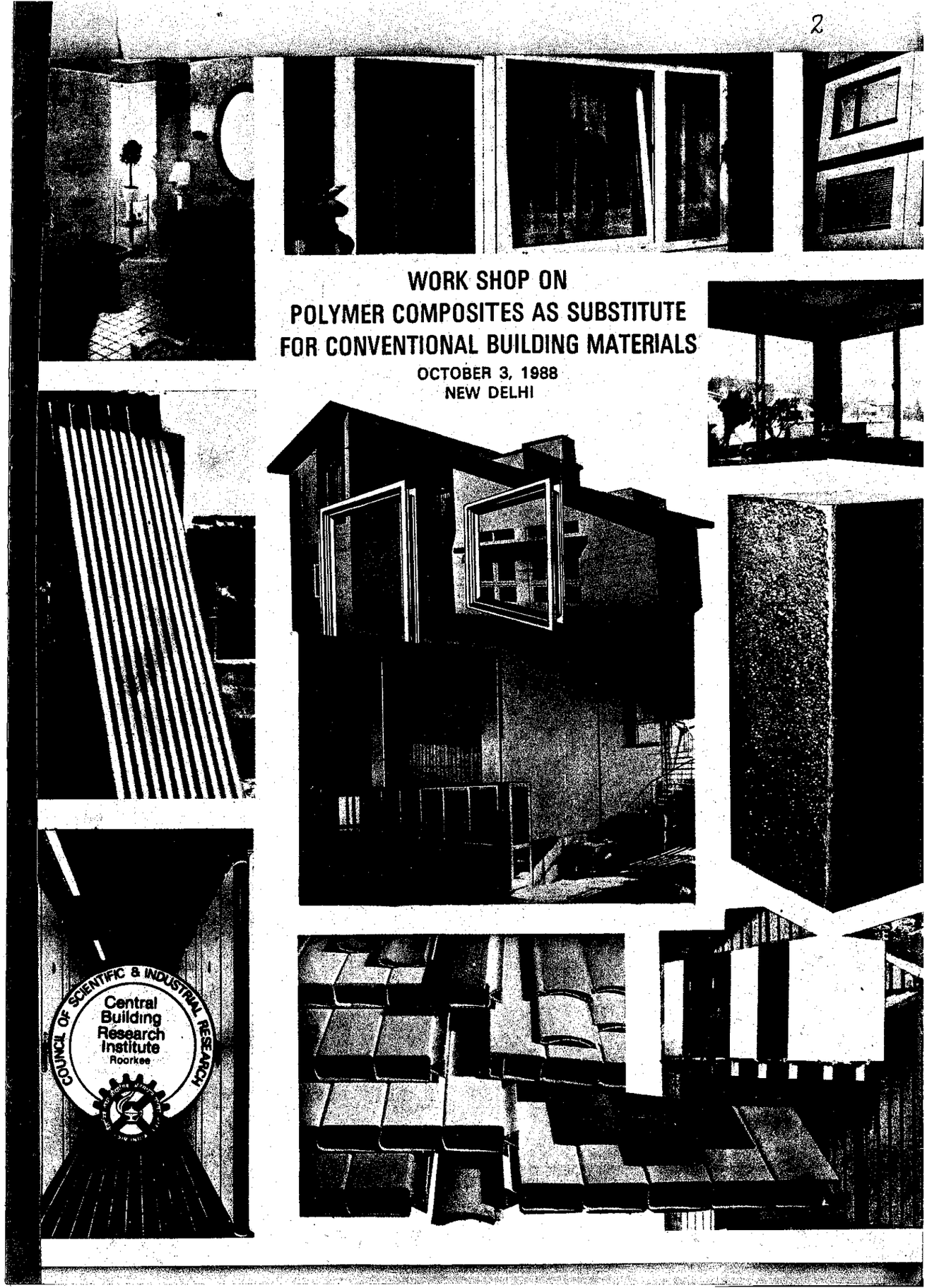

WORK SHOP ON
POLYMER COMPOSITES AS SUBSTITUTE FOR CONVENTIONAL BUILDING MATERIALS

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Extruded PVC Building Products and Their Fire Performance

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Introduction

Shortfall in the availability of traditional building materials and the requirement of millions of houses to achieve a satisfactory progress towards providing shelter to most of the growing population make it essential to look for alternate building materials. Plastics are one such group of substances available at competitive price.

While the availability of conventional building matetials continues to be scares, the present availability being less than one fourth of the demand, the annual world production of plastics has increased from 3 million tonnes in 1955 to around 100 million tonnes today. Current annual production in India is 4.5 lakh tonnes and is expected to be 6.5 milllon tonnes by the end of the century. Plastics are put to a wide range of application including flooring, roofing, glazing insulations, light fixtures, panels and sidings, pipe fittings, conduits and plumbing etc. Polyvinyl chloride is one of the major plastics used in construction activities and its use is expected to increase further. Presently it falls between polyethylene and polystyrene but by the year 2000 it will be the world leader with annual production of 17×10^{19} Metric Tons[1]. According to a market study report of IPCL the consumption of PVC in building construction area in India will increase from 61135 MT in 1983-84 to 166410 MT in 1989-90[2]. Though, the use of PVC in buildings is on the increase a judicious approach is called for because PVC is a combustible material and once ignited can spread fire from the point of origion to other parts of the building.

Extruded Products of PVC

PVC was first observed in 1835 following the exposure of 1, 2 dichloro ethane to sunlight. The commercial importance was, however, not recognised until early 1900s[1]. The inherent flame retardant properties, wide range of plasticized compounds and the low cost has made it a major industrial chemical. In fabrication of building components it finds extensive use in frame and sash components, roofings, pipes, door and window frames, shutters, cladding for wooden or metallic runners of staircases, panelling, sidings and flooring. Partition wall of rigid PVC with expanded polyurethane infills are cheaper and have better sound and thermal insulations.

Thermoplastic nature of PVC makes it suitable for extrusion or molding into desired shapes by the application of heat and pressure.

Rigid Profiles are extruded from the melt mixed cubes of pellets at low temperatures. The profile is air cooled, uniformly, to avoid warping. Rigid PVC profiles have a wide variety of applica-

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tions, housing sidings and window frames are two large volume products,

In case of wire coatings a cross head die is employed in which the extruder is at an angle to the direction of wire travel. In a wiredie, the wire is surrounded by melt. A tubing die is used where a Jacket insulation is required to be coated over a cable.

In injection molding an extruder in run intermittently and used to fill a cooled mold, Both flexible and rigid PVC can be injection molded. Injection molded PVC pipe fittings are the largest volume products of injection molding.

Calendering is often used to produce a vinyl top coating on substrate. Typical examples are floor covering, wall covering and upholsery fabrics

A composite that has excellent dimensional stability and can be painted, drilled and nailed like timber has been developed by extruding PVC mixed with saw dust. By co-extrusion of PVC formulations or PVC with other thermoplastics, products may be fabricated in which the component parts have widely different properties.

Fire Performance of PVC Products

Fire is an exothermic combination of oxygen and fuel. The fuel in case of buildings, is a combustible component or contents. Fire can be initiated by a small source known as an ignition source and given favourable conditions may spread to other parts of the buildings. In so far as the materials of construction are concerned the properties which could affect safety are: Ease of ignition, spread offlame, resistance to penetration by fire, production of smoke and toxic gases and contribution to hear. Standard fire tests have been put forward by many international standard organisations for assessment of these properties. Flamability tests are employed to determine the response of a product or material when exposed to an ignition source. The responses usually measured are. Ease of ignition fire endurance, resistance and smoke evolution Standard fire test apparatuses for fire performance evaluation of building materials have been provided at Fire Research Laboratory of Central Building Research Institute, Roorkee for the first time in the country. Some of the more common small and medium fire tests used for PVC are given in Table 1.

Table—1

Fire Tests for PVC Building Products

Designation	Characteristics Measured
BS 2782 : Part 5 : 1970 (Method 508 E)	Flame Spread
ASTM D 635–77	Flame Spread
ASTM D 757–77	Flame Spread
ASTM D 2863–76	Ease of Ignition
ASTM E 108–75	Flame Spread
ASTM E 119–76	Fire Endurance
ASTM E 162–76	Flame Spread Fuel contribution and smoke
ASTM E 662–79	Smoke
Factory Mutual Calorimeter	Fuel Contribution
Corner Wall Fire Test	Flame Spread
MVSS 302	Flame Spread

PVC when involved in fire releases toxic combustion products. Dehydrochlorination of PVC becomes significant at temperature above 190°C and the higher the temperature the more rapid is the release of Hydrogen Chloride. It looses 90% of its chlorine as HCl upto 300°C. After dehydrochlorination of PVC has taken place the residue has a conjugated polyene structure which itself decomposes to give a complex mixture of products consisting of saturated and unsaturated hydrocarbons with a predominance of aromatic materials. The main toxic risk from PVC arises, however, from carbon monoxide and hydrogen chloride. It has been observed that if PVC is present in the fire load as furnishings, HCl is released earlier and at a rapid rate than if present as well lining[3]. The toxic aspects of HCl are given in Table 2.

PVC products, namely a calendered flooring material and an extruded profile for panelling were subjected to some of the fire tests and their performance is reported in Table 3. The legands used are: C-Combustible, P-Not Easily Ignitable, i_1—sub index, 1-Fire Performance Index, Classes 3-Surfaces of Medium Flame Spread, Class 4-Surfaces of Rapid Flame Spread and Dm-Maximum Specific Optical Density of Smoke Generated.

Table—2

Toxic Effects of Hydrogen Chloride

Concentration, ppm	Effects
5	Maximum Allowable Concentration (MAC)
15	Irritation
80 – 100	Intolerable for one hour
100 and above	Intolerable to breath
1000 – 2000	Dangerous for brief exposure
1500 and above	Fatal for 30 minutes exposure
4350	Fatal for brief exposure

Table—3

Fire Petformanie Characteristics of Extruded PVC Products

Material	Test Results						
	Non-Combus-tibility	Igni-tabi-lity	Fire Propaga tion Index I_1	Fire Propaga tion Index I	Flame Spread Class	Smoke Density, Dm Flaming	Smoke Density, Dm Non-Flaming
PVC Profile 21 mm 198.6 kg/m³	C	P	melts, cannot be classified			> 924.0	302.9
PVC Profile 21 mm 198.6 kg/m³	C	P	melts, cannon be classified			585.0	393.5
PVC Calendered Flooring Sheet 2 mm 1492.0 kg/m³	C	P	7.72	20.03	4	610.0	186.0
Kailwood 12 mm 495.0 kg/m³	C	P	16.14	41.15	4	228.0	328.7
Particle Board 12 mm 400.0 kg/m³	C	P	14.21	36.52	3	261.5	410.0
Fire Retardant Paint on Particle Board 12 mm 400.0 kg/m³	C	P	4.24	22.53	1	134.5	218.1

PVC is combustible but does not ignite easily by a small source of ignition e.g a glowing match stick or a cigarette. Fire performance of the later may be improved by applying suitable surface finishes. The main disadvantage of PVC products are smoke and products of combustion. Smoke from PVC is produced at a rapid rate compared to that from tradltional materials thereby reducing the time available for escape and hence endangering life safety. Smoke is accompanied by HCl gas which is irritant at low concentration and fatal at moderate concentratios encountered in fires where substantial quantities of PVC building products have been used.

Fire Retardant Additives

PVC is never used alone. It is always mixed with other ingradients before being processed. A thermal stabilizer is usually required because PVC is sensitive to heat. The amount of HCl gas emission can be greatly reduced by addition of inorganic, alkaline fillers to PVC materials. The amount of HCl decreases in the following order for the fillers used[4] :

Mg-silicate > $Al(OH)_3$ > $CaCO_3$ > $Ca(OH)_2$ > CaO > CaO-MgO

Some of the fillers, however, yield materials with aggravated mechanical properties and the improvement of these properties require that the qnantity of fillers used be decreased or other additives used. The effectivity of some of the additives and fillers used to reduce smoke evolution from PVC can be arranged in the followihg order :

Calcium Hydroxide + Ba–Ca–Zn-Borate-Silicate > Calcium Hydroxide, Aluminium Oxide > Ba – Ca - Zn-Borate-Silicate > Mg-Zn Compound > Zn Borate > Ferrocene[4].

Conclusion

PVC extruded profiles for panelling and partitions have come to stay with the architects and designers as convenient, maintenace free concept against conventional panels/partitions. Their judicious application is, however, essential. Fire retardant varieties should be preferred over the normal ones and the performance of materials proposed to be used should be evaluated. Only those mateials, which are found comparatively safer should be used.

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