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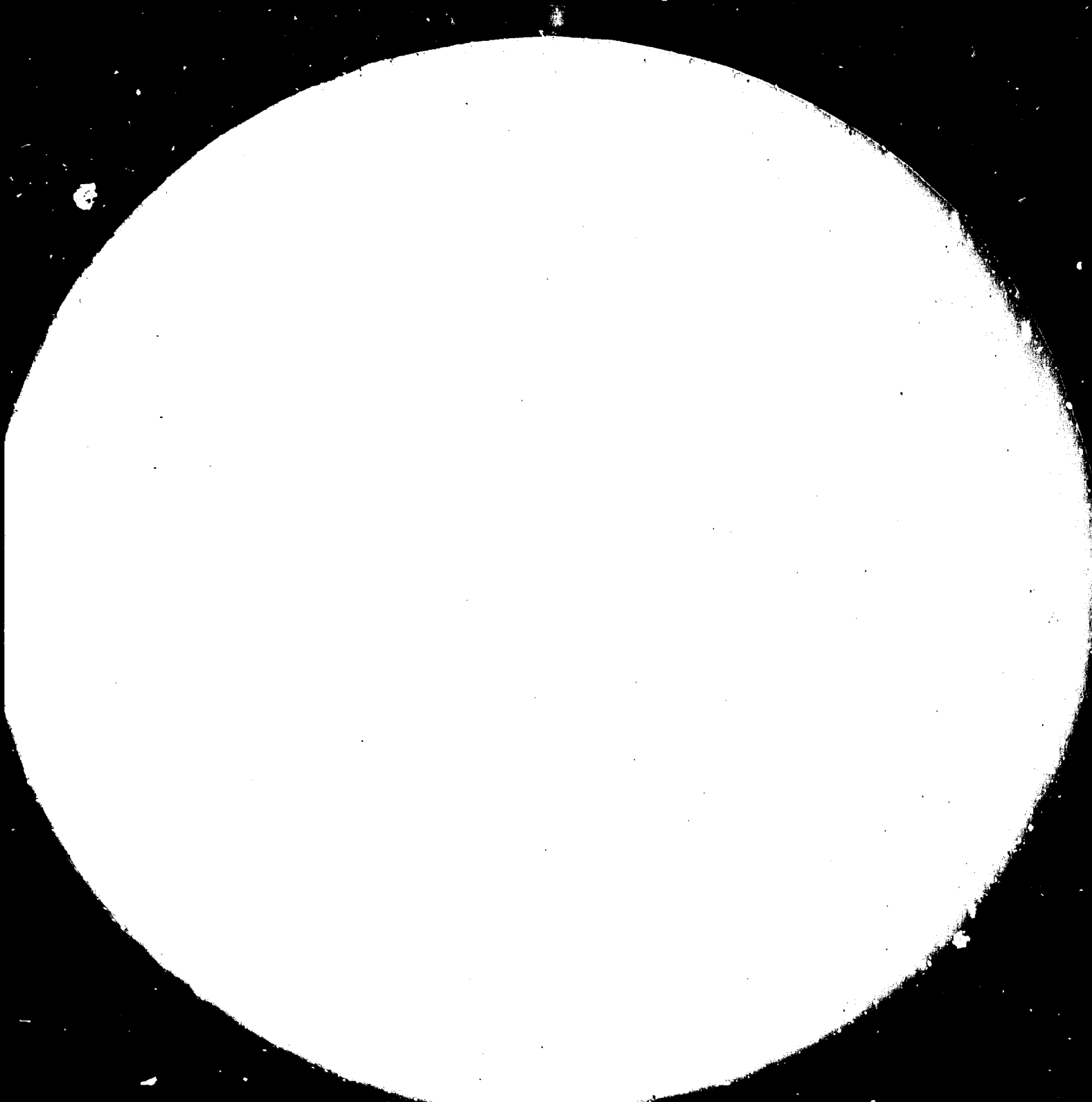

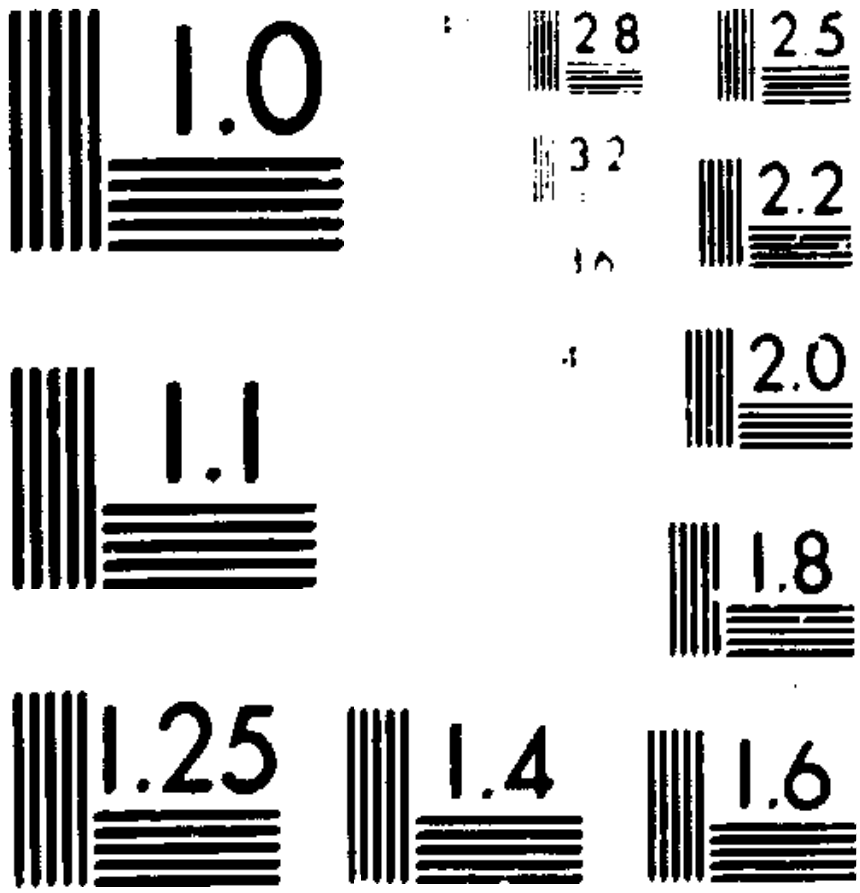
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PLASTICS IN THE BUILDING AND CONSTRUCTION INDUSTRY*

by

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SUMMARY

Plastics have a unique range of properties that fit them for numerous applications in building, but also impose some limitations on them.

Applications of plastics cover most areas of building and are discussed in terms of structures, secondary elements and services, which are their most important field of use.

Although there are some limitations on the use of plastics, there are a number of ways in which they might be used more effectively and some suggestion is offered on how this might be achieved.

1 INTRODUCTION

Plastics are not new or unknown materials, even in the conservative building industry which, in most countries, has used plastics for more than a quarter of a century in an increasingly wide range of building applications.

Brazil consumes about a million tonnes of plastics annually - about 50% of UK consumption, but enough for them to be widely distributed, so that most people are likely to be familiar with the materials in some of their applications. However, it has been estimated that, in the UK, as large a proportion as 20% of the output of plastics is used in building applications and it is unlikely that this will be reflected in their usage in Brazil. When the British economy was more active, as much as 8 kg of plastics per head of population was estimated to be used in building and construction, accounting for more than 7% of the total cost of building materials. The range of applications of which experience has been acquired is very large. It is the intention of this paper to pass on some of this experience to enable the plastics industry in Brazil to make an increased contribution to the better performance of all types of buildings.

In the paper, the emphasis is on the range of applications and uses of plastics in building in the UK and in a number of overseas countries. To help put this in context there is an introductory section on the properties of plastics in relation to their use in building - the advantages they confer and the limitations they impose. In discussing the various applications, comment is made on their performance in tropical countries, where high temperatures and long hours of sunshine can cause some problems. There are a number of constraints and obstacles to the wider use of plastics in building and these can usefully be considered in offering suggestions for the proposed Plastics Development Centre and how it might most usefully influence the growth of plastics in building and construction.

2 PLASTICS AND THEIR PROPERTIES

Although, in a general sense, the properties of plastics are well known, to many of the members of the Congress this knowledge concerns primarily properties related to processing and to short-term performance. It is worth considering particularly those properties that fit plastics for numerous applications in building. It should be borne in mind that there are a great many different plastics materials available, with properties that can be modified in various ways - by use of additives, plasticisers, stabilisers, colourants, reinforcements; by varying molecular sizes, shapes, and degrees of cross-linking; and by processing them in different ways. Nevertheless, as with metals, the properties of the different plastics have a good deal in common and are discussed in the following paragraphs.

No other materials can be produced in such a wide variety of forms and colours, and some also are available in translucent or transparent forms. They are processed by a range of techniques - injection and low-pressure moulding, extrusion, post-forming, as well as machining, to produce components of appropriate design, taking advantage of the materials' intrinsic properties.

Most building materials are fairly heavy, and lightness in weight is not necessarily a consideration with building components, but often gives plastics an advantage in ease of application or improved site handling, and also in transportation in remote areas.

Corrosion resistance, particularly where plastics are used as metal replacements, can lead to good durability in a wide range of environmental conditions. This is a major consideration where investment in new work is most important and is not detracted from by the need for maintenance and replacement of components. Plastics are also used increasingly as alternatives to timber and are not subject to biological attack.

The differences between plastics and conventional building materials are noticeable in terms of their mechanical properties. Lack of rigidity and a tendency to 'creep' limit their performance, and must be taken into

account in design. At elevated temperatures, there is a rapid decline in strength, so that maximum working temperatures are under 100°C for many thermoplastics. Account must often also be taken of the large thermal expansion of plastics relative to most traditional materials.

Fire behaviour often also imposes limitations. All plastics materials are combustible by reason of their carbon-based molecular structure and this inevitably restricts the structural use of plastics. Although they may not contribute much to fire load, the ability to spread flame, and the noxious fumes and dense smoke that many of them produce on burning, do require careful consideration.

Durability in hot climates is necessarily a cause for concern - as it is for most building materials. Their weathering behaviour may put plastics at a disadvantage compared with inorganic or metallic materials, and although improved plastics formulations enable many of them to be used satisfactorily in outdoor applications, the life expected for many building components limits the choice of plastics.

Traditional building materials are not without limitations, and plastics are used advantageously both as alternatives, and as a supplement to the existing range of building materials. Particularly in a country like Brazil, with an active and expanding petrochemical industry, plastics building products must be a major outlet for that industry, adding to its economic viability.

The information available at the time of writing the paper indicates that four main types of resin are available in Brazil, namely polyethylenes (LD and HD), polypropylene, polystyrene and polyvinyl chloride, and that most of these are locally produced. These materials account for the bulk of world-wide use of plastics in building but other materials play an important part and are often used in the more interesting applications; they may not all be readily available at present but it is useful to refer to acrylics, abs, polyurethanes, polycarbonates, phenolics and polyester resins; these and others find application in building and construction.

3 APPLICATIONS

There are few building components for which the use of plastics has not been considered. In all applications, the question should be asked, 'What advantage can plastics offer?', particularly if traditional materials are already used satisfactorily. Different areas of application are considered, under the headings of building structure, secondary elements and services. A general list of accepted areas of application of various plastics materials is shown in the Appendix.

(i) Structure

Traditional building materials have many advantages, not least in terms of local availability, strength and rigidity, and fire behaviour. Concrete blocks, clay bricks, timber, tiles, are available in readily manageable sizes that lead to construction methods and styles that are understood and accepted by users. For larger buildings and construction elements which require structural engineering design, structural steelwork and reinforced concrete, sometimes prefabricated, often fabricated on site, are the most normally accpeted materials. Plastics are less adaptable; when lack of rigidity and fire performance are taken into account, the use of structural plastics is limited. Glass-fibre reinforced plastics have been used, however, in many buildings ranging from simple shelters to sports halls and from petrol stations to airport terminals. Double curvature and folded-plate design may be used to achieve rigidity but can lead to architecturally interesting shapes. Problems with acoustics and thermal control as well as questions of cost, however, limit their use in more everyday and low-cost housing applications.

Plastics are widely used in lesser structural components; lightweight wall panels combining advantages of handleability, colour, durability and resistance to water penetration, may usefully incorporate several plastics components both in architecturally shaped and textured external surfaces and internally as insulation. Sometimes panel systems are used to upgrade structural walls of traditional and heavier materials. In their own right they can provide the basis for buildings better adapted than traditional designs to the economic use of air-conditioning, so widely incorporated in today's buildings.

(ii) Secondary elements

Corrugated translucent plastics sheeting was one of the earlier major building applications of plastics but durability, particularly in hot countries, remains a problem and it is more likely to find use under the eaves of a building than as roof-lighting, and the need in sunny countries like Brazil is often for limited daylighting rather than for the high levels achieved with roof-lights. Nevertheless, the use of plastics dome-and pyramid-lighting units for roofs has increased in recent years aided by improved designs and better materials.

There is a growing use of plastics as alternatives to timber in doors and window-frames - this last being one of the major growth applications in Europe in recent years. The freedom from maintenance and from termite attack can be a worthwhile advantage although, as they are less easily trimmed to size than timber components, design modifications may be necessary.

One of the best accepted uses of plastics is to provide decorative and hygienic surfaces with better water-resistance than traditional finishes, on a range of substrates.

At the present time, when expectations of thermal comfort are higher than in the past, either through more heating in cold climates or air-conditioning in hot weather, and when energy conservation is at a premium, the use of lightweight cellular plastics has increased greatly in importance. They are very effective thermal insulating media in slab or sheet form, and in some cases are foamed 'in situ'. Low weight to volume ratio makes transport uneconomical over long distances, but manufacturing investment and running costs are modest, and the manufacture of polystyrene beadboard, and some forms of polyurethane foam can be useful parts of a developing plastics industry.

(iii) Services

It is in the field of building services, and particularly replacement for metals, that plastics find their most important role in building. Their relatively high cost is less of a deterrent to use in this area of high

performance applications, where metals are the principal alternatives and where accurately shaped components are essential. Formability facilitated the initial introduction of plastics in designs that had been developed for metal components; this same formability has in many cases led to the re-design of systems, where the plastics' properties are used to advantage. Corrosion resistance also leads to reduction in maintenance with systems that may not be easily accessible, and the relative ease with which some metals are damaged in handling may give plastics an advantage.

a) Water supply

A British Standard for polyethylene pipe for cold water services was first published in 1953 and the intensive development since then, of both plastics materials and processing methods has led to a continuous improvement in performance. PVC, polyethylene and polypropylene are all used for this application, although the relative costs of copper and plastics in the UK have tended to favour the former, as well as its proven performance for hot water services. When plastics are used, pvc is usually the choice for internal water services, while polyethylene, because it is available in continuous lengths which can be uncoiled from drums, is commonly used for outdoor applications and long-distance supply. Long-term testing of strength and chemical properties have confirmed the materials' suitability. Joint systems based on mechanical, fusion and solvent-welding techniques make the installation of plastics water systems quick and straightforward and appropriate methods have been designed for support of pipelines and the accommodation of movement. In this 'International drinking-water supply and sanitation decade' pipes and drains are an essential requirement for this aspect of improved living standards in the developing world, and plastics have a major role to play in this development.

As well as pipes and a range of fittings to go with them, valves, taps, cisterns, basins and baths are all now made in plastics and extend the use of these materials in water supply.

b) Drainage

The exclusion of rainwater is a constant consideration in the design of buildings, and rainwater pipes and gutters were the first drainage application of plastics in those countries where accepted usage could accommodate a change to the new material. In the UK, plastics have virtually displaced all alternative materials in recent years, and have been followed by the introduction of plastics waste and stack pipes for all domestic effluents. An even more important market is for underground drainage, where, following studies of performance under changing temperatures and a range of soil loadings, PVC systems are now widely used. For these various systems, large ranges of moulded joints and fittings have been developed to be used with the extruded pipes, as well as plastics inspection tanks, settlement tanks and cesspits, mostly in glass-reinforced plastics; the simplicity of installation of these systems has helped to compensate for an increasing complexity of plumbing requirements, and a decline in the availability of skilled plumbers.

Experimental hot water service systems have been produced in plastics but have made only limited progress because of difficulties in designing to allow for the large thermal movements and for tendencies to creep at elevated temperatures. For ventilation pipework, though, plastics pipes have made considerable progress, despite the need for designs of systems to exclude the possibility of spreading fire.

It will be appreciated that plastics used in services lead generally to improved building performance but make no contribution to structural advances. Often, better standards of accommodation and performance are more necessary, particularly in developing countries, than 'improved' basic forms of construction.

4 OBSTACLES TO THE WIDER USE OF PLASTICS

Reference has been made earlier to technical limitations on the use of plastics. In particular, their resistance to penetration by fire cannot compete with that of most inorganic building materials, limiting their

structural use. The ease with which many plastics are ignited, and the rapidity of flame-spread across the surfaces of some plastics, may often impose more severe restrictions, although there are ways to improve their performance. The BRE Fire Research Station has actively studied the problems of plastics for many years and has made major contributions to assessment of the fire requirements for buildings and of the performance of plastics. The Station's experience is the basis for advice on fire requirements and regulations in a number of overseas countries: indeed, at time of preparation of this paper, the Station is involved in the preparation of a design guide for Brazil on the protection of structures against fire.

The durability of plastics may not always be good enough for outdoor building applications even in the UK climate; in the tropics, higher temperatures and longer hours of sunshine accelerate the weathering process by a factor of three or more. Nevertheless, some plastics do have acceptable weathering behaviour, although the evidence of this is often limited. In the past, the Building Research Establishment has studied the weathering of plastics in Ghana and Nigeria. Currently the Establishment has in progress investigations on plastics, among a range of building materials, exposed at weathering sites in the United Arab Emirates and in Sierra Leone, and also on their resistance to sand-abrasion at a site in Kuwait. Even the incomplete knowledge available at present enables useful advice to be given on their behaviour in the tropics.

Despite the limitations, plastics do have considerable technical advantages which may indicate that they would be preeminently suitable for solving many of the problems of a country undergoing rapid development, but they do not necessarily surmount the obstacles in introducing plastics in construction.

Relatively high cost has often been quoted as a deterrent to the use of plastics. In world markets this consideration does not always apply nowadays, even in terms of initial costs. Costs-in-use may show benefits

for plastics although, as they may result from savings in labour cost, the advantage may be marginal in a country where labour is plentiful.

The availability of plastics, and its relationship with supplies of products made in other materials, is an important consideration. With the flourishing plastics industry that exists in Brazil, the need may be to develop products appropriate for the local market and to distribute them through effective lines of supply. The demand is likely to be large enough, with the limitations on importing materials from active sources of supply in Europe and North America, to enable a viable market to be established.

It has been the experience in many parts of the world that a technological background increases the acceptability of new products and methods. Although there may be difficulties outside the cities, the market in Brazil should still be able to accept large increases in the use of plastics, with the realisation of improved effectiveness of building performance. It should be borne in mind that the long-term acceptability of plastics products is likely to be influenced greatly by the performance of the plastics components that are introduced first, and advantage is more likely to be obtained with well-designed and manufactured products capable of setting good examples of the materials.

In the building field especially, it is vital to accompany any introductory scheme with an appropriate programme of education. This has been very well illustrated in India, where effectiveness of education in plastics for building services, in a scheme sponsored by the National Buildings Organisation, has been a significant factor in the effective use of plastics in many development schemes, large and small.

Building codes are usually intended to ensure satisfactory standards of safety and health but because they are generally drafted on the basis of experience of traditional techniques, they tend to restrict new methods and materials. In ensuring that the regulations provide appropriate cover

for the use of plastics, it is necessary that responsible manufacturers and suppliers should ensure that new products will perform satisfactorily and provide a basis for sound, orderly development. The formulation of appropriate national or industry standards - based, if necessary, on the standards of highly developed countries but with appropriate modification to comply with local requirements - and the provision of sound codes of practice, based on thorough practical assessment in a realistic situation, should be normal stages in the introduction of new plastics products for construction.

5 FUTURE DEVELOPMENTS

It may be, in the Brazilian economy, which differs in outlook from that of many European countries, that there will be opportunities for exciting new structural applications of plastics in construction but, in the author's opinion, the greatest advances are likely to take place in the more mundane areas of application, partly in secondary elements of construction, windows, panels, thermal insulation, and especially in the area of building services; these developments will contribute especially to refinements in building performance and will have the most widespread impact on construction.

Reference has been made to proposals for a Plastics Development Centre, to be situated in Sao Paulo. Such a centre could have a very significant influence on the appropriate development of plastics for construction. It may not always produce and develop the most effective new ideas - particularly when there are private individuals and organisations able to achieve this, with a measure of entrepreneurial spirit. Where it can make the best contribution is in assessing and advising on materials and their performance, in rating the effectiveness of component design, in determining fire requirements for plastics for building and in relating their performance to these requirements. The construction industry is loath to accept new products and while codes and standards may not necessarily provide complete assurance of the performance of plastics

products they do, nevertheless, help to allay the fears of builders, whose product - the building - is expected to last for a very long time. Improvements in the quality of plastics and plastics products for building occur constantly and some contribution may be made in that direction. The Centre is likely to be most effective in undertaking studies that will increase confidence in, and familiarity with, the performance of plastics. In that way, it will ensure continued growth in their use and increased contribution to better building in Brazil for the future.

APPENDIX

PRINCIPAL AREAS OF APPLICATION OF
MAJOR PLASTICS MATERIALS IN BUILDINGS

Polyethylene (polythene) (PE)	Cold water pipes, pipe joints
	Cold water cisterns
	Sink and bath wastes
	Cable insulation
	Damp proof courses and membranes
	Site protection
Polypropylene (PP)	Cold water and WC cisterns, overflow tanks
	Sink and bath wastes
	Fittings for pitch-fibre pipes
	Wall ties
Unplasticised PVC (UPVC)	Cold water supply pipes and fittings
	Rainwater gutters, pipes, fittings
	Soil and waste stack pipes etc
	Underground drain pipes, connectors, inspection chambers
	Vent pipes, connectors, vent ducting
	Electrical conduit and trunking
	Wall-skirting
	Roof lighting and cladding sheets, dome lights
	Wall lighting
	Window frames, shutters
	Door sets, frame sections
	Weatherboarding
	Electrical conduit

Plasticised PVC	WC connectors
	Electric cable covering and insulation
	Water-stops, roof-sarking
	Floor coverings
	Wall covering tiles, wallpaper
	Coatings on boards
	Suspended ceilings
	Panel jointing strip
	Stair hand rails
	Flexible roof membranes
	Window canopies
	Air-supported buildings
Flexible pitch/PVC	Damp-proof courses
	Roof membranes
Post-chlorinated PVC (CPVC)	Hot water and central heating pipes
	Internal sink wastes
Acrylonitrile-butadiene styrene (ABS)	Water supply pipes and fittings
	Internal sink and bath wastes
	Inspection chambers, access systems
	Ventilator pipes and grilles
Polystyrene (PS)	WC cisterns
	Wall tiles
	Lighting fittings
Expanded polystyrene (EPS)	Various thermal insulating applications - walls, floors, flat roofs, pipes, soffits
	Impact sound absorbing sheets
	Ceiling tiles

Polymethyl methacrylate (PMMA) (acrylic)	Baths, basins, sinks
	Tap heads
	Light fittings
	Roof and dome lights
	Wall and window glazing
	Door furniture
	Wall lighting panels
Polyurethane (PU) and polyisocyanurate (PIC)	Various thermal insulating applications
	Flat roofs, ceilings, pipes
	Sound absorption
	Industrial flooring, floor finishes
	Jointing gaskets
	Draught excluders
Polycarbonate (PC)	Light fittings
	Vandal-resistant glazing
	Roof and dome lights
Nylon	Tap fittings
	Hinges, door and window furniture
	Door runners
	Protective coatings
Phenol-formaldehyde (PF)	Decorative laminates (backing) and wall-coverings
	Electrical fittings
	WC seats
	Composite panels of foam as thermal insulation
Melamine formaldehyde (MF)	Decorative laminates (facing)
Urea-formaldehyde (UF)	Wall cavity filling (foam)
	Electrical fittings
	Adhesives and binders for plywood, chipboard, etc

Glass-reinforced polyester (GRP)	Cold water cisterns
	Baths, basins
	Pipe liners; pipe fairings
	Cesspits, collection tanks
	Roof lighting sheets, domes etc
	Wall panelling, decorative murals
	External cladding panels
	Fascias
	Bathroom, heart units
	Structures - sports and swimming pool halls
	Domed roofs
	Church spires
	Architectural features
Other resins	
Epoxies, polyesters, acrylics, polyvinyl acetates	Adhesives, bonding agents, concrete additives, protective membranes, surface coatings
Synthetic rubbers	Roofing and waterproofing membranes
	Jointing and sealing materials
	Gaskets