EB/12-A 1977 1311 (51)

THERMAL CHARACTERISTICS OF REINFORCED PLASTICS

by

V. V. VERMA & R. K. JAIN

Central Building Research Institute, Roorkee

Reprinted from June 1977 issue of

THE INDIAN ARCHITECT

A-15 Pamposh Enclave, New Delhi-110 048

THERMAL CHARACTERISTICS OF REINFORCED PLASTICS

by

V. V. VERMA and
R. K. JAIN,
C. B. R. I., Roorkee.

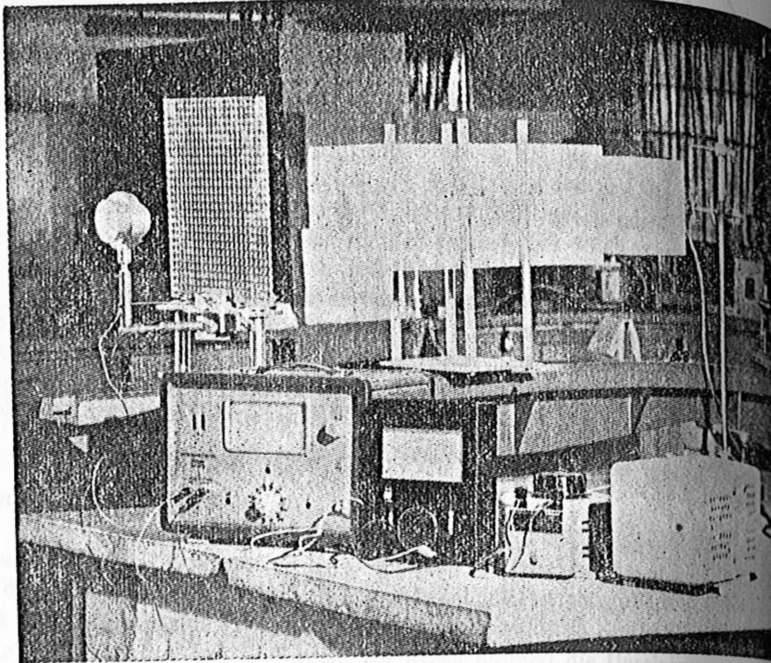

Fig. 1.

Abstract

Glass has been so far the most preferred and commonly used material, but in actual practice glass transmits 80% solar radiation causing greater thermal discomfort inside. A study, to measure the heat transmission properties of reinforced plastics, has been conducted in C.B.R.I., Roorkee. It is found that the reduction in heat transmission through reinforced plastics is better than plain glass sheets. Secondly, on weathering heat transmission characteristics of reinforced plastics further improve, which seems to be a promising alternative to glass.

Introduction

As an element in an exterior wall, a window must also control heat flow. All radiant energy, both visible and invisible, produce heat when absorbed. Solar radiations account for visible 43% of the total energy, ultraviolet upto 30% and infrared upto 54%.

The materials at present in vogue for side lighting are glass and plastics[1,2]. For its high transmittance and transparency; glass has been so far the most preferred and commonly used material, but in actual practice glass transmits 80% solar radiation causing great thermal discomfort inside. The vulnerability of glass to shocks impacts and consequently its frequent replacement is also a problem in many cases. From these considerations the glass fibre reinforced plastics (G.R.P.) seem to be promising alternative to glass reinforced plastics; are, however, liable to show poor weathering performance[3] when in exposed situations such as in roof lighting and window applications.

A study of the heat transmission characteristics of reinforced plastics in relation to its compositional variables and influence of weathering should be of help in the pre-assessment of the heat transmission indoors when these sheets are used for side lighting.

This paper presents the data to show the suitability of these sheets of different compositional details from the point of view of their heat and light transmission both. Study has been carried out on reinforced sheets of different compositional details such as with different types of resins; different types of glass fibres, moulding and curing conditions and surface treatments by subjecting them to natural weathering exposure at Roorkee for three years.

Light transmission of Reinforced plastics decreases on weathering[4]. Heat transmission of these sheets may be expected to decrease as a result of weathering. But the sheets which are good from the heat transmission point of view may show faster deterioration in light transmission. Therefore only those grades are to be taken as best whose light transmission decreases to a minimum ex'ent on weathering.

2.0. *Preparation of Samples and Exposures*

2.1. *Casting Procedure*: Two mat and four mat laminates were prepared in the laboratory by the usual hand lay up process. Required number of glass fibre mats impregnated with resin were laid one over the other. Air bubbles were squeezed out by using a squeezing roller in all laminates except in air en'rapped laminates. Temperature and humidity conditions were kept constant during the casting of laminates. Laminates were prepared between two glass plates and kept at room temperature for 24 hours before subjecting them to a post-curing of 24 hours at 100°C in an air circulating oven.

Under-cured laminates were not given any post curing and left at room temperature till exposure. In paraffin cured laminates, paraffin solution was added into resin to check air inhibition and one side of mould left open to air to achieve a specially resin-poor surface. A gel-coat resin was used to give a gel-coat layer on both sides of laminates. Fine glass tissue mat was used as a surface mat to attain resin rich surface in some laminates. Thickness of surface treated laminates was 3.3 ± 3 m.m. whereas other laminates were 2.7 ± 0.2 m.m. thick. Four mat laminates which as denoted by a letter T after their identification mark, were 4,55 ± 0.4 m.m. and 3.75 ± 0.4 m.m thick in case of surface treated and other laminates, respectively.

2.2 *Material Details*

Chopped Strand mats of A and E type glass fibres of texture 450 gm/m² were used for producing laminates. A type glass fibre contains alkali as Na20 and K20 to the extent of 14% and E type glass fibre less than 1%. Polyvinyl acetate was present as binder and glass surface contained a silane keying agent suitable for bonding with polyester resins. Total organic content of the mats was found to be 4.5 and 6.2% in E and A glass mats, respectively.

Three types of lay up resins and a gel-coat resin were used in the study. Their main characteristics are described in Table I and some other details are given below.

A general purpose resin (G.P.) suitable for producing glass fibre reinforced polyester roof light sheets chemically a propylene maleat phthalate polyester in syrene monomer containing a small proportion of methyl metha crylate (M.M.A.) monomer and a UV absorber. A gel coat resin (O.C.) is similar to G.P. except that it contains no MMA and no UV absorber but contains a thixotropic agent.

Catalyst used is a solution of methyl ethyl Ketone peroxide in dimethyl phthalate plasticizer

Table 1: (Characteristics of Resins)

S.No.	Characteristics	General purpose	Fire-resistance	Isophthalic based	Gel-coat Tixotropic
1.	Viscosity at 25°C (CST)	200	850	600	
2.	Specific gravity	1.11	1.11	1.12	1.11
3.	Acid value (mg KOH/gm)	25	15	12	13
4.	Volatiles (%)	36	36	40	36
5.	Water absorption of cast resin at 25°C in 24 hrs. (%)	0.13	0.12	0.10	0.12
6.	Temperature of deflection under 18.5 kg/cm²	75	60	100	75

and accelerator is solution of cobalt soap in low boiling white spirit. Eleven different types of laminates were prepared including all the above mentioned variables. A detailed statement about these laminates is given in Table 2 along with glass/resin ratio in each case.

2.3. *Exposure*

Samples were mounted on fixed racks facing south at an angle of 45° with the horizon at Roorkee. Range of monthly average of maximum temperature during the period of exposure was 20.6-39.3°C, minimum temperature 5.6-25.2°C and relative humidity 25.4-79.5%. Total rainfall in a year was 1361.7 m.m. and total sunshine hours 2960.5.

3.0. *Measurement on heat transmission characteristics*

Transmittance for normal incidence was determined with the help of the multijunction radiometer and a caliberated infrared lamp in the laboratory.

In this apparatus, a parallel collimator beam of radiation from a infrared lamp operated at a constant voltage is made incident normal to the sample which is mounted in front of the radiometer. The radiometer is fixed at 90° to the beam. It is properly screened from any direct light from the sample. The transmittance is determined by taking the reading of the radiometer with and without the sample. The photograph of the apparatus is shown in Fig. (1).

4.0. *Results and Discussions*

That transmission values of Reinforced plastics of different compositions originally after 2 years and 3 years of natural weathering and percentage reduction in heat transmission on weathering have been shown in Table 3. It is evident from this table that laminates with E type glass fibres poses high heat transmission values in the range of 0.52 to 0.62 in unweathered samples whereas laminates with A type glass fibres possesses heat transmission values in the range of 0.27-0.38 which is about 50% lower than E type laminates. This is a desirable criteria in favour of A type laminates for their use as a glazing material in roof lighting. It is interesting to note that A type laminates possess high diffusing factor compared to E type laminates (A: 0.518-0.572, E: 0.024-0.095) as seen in a work reported earlier[4] and this is the reason for lower heat transmission shown by A type laminates. Out of E-fibre laminates only paraffin cured laminates show lower heat transmission and this is because of high diffusion factor (0.620) of this laminate due to uneven surface obtained as a result of paraffin curing.

No appreciable difference in heat transmission values has been found in samples due to variation in type of resin, manufacturing variables and surface treatments except paraffin cured sample which has been mentioned above.

On weathering heat transmission of all samples decreases and it lies in the range of 0.24-0.37 for laminates with E type glass fibre. On an average there is a reduction of more than 40% in the heat transmission values barring a few cases. By increasing thickness of laminates as in the case of 4 mat laminates, heat transmission has been found to be about 20% less compared to two mat laminate in all cases. On weathering, there is a further reduction in heat transmission similar to the trend seen earlier in the case of two mat laminates. Thus, on weathering, reinforced plastics show reduced heat transmission which is a plus point in favour of use of these sheets as glazing materials. Paraffin cured laminate and fire-retardant laminate show reduction in heat transmission on weathering to the extent of 80 and 60 per cent, respectively. However, although these sheets possess good heat transmission characteristics, originally, and also improve it further on weathering, all grades of sheets cannot be recommended for use based on their heat transmission characteristics alone. Reinforced plastics have erosion of resin, etc., which may be responsible for greater diffusion and thereby reduction of heat transmission; it is important to consider other characteristics such as light transmission of these laminates on weathering in order to be able to select suitable grades of sheets. The property of some of the glasses is also shown (in Table 3), which shows higher thermal transmission as compared to plastics, except in the case of heat absorbing glass.

Table 2: (Compositional details of laminates)

S.No.	Sample No.	Manufacturing variable surface treatments	Type of resin	Type of glass fibre	Glass contents %
1.	011	normal	General purpose	E	26.5
2.	111	undercured	"	E	26.5
3.	211	air entrapped	"	E	28.55
4.	311	paraffin cured	"	E	24.1
5.	411	surface mat	"	E	28.65
6.	511	gel-coat	"	E	21.80
7.	012	normal	"	A	29.30
8.	412	surface mat	"	A	34.8
9.	512	gel-coat	"	A	26.6
10.	121	undercured°	Fire resistant	E	24.4
11.	031	normal	Isophthalic based	E	—
12.	041	normal	Biophenol based	E	—

° Shows severe colour change on curing.

Table 3: (Heat Transmission properties of plastics and glass materials)

Sl. No.	Sample	Heat Transmission			Percentage Reduction in heat transmission	
		Original	After 2 years weathering	After 3 years weathering	After 2 years weathering	After 3 years weathering
1.	011	0.62	0.45	0.40	27	36
2.	111	0.58	0.28	0.24	51	58
3.	211	0.55	0.36	0.33	34	40
4.	311	0.32	0.07	0.05	80	84
5.	411	0.52	0.28	0.24	47	54
6.	511	0.53	0.30	0.26	43	50
7.	121	0.58	0.24	0.20	60	65
8.	031	0.54	0.24	0.20	55	63
9.	041	0.54	0.37	0.33	31	45
10.	012	0.27	0.18	0.15	33.3	52
11.	412	0.38	0.17	0.13	55	65
12.	512	0.34	0.21	0.18	40	47
13.	012T	0.41	0.30	0.26	27	36
14.	411T	0.51	0.30	0.25	41	50
15.	511T	0.40	0.30	0.26	25	34
16.	012T	0.45	0.13	0.10	71	79
17.	Perspex	0.58	—	—	—	—
18.	Plain glass sheet	0.77	—	—	—	—
19.	Wired glass	0.55	—	—	—	—
20.	Heat Absorbing glass	0.15	—	—	—	—

In Table 4 values of % reduction of light transmission of different grades of sheet in one year weathering has been given. Light transmission was measured for 'normal incidence in accordance with the method and details described in an earlier publication[4]. The data in Table 4 shows that sample No. 511, 012, 412, 512, 011, 111, 211 and 411 show reduction in light transmission less than 10% whereas all other samples possess a value higher than 10%. Therefore these samples are best both from heat as well as light transmission point of view. However, this has been found on the basis of one year natural weathering data and should be checked for prolonged weathering exposure.

Table 4: (Light Transmission Properties)

S.No.	Sample	% reduction in light transmission on one year natural weathering
1.	011	8.5
2.	111	6.1
3.	211	9.0
4.	311	53.5
5.	411	7.2
6.	511	2.3
7.	121	38.8
8.	031	25.0
9.	012	2.9
10.	412	5.5
11.	512	3.0

Conclusion

1. Heat transmission of plastic sheets is much less compared to glass sheets (except heat absorbing glass), and hence they are more suitable for glazing application and will create more favourable thermal conditions inside.

2. Reinforced plastics with A type glass fibres possesses lower heat transmission than sheets with E type glass fibre.

3. There is no difference in the heat transmission characteristics of reinforced plastics with different types of resins and manufacturing variables except the paraffin cured and fire resistant grade laminates for the reasons discussed earlier.

4. Sheets with higher rate of weathering degradation show less and less heat transfer as the weathering proceeds.

5. On weathering, heat transmission characteristics of reinforced plastics further improve.

Although reduction in heat transfer has been noticed to the extent of 80% on weathering in some grades, but such sheets are not suitable for use as they, on the other hand, deteriorate much faster in light transmission characteristics.

Only those sheets which have fairly good resistance towards weathering should be used for glazing application.

Acknowledgement

Thanks are due to Mr. N. K. D. Choudhury, Head of Physics Department, for his keen interest and constant encouragement. The investigation forms part of the regular research work of the Institute and is sent for publication with the permission of the Director.

References

1. Millar, R.A., Black, L.V., Journal of American Soc. of Heat; Vent. Engr. (1932), P 63.

2. Rogers, Tayer Sterwart, Thermal design of buildings, John Willy and Sons.

3. Jain, R.K. and George Joseph, Journal, Popular Plastics, 15 (10), 39-41, 1970.

4. Jain, R.K., Saxena, B.K., Bansal, G.D., and Asthana, K.K., Popular Plastics Supplement, July, 1975. PP 1-8.