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Expert Group Meeting on the Use of Plastics in the Building Industry

Vienna, Austria, 20 - 24 September 1971

DRAFT REPORT 1/

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Contents

-Preface

I The vast housing problem of the developing countries is not capable of solution by traditional means, nor is the supply of conventional building materials adequate to permit this. Mass production techniques are required to make a significant contribution to solving the housing needs. Plastics which have established themselves in developed countries in certain areas of applications in the building industry, and are available in increasing quantities through the development of the petrochemicals industry in the developing countries, could provide a fairly satisfactory solution to the problem.

2. Keeping this in view, the Expert Working Group Meeting on the Use of Plastics in the Building Industry was held at UNIDO headquarters, Vienna, from 20 - 24 September 1971.

3. The Meeting was opened by Mr. N.K. Grigoriev, Director, Industrial Technology Division, on behalf of the Executive Director of UNIDO. Mr. Grigoriev welcomed the participants on behalf of UNIDO. He expressed the hope that the observations and recommendations of this Working Group would provide technical, economic and administrative guidance for development of non-traditional methods and materials related to the housing problems in the developing countries. UNIDO is actively engaged in assisting countries in the development of traditional building materials industries. The housing needs, however, are estimated to be far above the capacity of traditional materials and, that the deliberations of this meeting would help solve one of the most urgent problems facing this and future generations. UNIDO through the help of this meeting would be able to work out a sound approach to the activities of the organization in the plastics industry in the developing countries.

4. On behalf of UNIDO, Mr. C.E. Rydeng conducted the meeting and participated in the deliberations.

5. A Project-Description Note (Annex I) prepared by UNIDO formed the basis for discussion at the meeting. Twelve papers were presented (list of document is attached as annex 4)

6. In addition, the discussions at the meeting covered the following aspects on the agenda:

Building Systems using Plastics

Plastics deterioration in Building in Tropical Areas
Prefabrication Trends with Plastics in Building
User requirements and Performance Specifications
Research and Development Needs

The report contains information about the scope of the utilization of plastics in building industry, the conclusions and recommendations adopted by the participants Summaries of the papers are contained in Annex 2.

7. The meeting was attended by participants and observers from Austria, Belgium, Federal Republic of Germany, Hungary, India, The United Kingdom. The United States, Netherlands, Sweden and Switzerland. (List of participants is attached. Annex 3)

8. Mr. J.P.R. Falconer, Associate Prof. of Architecture and Director, Washington University, Centre for Development Technology, St. Louis, Missouri, USA, was elected chairman, and Dr. J.R. Crowder, Head of Plastics Section, Building Research Station, Watford, UK, and Mr. B. Lundin, Managing Director of the Swedish Plastics Federation, Stockholm served as two Vice-Chairman for the Meeting. Mr. O.P. Ratra, Assistant Director (Plastics), National Buildings Organisation, New Delhi, India, acted as Rapporteur.

9. Site visit, as discussed in Annex 5.

Introduction

10. The world production of plastics has been increasing during the last ten years (Fig. 1). This has been in tune with the development and expansion of the petrochemical industries. For instance, in 1965, world production of plastics stood at 14.5 million tons, which almost doubled in 1970 to 30 million tons, and it is further expected to increase threefold by 1980. The major plastics producing countries are the United States, Japan, Federal Republic of Germany, Italy, the United Kingdom and France.

11. Plastics are next only to metals in the per capita comsumption of basic materials in the world. In 1966, the estimated figure was 5.0 kg. for plastics and 14.5 kg. for the metals, and it has been estimated that by the end of this century, it would be 243.0 kg. for plastics and 362.0 kg. for the metals. Presently, Federal Republic of Germany leads in per capita consumption of plastics (59 kg.) followed by Sweden (40 - 50 kg.), United States, Japan, France, Netherlands, Italy and the United Kingdom (20 - 40 kg.).

12. The plastics industry in various developed countries has been aware of the corresponding consumer industries. Building and construction sector is the major outlet for plastics followed by packaging and transportation. It is estimated that over 25% of world production of plastics goes into various building applications. The consumption figure in Europe alone during 1970 was 5.6 billion pounds. Whereas Federal Republic of Germany reported 30% of its 1970 production (4.62 million tons), utilised for building applications.

13. It is not surprising to note that building industry should have been invaded by plastics. The traditional building materials and methods invariably fall short of their supply and performance in the wake of growing demand on housing needs the world over. With the development of new materials including plastics, their potential for use in the building industry has been widely studied and exploited in developed countries over the last two decades. To date, building applications like the piping systems (for electrical conduit, cold water services, soil and rain water, water-mains and underground drainage), sanitary fittings and fixtures, floor coverings, building hardware, wall-claddings, emergency structures, and needless to mention a score of others, such as electrical fittings and lighting fixtures, thermal and sound insulation, surface coatings, wall coverings, water

proofing and damp-proof course, have all been taken care of by different known plastics materials (Fig.2) . Among the widely studied and experimented plastics materials for the building industry include polyethylene (low-and high-density), PVC (Polyvinylchloride), glass-fibre reinforced polyester resin, and plastics foam- (polystyrene, polyurethane, phenolformaldehyde and building systems using plastics have been designed. Their suitability for different regions in the world, and their commercial feasibility are, however, subjects of further study and wide experimentation.

14. During the year 1969, over 245,000 tons of different plastics were utilised by the building industry in the United Kingdom. This quantity represented 4 per cent of the total spent on materials by the building industry in that country. Plastics piping system is the major application of plastics in building. In the United Kingdom alone, PVC gutters and drain pipes have captured 80% of the market which includes both new and replacement work. PVC soil pipes which considerable consumption of PVC per dwelling especially in high-rise buildings are becoming increasingly popular, with about 8,200 tons of PVC utilised in 1969. The production of PVC pipes and fittings during 1969 was: USA - 160,000 tons; Japan-186,745 tons; Federal Republic of Germany - 73,000 tons. In Western Europe, thermo-plastics pipes and fittings are recording an average growth rate of 20% per year. The pattern of growth in the next five years is estimated to be as high as 40% in some countries, and as low as 15% in others. In the Federal Republic of Germany, the consumption of thermoplastic pipes and fittings has spurred by an increased tempo of building and municipal code approvals plus wide spread acceptance by contractors showing an increase of 35% in 1970, to about 150,000 tons. Italy's growth rate was less than 9% with 43,500 tons of thermoplastics used. In France, the consumption rose from 75,000 tons in 1969 to nearly 98,000 tons in 1970. In the United Kingdom, PVC pipes production is estimated to increase from 48,000 tons in 1970 to nearly 100,000 tons by 1975. The light-weight of plastics used in the manufacture of pipes and fittings has contributed a fair amount of savings in the use of metals. For instance, one volume basi. , 50,000 tons of PVC represents 300,000 tons of pipes made of cast iron and asbestos cement.

15. Plastics are a group of organic materials and in respect of their usage in the building industry, these are basically 'delicate' to handle, though in their service performance, plastics have shown great promise in satisfactory service performance over many of the traditional building materials.

16. One great advantage of plastics, which has been taken into consideration for use in the building industry is their adaptability to mass-production techniques. Their light-weight, corrosion-resistance, built-in-colour, light transmission and ease of manipulation to manufacture building components in any specified design are some of the characteristics which have favoured their acceptance in the building applications.

17. Plastics, being new building materials, their history of usage hardly two decades old, have had to face resistance of their introduction into the building industry, which is more often termed as 'conservative' in its approach to new building materials and techniques. Their weathering characteristics in outdoor use and durability in relation to the traditional materials are some of the questions which still remain to be answered satisfactorily, particularly in respect of their use in tropical areas of the world. This naturally calls for study of the user requirements in a particular region and creating awareness and confidence among building code officials of their inclusions in building specifications. Concreted efforts have, however, been made to this effect in developed countries, and satisfactory solutions to these questions and problems are being offered to the building industry.

18. The plastics industries have come up in a number of developing countries. With the establishment of petrochemical industries in developing regions, the plastics industries hold out great promise for future expansion and diversification. For instance, leading plastics producing countries in the ECAFE region are India, China (Taiwan), Iran, Pakistan, Republic of Korea and the Philippines. A range of plastic products, using indigenous and imported plastics raw materials and processing machinery are manufactured in these countries. Lately, plastic products of interest to the building industry have also been introduced in some of these and other developing countries.

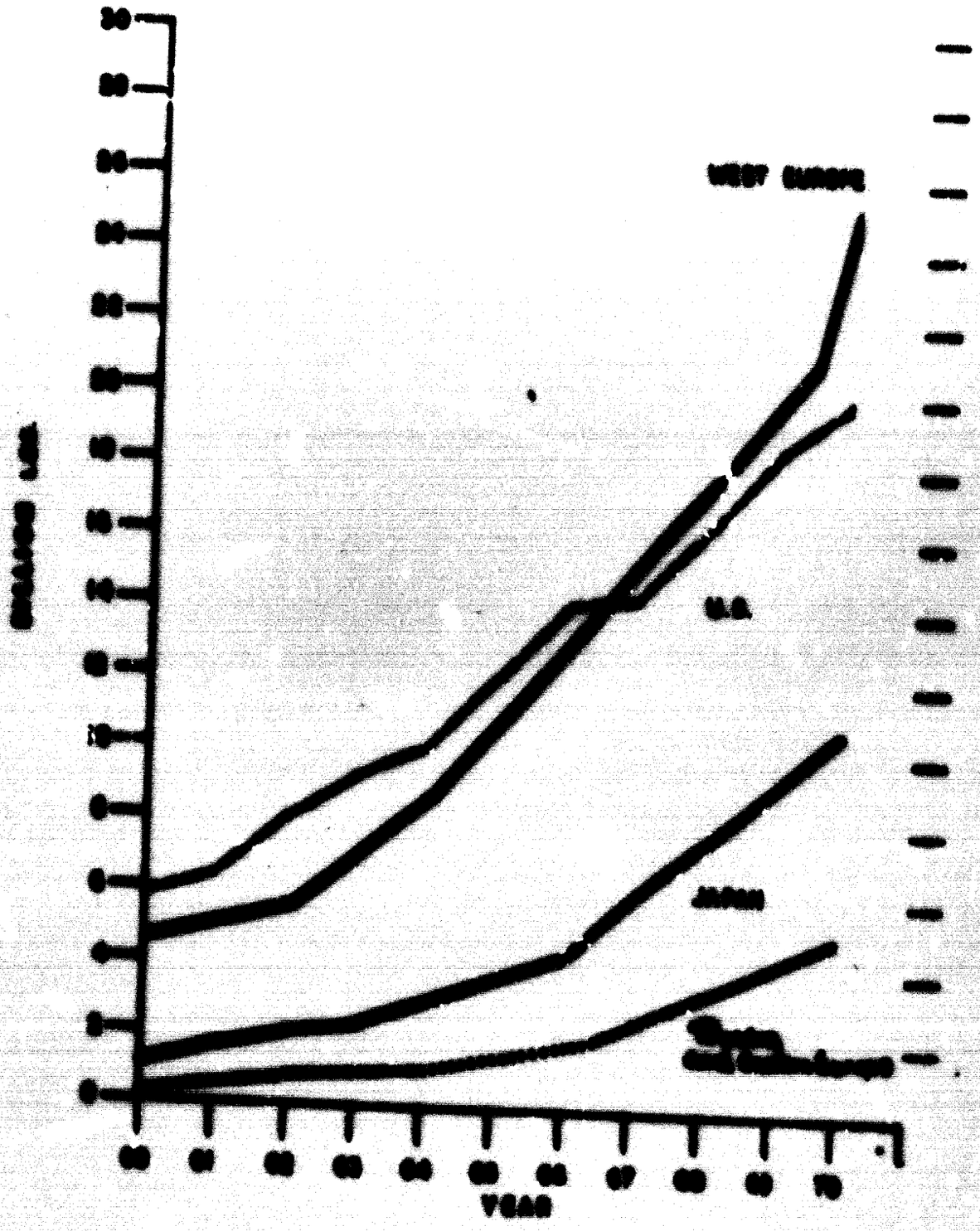
19. The development and introduction of plastics as building materials in developing countries have many aspects of the problem. These include availability of plastics raw materials indigenously (preferably), their conversion into products of interest to the building industry - again this has to take care of the experience in the field in developed nations, and lastly the climatic and socio-economic conditions in the regions, which call for a case for detailed study before planning introduction of these relatively new building materials. It needs hardly a mention here that production and application technologies in respect of plastics industries in the developing countries are invariably borrowed from developed nations.

20. User requirements and user habits in respect of building materials are much different in developing countries as against developed nations. Furthermore, guarantee for satisfactory service performance of new materials calls for formulating methods of assessing performance, or in other words, laying down '<u>performance specifications</u>'. This would facilitate systematic development and introduction of plastics as building materials in the developing regions. Re-orientation of the user habits in adopting the use of plastics in building necessitates organising education and training programmes for civil engineers/architects/building contractors. This would help provide the relevant technical information on the subject to the local building trade. Publication and issue of technical notes/bulletins on different aspects of use of plastics in building will be yet another step forward in this direction.

21. Developed nations have devoted much time and thought in organising research and development programmes in the plastics industries. Developing countries have to initiate similar programmes keeping in view the potential, and local resources and requirements.

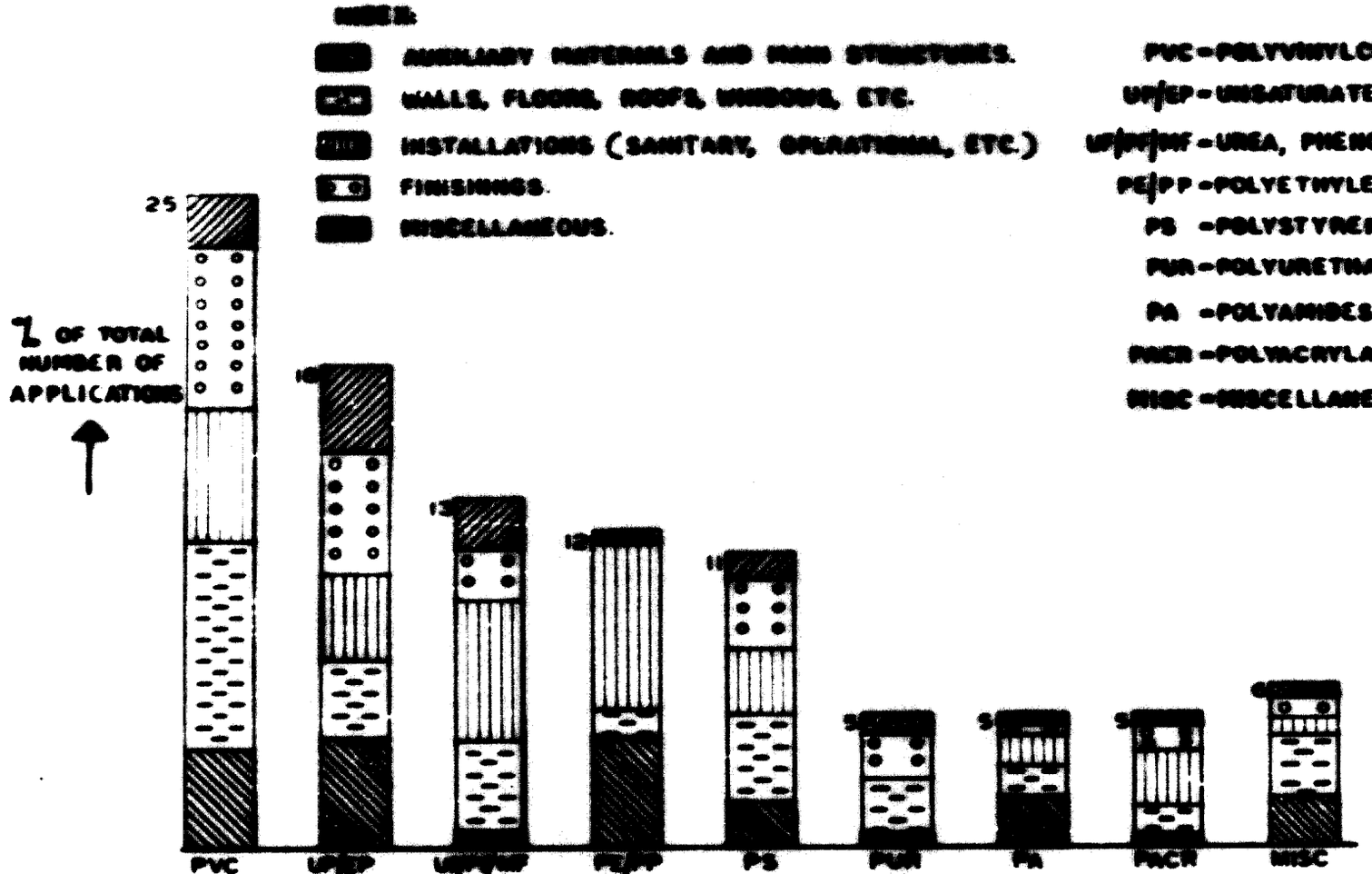
22. The future growth of the use of plastics in building is linked with close co-operation and participation jointly of plastics and building industries and working out of their respective requirements. The plastics industry has to satisfy its major consumer - the building industry - in all its aspects, socio-economic, technical and performance - evaluation. This would help supplement the supply of traditional building materials and encourage plastics industry's participation in solving the growing demand on housing needs the world over.

WORLD PRODUCTION OF PLASTICS



U.S.A 8.8 million tonnes.
JAPAN 8.0 million tonnes.
W.GERMANY 4.2 million tonnes.

DISTRIBUTION OF TYPES OF PLASTICS IN BUILDING APPLICATIONS



PVC - POLYVINYLCHLORIDE
UP/EP - UNSATURATED POLYESTER/EPOXYRESINS
UF/PF/MF - UREA, PHENOL, MELAMINE FORMALDEHYDE
PE/PP - POLYETHYLENE, POLYPROPYLENE
PS - POLYSTYRENES
PUR - POLYURETHANES
PA - POLYAMIDES
PMCR - POLYMCRYLATES
MISC - MISCELLANEOUS POLYMERS

Conclusions

23. The following conclusions are based on the discussions at the meeting.

24 The vast housing problems of the developing countries are not capable of solution by traditional means, nor is the supply of conventional building materials adequate to permit this. Mass-production techniques are required to make a significant contribution to increasing the supply of houses; plastics, which are available in growing quantities through the development of the petrochemical industry, lend themselves very well to such mass-production processes.

25. Since plastic products are relatively new and unfamiliar building materials in developing nations, education and information on their properties and handling characteristics, is essential to their appropriate utilisation in building. The UN agencies can assist in this process by means of collection and dissemination of technical information on components and systems which incorporate plastics materials.

26. The experience of many industrialized countries has shown that the acceptance of new building materials, including plastics, can be facilitated by formulating performance specifications and incorporating these in building codes and specifications.

27. In the course of the meeting, a number of specific building systems were presented and discussed. These systems showed the potential for applying industrialized housing techniques utilising plastics, and deserve further evaluation and consideration as solutions to mass housing needs.

28 It was felt, however, that the real potential of any system can best be assessed by relating its characteristics to the user requirements, local climatic conditions, and resources of specific developing regions. The working group agreed that this information could be made available to UNIDO so that the scope of the utilisation of plastics in building in a particular developing region could be assessed.

Recommendations

29. As a result of the discussions, the Expert Group formulated certain recommendations for action that might be initiated by developing countries and by UNIDO in co-operation with developed countries with a view to encourage development, introduction and promotion of the use of plastics in the building industry The recommendations are summarised below:

A. Developing countries:

1 The Working Group recommends that with the availability of plastics raw materials in a number of developing countries, the use of plastics as building materials should be encouraged wherever found suitable and economical Also this would help supplement the shortages of traditional building materials in the region. The Group recommends specifically that UNIDO make available, as soon as possible through Senior Industrial Development Field Advisers to developing countries, the results of this meeting and indicate that UNIDO can provide expert help to the developing countries to assess their particular problems.

2. Keeping in view the varied climatic and socio-economic conditions in the developing countries, the Working Group felt that the development and introduction of plastics building products should be gradual and systematically organized

3. It would be essential to educate the builder in the proper selection and use of plastics building components This would necessitate organizing education/training programmes for the benefit of architects/engineers/building contractors, publication and issue of suitable technical literature on various aspects of use of plastics in building

4. It would be worthwhile collecting and compiling case-histories of the use of plastics in building, if any, in the developing countries This would facilitate future development of the use of plastics as building materials in the region

5. Relevant performance specifications in respect of plastics building components should be formulated to facilitate their ready acceptance by the local building industry.

B Developed Countries:

1 Devote attention to assisting the developing countries, particularly in supporting UNIDO programmes, to encourage mass-production techniques for housing

2 Take part in specific UNIDO projects to encourage dissemination of information about plastics for building applications, particularly bearing in mind that this offers opportunities for faster rates of house production. This could include the provision of non-commercially oriented literature and specialist advisors and the provision of models and full-size samples of buildings put up with systems suitable for use in developing countries, to be displayed at seminars and building exhibitions.

3. Participate, as far as possible, in setting up industrialised housing systems to use present and potential local resources.

C. UNIDO in co-operation with the United Nations Centre for Housing, Building and Planning and other United Nations and international organizations and agencies:

1. Send out inter-disciplinary teams of experts to developing countries to examine user requirements and relate this information to the possibility of local industrial production of housing using plastics with emphasis on present and potential local resources;

2. Initiate Fellowship Programmes for experts from developing countries and organize, as early as possible, inter-regional seminars in developing countries on the use of plastics as building materials;

3. In order to expedite the organization of necessary meetings, UNIDO should consider the joint participation with outside professional organisations in provision of facilities and funds for such meetings;

4. Establish criteria for evaluating housing systems, which incorporate the use of plastics, make available this information at the request of developing countries and assist them in evaluating the cost, performance and adaptability of any proposed system to local climatic and socio-economic conditions;

5. carry out feasibility studies based on the prospective market in developing countries for housing systems incorporating the use of plastics materials;

6. Organize an Expert Group Meeting on mass-production techniques for housing in the developing nations and

7. Encourage and assist the developing countries in organizing research and development programmes in respect of the use of plastics in building to meet the local building industry needs.

Annex 1

Project Description

Expert Working Group Meeting

on the

Use of Plastics in the Building Industry

30. The increasing need for building materials, coupled with the growing capacity of the petrochemical industry in certain developing countries has encouraged UNIDO to examine the utilization of plastics in building. It is expected that this activity will expand the quantity and variety of building materials and at the same time will develop an outlet for locally produced petrochemicals.

31. The housing problem throughout the developing countries represents one of the greatest challenges in history. The demand for dwellings and the number of people without adequate shelter is increasing in proportion to the population growth. It is therefore felt that all possible measures should be taken to increase productivity within the building construction sector. This applies to both traditional and non-traditional production and uses of materials.

32. UNIDO is already convening seminars and workshop and in-plant training programmes within the traditional field of the building materials industries hoping that the greater availability of traditional building materials also will lead to increased activity in the building construction sector. In the non-traditional sector, many experiments have been carried out but until now, no massive building construction venture has been introduced. Availability of non-traditional building materials does not necessarily lead to any increase in the non-traditional building construction sector, due to the questions of technical or economic feasibility, or even acceptability. Except for a few special uses in the building construction sector, where non-traditional materials have been used, all major ideas and materials have been known for the at least last century.

33. Since the traditional building construction sector will have difficulties in satisfying the ever growing demand for housing, there exists a need for examining non-traditional solutions. This means that all non-traditional materials and technologies have to be

reviewed, bearing in mind that the potentiality of each materials has physical and chemical properties aiming at specific functions or excluding specific functions. Perhaps no substitution for many traditional materials will be found within this century, if production prices are taken into consideration.

34. Functional possibilities

As long as we speak about traditional construction, it is possible to introduce new materials to a limited extent, without taking too much into consideration the environmental change introduced, since the main part of the house is traditional. But if we hope to increase productivity within the building construction sector, by introducing a vast variety of new materials such as different plastics, we have to consider the whole complex, taking into consideration for each functional proposal "to go where in the house, and with what", in order to make the projected house. It is not enough to have the best and least costly materials for walls if no type of roof can be found to fit into the functional idea. Therefore, ideas for new structural materials must be complete in the sense that all functional requirements have been worked through in order to provide a complete and acceptable human shelter.

35. Materials

A variety of new materials is available today ranging from foams to solid materials most of which are basically organic having up to 90% filler material included, therefore they have properties approaching those of the solid filler material. Most, if not all, of these materials have no permeability to moisture and air, and the electrical properties are quite different from those, say of adobe or from asbestos cement products.

Therefore, it is necessary to specify the properties for all availab materials, and then try to put a valid human shelter together. Among the properties to be considered, although of a secondary nature, is durability. Durability is always connected with the environmental conditions and it is wise for producers of construction materials to consider how the different materials stand up under the influence of: ultraviolet light (sunshine), stress, strain, ageing wear (e.g. sandstorm), temperature changes, dry climates, termites, bacteriological attack and

chemical attack (by SO_2 or other waste gases). All of these occurrences are part of daily life in many parts of the world, and it is necessary to know the result of their impact on these new materials. Maintenance requirements should also be considered as new materials will call for special procedures to avoid unsuitable repairs.

36. Object

With this exercise we hope to provide new information for the building construction sector and to collect and display new ideas. We are not seeking emergency solutions with less desirable elements as regards housing environment. Experts working on ideas must carefully specify whether a selected material does not quite meet their ideal standards, since further improvements might soon furnish them with the required material. All proposals in this field should be action oriented.

Annex 2

Summaries of papers presented at the Meeting

Scope for Plastics in Building

J.R. Crowder

Plastics are very valuable for building, but their scope is not limitless. They have limitations in fire performance, lack of rigidity and tendency to creep. They have temperature limitations and high thermal movement.

Roof requires to be light in weight and may offer an application for plastics. Roof-support, normally walls require rigidity, often mass to increase thermal capacity and plastics offer fewer advantages, although there may be a place for them in sandwich composite construction. Joints call for greater care in design with larger plastics units than with smaller units of traditional materials. Floors offer scope for plastics mainly in coverings and foundations.

There is some scope for plastics in secondary elements, doors, lighting and windows, partitions and finishes. All must be considered on a cost/effectiveness basis as compared with other available materials.

Plastics have application in elements to control the environment - particularly thermal insulation but they offer their greatest advantages in the field of services, because of the forms in which they can be produced - extrusions, mouldings etc., and their remarkable resistance to corrosion and biological attack.

Use of Plastics leads to improved living standards rather than meeting the basic requirements. Obstacles to progress apart from technical limitations are: economic price and availability of the materials; psychological resistance to new ideas and legislative - restrictive regulations based on traditional materials.

There is need for development of better materials and better understanding of the properties of existing materials but much greater is the need for education of the user and designer to ensure that maximum advantage is taken of the formability and limitations of plastics.

Problems of Plastics Biodeterioration in Tropical Areas

H.O.W. Eggins and J. Mills

Polymers are largely resistant as food materials for all organisms; there is some evidence to suggest that certain polyurethanes might have a water soluble function which can be utilised, and they can be mechanically damaged by insects when used in the form of foams.

In contrast, plasticisms may be attacked by microorganisms but can be protected by the use of appropriate compatible biocides (by consultation with manufacturers) or by the use of the many non biodegradable plasticisers (care should be taken to ensure resistance).

Termites and rodents can mechanically damage plastics, where these act as barriers this problem can be alleviated by increasing hardness or by the use of appropriate repellants and/or biocides.

Microorganisms such as fungi, algae, or vertebrae can grow on the surfaces of plastics and cause severe aesthetic deterioration, although the mechanical properties may remain unaffected.

Laboratory testing can give some indication, sometimes very clearly, of the possible biodeterioration hazards of a particular material, but it cannot be too strongly stressed that environmental and in service testing is essential to ensure freedom from such hazards. The use of biocides should always be used cautiously. Much information already exists on these hazards and we would always recommend adequate consultation and where necessary, testing in conjunction with recognised experts.

The Problem of Emergency Housing in Developing Countries

H. Schultheis

The introduction of plastics in building as a structural material has been highly developed in the last ten years. Particularly in the field of industrial construction, prefabricated construction elements for hangars, halls, production units and so on, the continuation of PVC coated steel sheets with a polyurethane foam core. In the sector of apartment houses, constructions using prefabricated wall elements and installation units using plastics rose to a considerable amount. The elaborated fabrication methods of these kinds of construction can with some modifications easily be translated to the housing programmes of developing countries.

A system of producing polyurethane foam by the spray method has been developed. The system was used for emergency housing for earthquake victims in Turkey. This consisted of blowing up an hemisphere of plastic sheet rotating on a disc and spraying up the foam mixture of polyurethane components. By this method, a thick layer of foam was established on the surface of the hemispheric balloon, and after solidification of the foam and removing the blown plastic foil, an hemispheric 'igloo-like' room was produced, which could serve as a first shelter for victims of earthquake, fire disaster or other cases of emergency. This system was proved in its sufficiency first in May 1970, when a very heavy earthquake in Turkey caused great damage and destroyed the houses of many thousands of people. A number of such 'igloo-like' shelters were built up for the victims. Similar shelters were also erected for earthquake victims in Peru, South America.

The experiences made by these occasions showed that it is possible to build up first aid houses in about one hour for each unit and to equip them with the necessary windows, doors and also sanitary installations.

Plastics with Traditional Materials in Industrialised Building

P R. Chant

Plastics would not be used for bad bearing applications due to their creep characteristics so that plastics in combination with the traditional materials would be the general theme, the latter filling the structural role, plastic materials would only be used where they were both economically and technically the most suitable material for a given application. Small, repeated components would be used which would be suitable for all functional types of building and for all design variations for one type. This latter point would enable almost complete design freedom, at the same time enabling simple inter changeability of components as well as simple replacement which would facilitate both layout variations after completion of the building and maintenance.

The performance of the components has been fully demonstrated in the laboratory and in the field for Western European conditions. The performance in an underdeveloped country would depend on the actual location and would need to be evaluated where necessary to study the particular effects likely to be encountered.

Use of Plastics in Building in India

O.P. Vatra

The increasing investment in house building activities to meet the growing housing needs in India has correspondingly demanded the development and expansion of the building materials industry. The shortage of traditional building materials and their successive high cost of production have necessitated the development and introduction of new building materials including plastics, which may be economic in use and also offer certain advantages in their service performance.

The petrochemical based plastics industry has already been established in India. The present production of 100,000 tons of plastics raw materials is expected to increase to 260,150 tons by 1973-74 and 542,700 tons by 1979-80. Consequently a portion of the raw materials would get converted into products of interest to the building industry. Already a range of plastic building products have been introduced and these have been under performance evaluation over the last five years. Since plastics are relatively new building materials, difficulties have been experienced in their introduction in the building industry. To overcome the difficulties and create proper awareness and appreciation for advantages and limitations of the use of plastics in building, the National Buildings Organisation, which is a national co-ordinating agency for the building industry in India, has taken the following steps:

1) establishing suitable communications media between plastics building products manufacturers and their users, through issue of technical notes/publications;

2) organising training courses/get-togethers in the proper selection and utilization of plastics in building;

3) formulating suitable standard specifications and codes of practice incorporating plastics as building materials; and

4) undertaking experimental installation of plastics building products with a view to assess their service performance.

The use of plastics piping systems for cold water services has made a beginning in India. Sanitary fittings and building hardware in plastics are gaining favourable acceptance in India.

With the availability of larger quantities of plastics raw materials, efforts are being made to develop and introduce new building products based on the experience gained in the developed countries, and user requirements of the Indian building industry.

Some Problems Associated with the Development of Building Industry

C.G.R. Hallam

The demand for increased output of buildings coupled with higher environmental standards is encouraging the building industry to use new methods of construction and management. Performance statements coupled with cost control are tools currently being employed. It is difficult to accurately specify the physical performance required of a building component, but it is almost impossible to be sure of the psychological and cultural requirements which various regions of the world will require as we move from the traditional building methods to new building materials and forms.

The main questions raised during the discussions were:

1) the problem of manufacturing need against site assembly need, and
2) how a building designed for one social purpose - such as a holiday house - may be rejected if used in another context - such as urban living.

It was felt that a prime need is for information to be prepared in such a way that direction can be given to future programmes of work -

a) information upon physical needs of a country or zone
b) information upon cultural needs of a zone

A small multi-disciplinary group of, say, architect, plastics technologist and local representative could well be a way of doing this.

Defining Functional Requirements on Building Materials

T. Cronberg

The main goal of housing is to satisfy the requirements of the user. With user's or human requirements, the requirements on the built environment are meant, which are derived from the user's needs. These human requirements are transferred to functional (when qualitative) or performance (when quantitative) requirements on housing hardware.

The characteristics of both human requirements and the corresponding functional requirements on hardware are:

- they are oriented towards the use of the building and the user.
- they are independent of the technical solutions and materials used.

To study the human requirements we must collect information on the user's habits. As information on human needs is hardly empirically accessible today, it is suggested that information is collected on user characteristics (such as his social and cultural background, age etc.) and user activities, for which the house is to provide a framework.

The human requirements are discussed and related to environmental attributes - climate, spatial and structural characteristics, appearance and equipment.

The transfer to requirements on building hardware - elements, components and materials - is considered regarding:

- which parts of the hardware affect the satisfaction of the requirement.
- the re-formulation of the user requirements to more technical terms.

When quantifying the requirements on hardware, information on the given conditions is necessary.

The implications for plastics as building materials will be two-folds

- the formulation of requirements in functional terms will help the introduction of new materials;
- when designing solutions using new materials, we have to know which requirements are important for the use of object and which requirements are related to the use of specific material.

Low Cost Housing in Developing Countries

S. Berglund

For an untraditional approach towards low-cost housing in developing countries, human requirements must be thoroughly studied for each area (traditions, climate etc.). The user's needs could then be met using plastics for different applications in a home. The idea is based on the fact that services are wanted by most people and these must be incorporated in the structure.

After the design of a masterplan, one could start preliminary ground work and then lay down a SERVICE NET that would contain pipes for fresh water and sewage, electrical wires etc. A SERVICE FRAME for equipment like water taps, toilet bowl and electrical outlets would be attached to the service net. The structure could be erected independently.

Report on the Use of Plastic Materials in the Mass Production of Low-Priced Houses for Developing Countries

K A. Rohé

Based on the information obtained from more than sixty developing countries, and incorporating the skill and know-how in the plastic fabricating area, as well as the knowledge of the long-term behaviour of plastics materials, the following may be summarized:

1. The reaction of the countries including government agencies as well as private companies, towards the use of plastic materials in the construction of houses may be described as definitely positive as long as the buildings under consideration, i.e. shape and appearance, look like conventional homes.
2. The system finally selected among a great number of already existing ones, and referred to as the WELZ System, was also widely accepted and, therefore, used as a basic concept to start with.
3. Parallel to the initial design work, an advanced manufacturing scheme has been developed in order to enable the production of the walls, roofs and partitions in a most economical way. This system allows for the continuous, fully automatic production of all the major sections required.
4. The first production line (10-20 houses/day) for the manufacture of houses utilizing the Welz System is already designed and will most likely be set up soon.
5. To set up plant for mass production (approximately 100 houses/day), approximately twelve to fourteen months are required, and according to the statement of competent equipment manufacturers, after that, one production line per month could be made available.

Plastics Building System

G Strauss

A box-like building system using plastics materials has been designed. Called 'Polybox', it essentially consists of six equal elements of 2.40/2.40/0.70 metres, moulded in glass-fibre reinforced polyester resin. The elements are assembled together by using neoprene structural gasket, to form a box-like structure. The elements are all of one size and are moulded using one mould. The elements could be assembled into a box easily by two persons, and converted into a room or two or a series by inter-forming. The box, when assembled, has a volume of 23 m^3 in contrast to the transporting volume of about 4 m^3 (all the elements being of the same size and design could be packed into a crate)

The construction of the element is so designed as to have a wall-thickness of 40 mm, with 2.0 mm of glass-fibre reinforced polyester resin skin on either side, and sandwiched with polyurethane foam as a core. The structure is basically a cube of dodecahedron divided into six equal elements. By using a separate supporting structure, the use of 'Polybox' is also suggested for multi-storied apartments.

The G.A.L. System

H.H. Olrik

The system is developed directly from an adaptable, light weight building system, used in Denmark for public facilities (kindergarten, nurseries, health stations). That system is based upon sandwich elements, 120 cm. wide and one storey high, made of chipboard on wood frames, the cavity filled with plastics foam, and with a skin of coloured polyester resin outside. Windows of any form can be cut out of the elements. The roof is a simple element of chipboard, foam and plywood covered with rooffelt.

To suit the conditions in developing countries the existing system is changed radically. The sandwich elements for both walls and roof are made of glass-fibre reinforced polyester and self-extinguishing type foam. Foundation and floor are made locally of concrete.

The elements can be made locally in a simple hand-lay up/or more mechanically in a fast process (one hour per house). The investment will be very small compared with that which is usually encountered with the production of building elements.

The elements are very light, three 40 m^2 houses can fit into a twenty foot container, forming a total load of four tons.

The number of standard building elements are very few, to reduce costs. The manufacturing process can start with hand workmanship and later be very much more mechanized.

It should be possible to erect the building on a 'self-help' basis, or with unskilled labour. Adaptability is required to suit any given house type and climatic conditions, including the initial construction and any future extensions. Production must be multi-purpose: both for high and low rise buildings and for separate functions, such as for schools, hospitals and administration buildings.

A Survey of Plastics Materials and Their Effective Utilization as Building Materials

A. G. Winfield

The original 1969 study and its updated 1971 addendum is an historical statement of the state of the art of plastics in building in most major countries of the world from the 19 Os to the present time.

The paper presented work accomplished and being currently researched in a selection of major American universities. It also outlined five projects in which the author was personally involved, including:

Emergency building programme for areas devastated by natural emergencies, i.e., flood, tornados, earthquakes etc.

The WIN-MAR System of low cost housing for developing countries.

Plastic Foams for Housing

W.T. Meyer

Urea-formaldehyde chemicals for foam generation are now manufactured in the USA, West Germany and Canada. Urea-formaldehyde chemicals foam is an excellent thermal and acoustical insulation material. The foam is a modified urea-formaldehyde resin. It is generated from two water solutions: one is the urea-formeldehyde resin, and the other is a foaming agent. One volume of liquid yields over thirty volumes of foam. The resin is cold-setting and forms a low-density, non-combustible, non-toxic resilient plastic foam. The material has the ability to flow into odd-shaped spaces. Setting takes place ten to sixty seconds after it leaves the applicator gun. The structure of the foam is a microscopic sized cell agglomeration interspersed with microscopic capillaries which are irregular and discontinuous. The standard density of the foam is 0.6 lb/cu. foot. It has 60% closed and 40% open cells.

Temperature or humidity variations will not cause the foam to change volume or exert pressure. The foam does not offer any structural application in the building industry. Hence, it needs spraying directly on the substrate, to provide thermal and sound insulation characteristics.

The paper discusses some of the possibilities of using this foam in the building industry.

Annex 3

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Mrs. R.H. AL KAISSI	Administrative Assistant Industrial Technology Division
Miss S. HILLS	Industrial Technology Division

Annex 4

List of Documents prepared for the Meeting

ID/WG.96/3
ID/WG.96/14

A SURVEY OF PLASTICS MATERIALS AND THEIR POTENTIAL EFFECTIVE UTILIZATION AS BUILDING MATERIALS AND BUILDING APPLICATIONS FOR DEVELOPING COUNTRIES
Armand G. Winfield
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ID/WG.96/4

PROBLEMS OF PLASTICS DETERIORATION IN BUILDING IN TROPICAL AREASE
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ID/WG.96/5

THE USE OF PLASTICS IN BUILDING IN INDIA
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ID/WG.96/6

REPORT ON THE USE OF PLASTIC MATERIALS IN THE MASS PRODUCTION OF LOW PRICED HOUSES FOR DEVELOPING COUNTRIES
Karl A. Rohé
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Lugano, Switzerland

ID/WG.96/7

SOME PROBLEMS ASSOCIATED WITH THE DEVELOPMENT OF THE BUILDING INDUSTRY AND WITH THE ACCEPTANCE OF NEW MATERIALS, COMPONENTS AND BUILDING FORMS
C.G.R. Hallam
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ID/WG.96/8

PLASTICS WITH TRADITIONAL MATERIALS IN INDUSTRIAL BUILDING
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ID/WG.96/9

SCOPE FOR PLASTICS IN BUILDING
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ID/WG.96/11

PLASTIC FOAMS FOR HOUSING
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ID/WG.96/12

DEFINING FUNCTIONAL REQUIREMENTS ON BUILDING MATERIALS
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ID/WG.96/13

LOW COST HOUSING IN DEVELOPING COUNTRIES
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Annex 5

Display of 'Polybox' System

The participants of the meeting were provided an opportunity to visit the site in Vienna where 'Polybox' System had been erected. The System has been designed by Mr. C. Strauss, a practising architect in Austria. The System utilizes glass-fibre reinforced polyester resin (GRP) and polyurethane foam as the plastics materials. It consists of six elements of equal size (2.40/2.40/0.70 metres) and design, and makes use of one mould for GRP mouldings.

The System is novel in design as it provides easy manipulation in its erection, extension and provisions of common facilities. Neoprene structural gasket is used to join the elements. The System is basically a cube of dodecahedron having a volume of 23 m^3 and the individual elements could conveniently be packed into a crate for transportation.

The participants appreciated the compact design and assembly of the System.

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