small towns or within groups of villages.

Although many developing countries have ambitious plans for the construction of new transport facilities, particularly for road construction, the vehicles that would be required to carry materials and components from central factories have a high proportional import content and virtually guarantee a continuing strain on scarce foreign exchange reserves for replacement parts and fuel. On a 10 to 20 year view it appears likely that these economic implications will grow steadily more serious and more policy makes will appreciate that the most effective way of reducing overall transportation costs is by reducing the causes of traffic, and the local manufacture of building materials could be very beneficial to this end.

Thus it would appear that there is a general case for the encouragement of efficient small-scale building material manufacturing facilities, although the degree of dispersion would of course vary from country to country. It is important to remember that intermediate or appropriate technology is by no means synonymous with primitive technology. In fact the initial input of thought, design and planning must be of high qulity to ensure that the final product is acceptable and marketable, and that its manufacture does not make excessive demands on local skills and is feasible bearing in mind the range of qualities of local materials.

It would be inappropriate for this introductory paper to discuss the problems of particular countries, but it does appear that it would be advantageous for the UNIDO Industrial Construction Unit to consider initiatives in the scaling down of industrial construction techniques to suit local requirements, materials and skills.

2. CONSTRUCTION DESIGN AND TECHNOLOGY

The design sector has a vital role to play in ensuring that industrial structures are appropriate to local needs. In many developing countries a large proportion of the local architects, civil engineers and quantity surveyors have received at least a part of their training overseas, and consequently face a more taxing task than their counterparts in industrialised countries in adapting their methods and techniques to

local needs and conditions. It is not therefore surprising that, in a large number of developing countries, designs are based on overseas practice modified by local conditions. This process of modification to suit local conditions is often made more difficult by the lack of local standards, codes of practice and published information.

Yet it is at the design stage that a major contribution to cost saving could be made. Even a highly skilled contractor using advanced construction techniques cannot produce a truly suitable and economical structure if the fundamental design is not appropriate to the needs of the eventual user.

Thus the designer's skills should embrace traditional as well as modern materials, local skills as well as advanced techniques and local socio-economic habits and conditions. The best results are likely to be obtained by designers with a sound knowledge of modern flexibility to adapt these to local needs. This required range of skills is only likely to be achieved if construction thought is given to the continuing training and education of local professional talent so that knowledge can be regularly updated. National building research organisations, universities and other training institutions have a part to play in this process, but UNIDO could also have a key co-ordinating role by providing the necessary external advice and expertise and ensuring that experience and innovation is shared and disseminated.

The pool of professional design skills is one of the most valuable national resources, and in many developing countries these skills are particularly scarce. In these circumstances, the tendency to design a 'bespoke product' to suit each individual client is perhaps a little extravagant, and more consideration should be given to the potential advantages of standardisation and modular co-ordination. A further stimulus to standardisation is the need for versatility as industrial needs change. As Kriuker pointed out at the 1973 UNIDO Expert Meeting on the Construction Industry in Developing Countries:

> 'A characteristic feature of modern industry is the increasing improvement of its technological processes, the creation of new

> kinds of equipment of every type, the elaboration of highly sophisticated assembly line procedures and the manufacture of more and new product lines. All this has an effect on the buildings and facilities that are to be planned. Shorter lead-times for technological processes coupled with the availability of equipment of constantly increasing efficiency require the design of new, versatile types of buildings and institutions in which the need for reconstruction will be held to a minimum.'

Whilst the pace of change is unlikely to be so great in most developing countries, the need for versatility and adaptability remains. Whatever future population trends may be, it is certain that most developing countries will have to cope with steady increases in their populations of working age for the next 10-20 years. Assuming that they appreciate the scale of the problem and consciously pursue a policy of work creation, the need for additional workplaces could be very large. It would be surprising if this growth of additional workplaces were not matched by a variation in patterns and types of work, so that factories, warehouses, workshops and other industrial buildings will have to be regularly adapted. To the present priorities of low initial cost and speed of erection it would therefore be wise to add a third - versatility.

It is important to remember the one feature that cannot be made adaptable (except in the case of mobile buildings) - the site. As most permanent buildings are designed to last at least 40-60 years, it is vital that new industries and factories should be sited strategically in relation to planned national, regional and local development. This will probably be achieved more successfully with a network of small local industrial units than by concentrating development on a small number of large trading estates.

Detailed design features that may be worthy of consideration on individual projects include the provision of sufficient foundations to take future increases of loading from heavier plant and machinery or increased storey heights, open planning with moveable partitions

to accomodate changing work patterns and the installation of service ducts so that pipe and cable inputs can be readily adapted.

It is at the design stage that a real stimulus to standardization and dimensional co-ordination could be given, and these factors could lead to considerable economic benefits by avoiding duplication of work both by designers and builders. The difficulty is usually the vicious circle of designers being unable to specify standard products until they are produced by manufacturers, while manufacturers are reluctant to invest heavily in research, development and production until a substantial market is available. This vicious circle could be broken by determined action by governments introducing laws, codes of practice and mandatory procedures covering dimensions and standards. Developing countries are perhaps in a particularly strong position in that they lack an entrenched conservative manufacturing sector, and their newer industries should be prepared to welcome the potential economics from dimensional co-ordination. By offering constructive advice on standard setting, UNIDO could greatly assist this process.

The designer also has a key role in monitoring and controlling the transfer of technology from industrialised to developing countries and between developing countries. Many difficulties are bound to arise if proper account is not taken of climatic differences, local materials, levels of skills, degrees of mechanisation and administrative and managerial approaches. Unfortunately most designers, whether in the private or the public sector, find that the day-to-day pressures from their clients allow little time for systematic work on innovation, research or development. This gap in the administrative structure of so many developing construction industries deserves particular attention.

As Campbell pointed out in a paper submitted to the recent UNIDO Expert Group Meeting: [5]

> 'There is a common fallacy that innovation will follow scientific research but in fact this seldom occurs, partially because most researchers have little idea of the whole market and are

therefore unable to 'design' their products and also because there is no marketing. Linked with this is a factor which has importance in many other areas in developing countries and this is that a researcher's career is promoted by research papers and higher degrees; development work of the sort required in developing countries gains little or no credit. There is no career for a 'promoter of technology' anywhere in the public sector and no employment facilities in the private sector in developing countries.'

Campbell suggested that there was a need for an international organisation without commercial connections to fill this gap by systematically generating information for innovation and methods of innovation. This information should be channelled through the design sector as the key decision makers of the industry, typically handling several tens of thousands of bits of information on products and methods. Thus, the appropriate unit would be required to build up good contacts with design sectors in developing countries, and should devote particular attention to processing the information in a form such that it can be used without modification. Campbell further commented that: -

'Such does not exist in developing countries but in fact not very much effort is required to convert existing information into a format to suit architects and other designers; and this could easily be handled internationally.'

UNIDO could well consider the possibility of itself acting to assist developing countries by setting up a Construction Information and Advisory Service covering appropriate materials, methods and techniques, leading to the establishment of a comprehensive network of Construction Information Centres in developing countries.

This additional service would complement the valuable work done at present in the general industrial field by the UNIDO Industrial Information Clearing House run by the Industrial Services and Institutions Division, but would be geared to the special problems and needs of the industrial construction sector.

3. THE PROCESS OF CONSTRUCTION

If it is accepted that the designer has a key role in the transfer of construction technology, it must also be noted that the implementation of this technology depends on the skills and experience of the contracting sector. Unfortunately the indigenous constructing firms in developing countries often find it difficult to recruit sufficiently high level manpower to match their growing responsibilities. Among the specialist functions required within a firm of building and civil engineering contractors are:

1. Estimating
2. Planning and Programming
3. Purchasing
4. Plant Management
5. Site Supervision
6. Personnel Management
7. Preparation of Interim and Final Accounts
8. Accounting and Financial Control
9. Office Organisation

A large international contractor would arrange for these various functions to be carried out by separate departments managed by experienced specialists. But the smaller local contractor must rely on his own resources to a much greater extent, and is often insufficiently experienced even to appreciate and evaluate the worth of external specialist services.

A further factor is the enormous range of size and type of construction agency, making the co-ordination and organisation of the purposeful development of the industry a particularly difficult task. In his paper to the 1973 UNIDO Expert Group Meeting, Nagabhushana Rau commented: -[6]

> 'There are no well-established institutions to voice the problems of construction agencies. The (Indian) Planning Commission has brought out a standard contract form to regulate tendering method but it is not made universally

applicable. The problems raised by the construction men are that:

1. Construction is not recognized as an industry.
2. Financial institutions do not render adequate assistance.
3. The tendering process is outmoded and one-sided.
4. Materials supplies are often irregular.
5. There is no relief for escalating material prices.
6. No co-ordination among different participants resulting in delays.
7. Labour laws do not take account of fluctuating work loads.
8. There are 15 separate laws applying to a construction site. Consolidation is needed.
9. The wage structure is low and not clearly-defined.
10. Acceptance of lowest bids, irrespective of competancy, is no encouragement to progress.'

Perhaps the heart of the problem for a building contractor lies in the special nature of the transaction which is implicit in the acceptance and completion of a building contract. A typical small/medium sized building contract may take 6 months to execute, and will be followed by a 6 month maintenance period while the contractor waits for the release of the remainder of his retention money. To add to the time span, it can be assumed that, in a typical case, a fixed price tender will have been prepared and submitted some two or three months before commencement on site. It is true that interim payments will be received as the work proceeds, but the fact remains that the eventual success or failure (in terms of profit or loss) of each individual transaction cannot be accurately determined until 15-18 months have elapsed from the date of the original commitment. Furthermore each individual transaction involves a substantial sum of money, often a quarter or even a third of the firms total annual turnover and a higher proportion of working capital.

It is perhaps surprising that there have been so few systematic analyses of the problems of entreprenours in developing construction industries. One such study by the Intermediate Technology Development Group of the case histories of various indigenous contractors in Kenya

suggest that basic management rather than advanced technical skills is the key to survival in this competitive business: -[7]

> 'The common factor in the case histories of these four successful one-man firms seems to be the stress laid by the principal on shrewd financial planning and control. This does not usually imply a particularly sophisticated system of documentation, and the firm's 'filing system' often depends mainly on the memory of the proprietor. This is a potential weakness that can be expected to show up more clearly as the business expands to a stage where additional managers have to be brought in.'

Although working capital is always a problem for building contractors, finance alone would be unlikely to provide a full solution. Banks are wary of lending to the industry for the very good reason that it is a business which is subject, almost endemically, to very high risks. In most countries, year after year building contractors top the list for bankruptcies. If a better credit rating for the industry is to be achieved, it will be necessary to iron out the marked fluctuations in the available amount of work and provide a carefully tailored training programme to improve technical and managerial skills.

In the industrial construction sector a steadier market could be achieved by standardising designs and letting a series of contracts so that a contractor could look forward to, and plan and invest for, a steady workload. If this was coupled with a management training and information programme over a period of years, the capability of participating contracting firms might be dramatically improved.

4. SUMMARY OF SUGGESTED RECOMMENDATIONS

(i) UNIDO should consider ways of encouraging the construction of pilot plants to prove the feasibility of small scale building materials production in rural areas, particularly of lime and cementicious materials.

(ii) UNIDO should encourage research into ways of scaling down industrial construction techniques to suit local requirements, materials and skills.

(iii) UNIDO should offer advice to developing countries on the setting of standards appropriate to local climates, materials, traditions and skills.

(iv) UNIDO should consider setting up a specialist Construction Information and Advisory Service covering appropriate materials, methods and techniques, leading to the establishment of a comprehensive network of Construction Information Centres in developing countries.

(v) UNIDO should consider ways of encouraging the establishment of management training and information programmes to meet the specific needs of contractors involved in industrial construction.

It is suggested that these recommendations should be read in conjunction with the conclusions and recommendations of the Expert Group on the Construction Industry in Developing Countries which met in Vienna from 29th October to 2nd November 1973.

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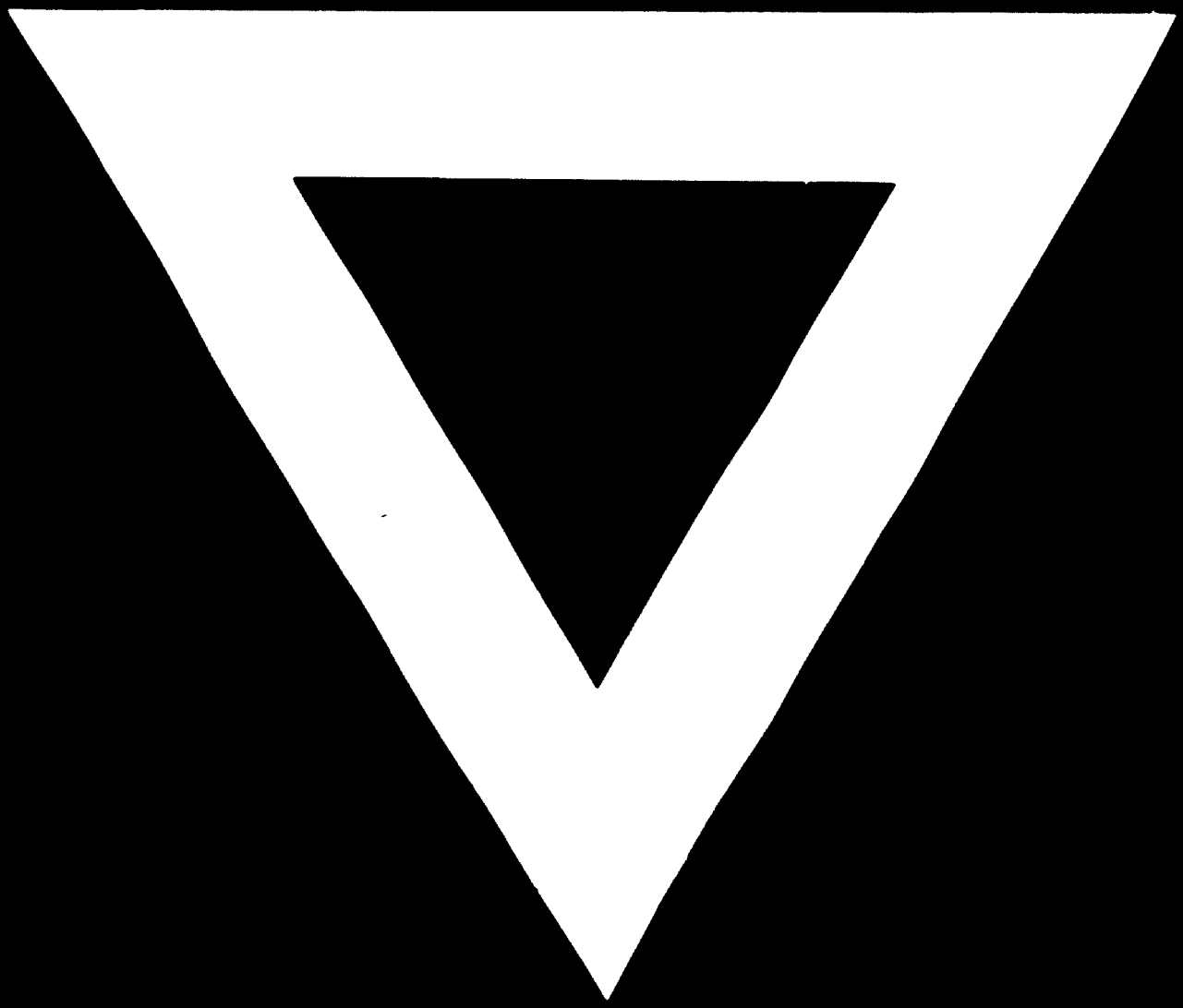

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