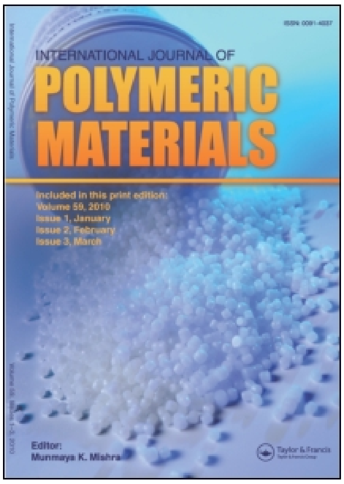

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Practical Prospects for Plastics in Building Construction

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This paper first reviews progress to date and the present status of plastics in building. Possibilities for the future are considered together with the favorable and unfavorable factors that will influence them. Among these factors are questions respecting durability, fire, costs, availability, systems of construction, education, manuals of practice, and standards. Possible areas of development include energy conservation and composites of plastics with other materials.

It is customary, at the transition from one decade to another, to assess what has happened during the past ten years and to attempt a forecast for the next ten. Hindsight is easy, foresight, especially in trying to predict the future of plastics in building, is something else again.

PRESENT APPLICATIONS

Progress has been made. Plastics are becoming more and more familiar in building. In some areas they are now staple products, generally considered to be the most acceptable materials for the application. Decorative high-pressure laminates, for example, are so widely used for table and counter tops, as well as numerous other applications in furniture and building finish, that it is hard to conceive of anything else in their place. Vinyl flooring in its various manifestations, together with "asphalt" flooring (predominantly plastic), is another application practically universally employed. Others, although not all so thoroughly entrenched as the above, include foam insulation, exterior and interior wall finishes, piping, area and local

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lighting, skylights, electrical insulation, door and window components, plumbing fixtures, and hardware parts. The list can be considerably extended.

CLASSIFICATION

Applications of plastics in building can be classified in various ways. One such classification is into (a) non-structural, (b) structural and semi-structural, and (c) auxiliaries to other materials.

Non-structural applications constitute by far the greatest volume and number of different uses. The items listed above, for example, fall into this category. They do not carry significant loads and their failure would not cause serious structural damage. Both thermoplastic and thermosetting plastics fall into this category. Their uses can be expected to increase in both volume and number of applications.

Structural and semi-structural applications do involve support of significant loads, and failure can result in serious structural damage and danger. Consequently, such applications must meet the same safety criteria as other structural materials.

COMPOSITES

For structural and semi-structural applications plastics are usually combined with other materials into composites whose properties transcend those of the constituents by themselves. These, in turn, may be classified as (a) particulate, (b) fibrous, and (c) laminar.

Polymer concrete is gaining in use in building. Polyester resins are used in place of portland cement, most commonly to provide building panels such as sandwiches of thin glass fiber-reinforced polyester concrete facings on a foamed plastic core. Such sandwiches can be thinner and lighter than heavier standard precast concrete panels plus insulation plus interior finish, or standard masonry. Their inherently higher unit cost is often offset by the smaller volume needed, and by reduced weight resulting in reduced supporting framing.

Fibrous composites almost always involve glass fiber combined with a matrix, usually polyester for building applications. The widespread use of corrugated and flat sheet may be expected to grow. These are semistructural in that they withstand wind and snow loads but are supported by structural framing. Truly structural applications usually involve shells formed to meet the imposed loads. Such shells have been employed in aircraft terminals as well as in exhibition halls and similar large enclosures. Conoids and hyperbolic paraboloids are examples. Tanks and pipe, especially to carry corrosive liquids or to be exposed to corrosive conditions, are other examples. If and as such load-carrying structures prove their worth and economy, their uses may be expected to grow.

Among the laminar types of composites, the structural sandwich has found considerable favor in building. It consists of relatively thin, strong, hard, dense facings on a relatively thick, weaker, softer, lighter-weight core. The combination provides strength, stiffness and lightness. One rather widely-adapted application is as wall and roof panels in cold-storage buildings. Cores are foamed plastic, and facings are various materials such as plywood and metal. A different type of sandwich employs thin glass fiber-reinforced translucent facings on a metal grid core. Sheet and laminated facings of various kinds combined with cores such as resin-impregnated kraft paper honeycomb cores provide other sandwiches.

All of the foregoing are existing or readily-visualized applications, and all may be expected to continue to be employed in building. There are some new developments in building that promise to be attractive for plastics.

ENERGY CONSERVATION

There seems to be little doubt that energy conservation and the utilization of unconventional sources of energy, especially solar energy, will play important roles in buildings in the future. Energy conservation is particularly important and calls for both careful design and judicious choice of materials. This offers attractive opportunities for plastics.

The first and most obvious application is in thermal insulation. Plastics foams provide some of the most efficient insulators available. They can be employed as pre-foamed shapes such as blocks, boards, and panels, or may be foamed in place, between studs and rafters, and to fill irregular and hard-to-reach spaces. Some are their own vapor barriers. The foamed-in-place varieties usually seal potential air leaks. Foam-cored sandwich panels already widely employed as in the cold-storage buildings mentioned above, as well as in the walls and roofs of industrial and commercial buildings, can be expected to find still wider use. Resin binders are employed with other insulating materials such as glass fiber. Plastics films provide vapor barriers where needed, e.g., under concrete floor slabs and in walls and ceilings.

Although windows are customarily glass, secondary glazing may employ rigid transparent plastics for tightness and ease of installation. Transparent film also provides a means of insulating windows and enclosing areas during cold weather. Weatherstripping can employ plastics as flexible seals. Metal window sash and frames that ordinarily transmit a great deal of heat commonly employ plastics as thermal breaks.

With costs of energy escalating, its conservation within buildings becomes more and more essential. Lights and equipment in the interior of a large building often generate so much heat as to need cooling year-around, whereas the perimeter in cold weather requires heating. It is becoming economical to gather the excess heat in the interior and transmit it to the perimeter and to cool the interior with cool air from the perimeter. Necessary ducts and piping can make good use of plastics.

SOLAR ENERGY

Other papers will discuss solar energy in detail, but a few words may be included here in connection with energy.

As solar energy, particularly for heating and cooling, becomes more widespread, opportunities should increase for plastics. Solar-energy applications are commonly called passive and active. The term "passive" means roughly that the building itself absorbs and stores solar energy, releasing it to the interior by non-moving means such as radiation, conduction, and convection. The term "active" means that the solar energy is absorbed and converted into heat in a collector, transmitted by some means such as air or water to storage, e.g., in a tank, or gravel bin, and then drawn upon as needed for heating or to operate a cooling system.

In either case, to avoid excessive outward losses from the original solar energy-absorbing surface, a transparent cover is employed whose function is to allow solar radiation inward, but to reduce outward loss. To accomplish this, the cover should be highly transparent to the wave lengths of radiation from the sun, but should interrupt re-radiation from the absorbing surface. Glass relatively low in iron, such as window glass, is commonly employed but is heavy and vulnerable to breakage. High-transparence plastics and glass fiber-reinforced plastics, lighter and less subject to breakage, are being used increasingly for such covers. Areas are necessarily relatively large to intercept enough solar radiation for a given application.

Efficiency of solar energy collection is increased if the index of refraction of the cover sheet is reduced. Some transparent plastics have lower indices than glass and are correspondingly more efficient for cover sheets. Resistance to weather and ultra-violet radiation is obviously important.

Active systems require piping, ducts, or both to transmit the collected energy to storage and from storage to use. The temperatures involved are usually low enough to permit plastics to be employed. Large storage tanks are sometimes concrete, and may require a waterproof lining, such as plastic sheet or film. Some passive systems use water bags on a roof. These can be plastic.

In both passive and active systems, there is a search for reliable low-cost latent-heat storage. In usual water and rock storage, temperatures rise and fall as heat is stored and withdrawn, making uniform temperature control difficult and impairing efficiency. Constant-temperature storage is preferable. In theory, at least, a number of salts and mixtures of salts can do this by freezing and melting at temperatures in the desired range for solar-energy storage. Some of these are corrosive and are best stored in corrosion-resistant containers such as plastics.

These are a few examples of possible uses of plastics in solar-energy installations. Others will undoubtedly arise as the field develops.

FIRE

Undoubtedly one of the principal questions facing the use of plastics in building is their susceptibility to fire. They are organic materials and, as such, may burn readily or with difficulty, but can all be destroyed by hot enough fires. This is true of other organic materials of construction such as wood; still, we use them because of their good properties, and try to take this limitation into account by proper design to avoid fire hazards. The same should hold true of plastics.

Other papers will discuss this aspect of plastics at greater length. It will be sufficient to say that good design provides for quick safe egress from buildings, the provision of thermal barriers for flammable materials such as foams, fire breaks and barriers. venting for smoke and gases, and quick fire suppression. A good designer also learns that the behavior of materials in laboratory fire tests is no indication of their behavior in real fires. Materials, including plastics, that behave well and may not support their own combustion in the laboratory may burn vigorously in real fires. The designer will, consequently, try to avoid such conditions and will provide for safe escape in case of fire.

COST-BENEFIT ANALYSIS

Owners and developers are turning more and more to cost-benefit analysis rather than first cost in determining true costs of constructing and operating buildings. What kind of cost-benefit analysis depends upon the owner's objective. If he is interested only in quick sale, first cost and sales appeal are probably the primary considerations. If he expects to operate and maintain the building over a long period low running costs may greatly outweight high first costs. In either event, plastics may benefit. Some may offer low first cost and appeal, but limited life, others may be expensive in the first place, but offer long life and limited maintenance costs.

Life is a relative term. Foundations and structures of a building must generally last as long as it does. Finish materials such as wall covering and flooring need not necessarily be as durable. Such items as painting and decorating which may be altered at frequent intervals need not be long-lived. Similarly, wiring and piping should be durable, but fixtures which can easily be changed and whose functions may alter with time and changing occupancy, may not need to be. Plastics may fit into any of these categories.

DURABILITY, PREDICTION

Questions of durability and predicting the useful life of a given application are vexing ones for relatively new materials in building such as plastics. Older conventional materials have a long history of use and users generally know reasonably well what to expect. Plastics do not (although each passing year adds to our knowledge) and, consequently, prospective users are hesitant and skeptical. Short-term laboratory tests do not necessarily predict long-term behavior.

It is suggested that a thorough study of existing applications of plastics in building could supply a great deal of information as to their actual behavior. There are many buildings, exposed to all conceivable climatic and use conditions, for varying periods of time, in which plastics have been employed. It is highly likely that the operating and maintenance crews of such buildings have a very good notion of how plastics behave, but that knowledge is not generally available. Some manufacturers may also have experience records, but they are not likely to reveal their failures. A systematic survey of these applications and their history of use could go a long way toward answering the questions raised by prospective owners, developers, designers, and builders. This information would also serve to demonstrate the relative validity of laboratory tests, and point the way toward more reliable tests and prediction of performance.

EDUCATION

In spite of the growing use of plastics in building, there is still considerable ignorance on the part of the building industry regarding the nature of plastics, their properties, their advantages, and their limitations. Considering the rather bewildering number of plastics and variations, and the rapid changes, this is not surprising. It does lead however, to either suspicion that plastics are only shoddy substitutes, and a reluctance to use them, or an euphoric belief that plastics are the answer to all problems. The truth, of course, lies somewhere between these extremes, and the plastics industry must educate the building industry to a sensible understanding of what can and cannot be expected.

There is a corresponding widespread lack of understanding on the part of the plastics industry respecting the nature and needs of the building industry. It is immense, but characterized by a large number of small units, none of which is large enough to dominate any segment of the highly-diverse field. It does little research, but relies upon its suppliers for that. It is highly competitive; it is easy to enter but easy to fail in it. It differs widely from the highly-centralized chemical industries that produce plastics materials.

SYSTEMS

It is not enough to have an excellent material for an application in building. The designer and user must be able to install it easily and quickly at minimum cost. This calls for the development of components and systems for the fabrication and installation of the given item. Fabrication is moving more and more into the shop, with field assembly of finished or semifinished parts. The most successful applications of plastics in building have been those for which carefully thought-out systems of installation have been developed, minimizing the efforts of the designer and user, who may be quite unfamiliar with the properties and limitations of plastics.

AVAILABILITY

Closely allied with the requirement for ease of installation is availability. A product may be specified, but if it is not easily obtained, substitutions will be made. Introducing any new product is not easy, considering the many thousands of building materials dealers and the intricate system of distribution. Nevertheless, unless products can be had readily, they are not likely to be used.

STANDARDS AND CODES

Buildings are built under the jurisdiction of local and state building codes. Until recently, plastics generally were not mentioned in codes, and required special dispensation by the local building official. This situation is changing, but plastics still are not universally allowed, or only under restrictions. On the other hand, all of the model codes now have sections devoted to foams and light-transmitting plastics, as well as general sections governing the use of materials, including plastics. They are widely adopted by local jurisdictions.

Codes in turn depend upon standards. Plastics materials standards, such as those of the American Society for Testing and Materials, are plentiful and are widely referred to by building codes. Some standards are specific to plastics, others apply to materials generally, and plastics must conform.

MANUALS OF PRACTICE

Designers, builders and building officials are considerably assisted by manuals of practice. These show how to put into effect the requirements of codes and standards. Such manuals are quite well-established and widely used for other building materials such as wood, concrete, steel, masonry, and others. They are still largely absent for plastics. The Plastics Structural Design Manual currently being prepared by the Plastics Research Council of the American Society of Civil Engineers is an example.

In a quick survey such as this, it is not feasible to cover all existing and potential applications of plastics in building. The foregoing attempts to set forth those uses that exist today, and to forecast some of the trends that may occur in the next decade.