BUILDING RESEARCH NOTE 76

SMOKE GENERATION BY LINING MATERIALS

Introduction

One of the most significant objectives of providing fire safety measures in buildings is to enhance life safety. Innumerable precious lives are lost due to fire accidents. Where there is a fire, there is smoke. Smoke generated during fires has been identified to be a major factor responsible for hampering escape and impeding rescue operations.

Smoke arising as a plume from a burning material consists of invisible hot gases, vapours, and visible liquid and solid particulate matter. Immediate effect of smoke is due to the tendency of the particulate matter to reduce visibility making difficult or even impossible for persons to find their way to safety from the fire affected area. Direct contact and inhalation of smoke could result in irritation of the membranes, incapacitation and asphyxiation. The constituent gases of smoke may be acutely toxic which may cause serious physiological disorders or impairment of mental capabilities.

Smoke is generated by combustible lining materials as they burn. One of the prime factors governing generation of smoke during fires inside buildings is the nature of lining materials used. Such lining materials, once involved in a fire, undergo thermal decomposition and generate smoke. The rate at which the smoke build - up takes place in an enclosure of a building is dependent upon the behaviour of these materials apart from other factors like the design of the enclosure, building, and ventilation.

Users or designers have a wide range of lining materials to choose from. Materials not only differ from each other on functional and aesthetic considerations but also with regard to their chemical composition, physical and chemical properties. The performance in a given fire situation of various lining materials varies. Some generate more smoke and so are relatively more hazardous than others.

Proper selection of lining materials, therefore, is of utmost importance in maintaining a desired level of fire safety in buildings. It is also essential to use only those lining materials which do not generate significant quantities of smoke during fire and comply with building regulations and codes.

To distinguish between smoke generating propensity of lining materials, standard tests are employed. Such a method enables relative performance of the lining materials to be determined and hence, offers a means of selection of materials having a lower tendency to generate smoke. The Smoke Density Chamber (ASTM Designation E 662 - 79) is one of the salient standard apparatuses employed for assessment of the tendency of materials to generate smoke by determination of a property known as the *Specific Optical Density of Smoke*.

In this Building Research Note, results of the Specific Optical Density of Smoke tests on some of the lining materials evaluated at the Central Building Research Institute are summarised. A brief description of the standard test method employed is also given. This study is limited to assessment of the opacity of smoke generated by different lining materials, while the toxicity aspects of the combustion products are a subject of separate study.

Specific Optical Density of Smoke Test

The Specific Optical Density of Smoke Test provides a means of obtaining a comparative performance of different lining materials on the basis of the specific optical density of smoke generated by specimens of lining materials and assemblies under the specified exposure conditions. The photometric scale used for this test method is similar to that of optical density scale of human vision. Smoke generated by the specimen of a lining material is allowed to accumulate within the test chamber and the resulting attenuation of a light beam is measured. Results are expressed in terms of the maximum specific optical density derived from the minimum value of per cent transmittance. The higher is the Maximum Specific Optical Density of Smoke generated by a lining material, the greater is the influence of smoke from the burning material in reducing visibility through smoke during fires.

Smoke Density Chamber

Smoke Density Chamber essentially consists of an enclosed combustion chamber in which smoke generated from the specimen of the material is allowed to accumulate. It has an arrangement for precisely mounting a specimen of the material in the test position. It is attached with a tubular electric furnace which provides external radiant heat flux on the exposed specimen surface during the test. Provision is also made for attaching a multi-flamelet burner.

The chamber is provided with a vertical photometer path, associated optics and instrumentation for measuring attenuation of the light beam by smoke accumulating within the chamber. Instrumentation for regulation and control of power supply to the external radiant heat furnace and for monitoring gas/air flow rates to the burner are also provided. A photographic view of the apparatus is shown in the Figure.

Specimen

Specimens for the test are required in the following dimensions : length 75mm, breadth 75mm, and of normal thickness upto a maximum of 25mm,

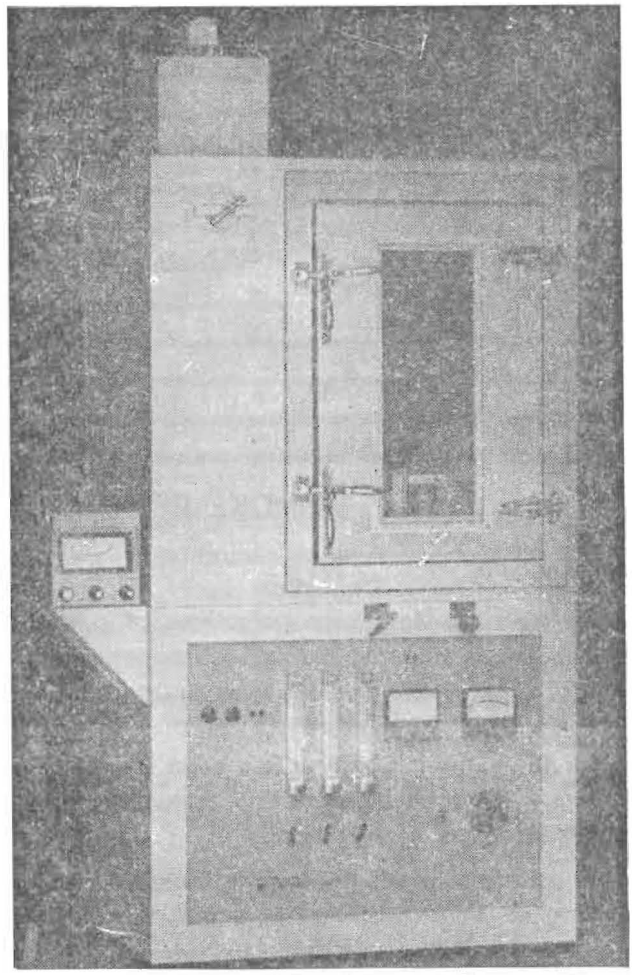

Fig. Smoke Density Chamber

Specimens of thickness greater than 25mm are sliced to thickness of 25mm.

A minimum of three specimens are normally required for a test, but it may be necessary to conduct the test on more specimens if there are large variations between the behaviour of the specimens. The variations may arise due to softening, melting and disintengration which would be reflected in the data obtained.

Smoke Density Test Procedure

In accordance with the standard procedure, the external radiant heat source is heated to yield a heat flux of 25kW/m^2 in the plane of the exposed surface of the specimen. The photometric system is adjusted for 100 per cent transmittance initially when there is no smoke inside the chamber. The specimen is quickly brought in the test position with respect to the external radiant heat furnace.

Two types of tests are made on each of the materials which differ in respect of the mode of exposure to external heat. In the Non-Flaming Exposure, mode the specimen is exposed to heat from the external radiant heat furnace only while in Flaming Exposure mode, specimen is heated by radiant heat as well as flames from multi-flamelet burner.

During test, smoke generated by the specimen of the material enters the light beam and causes reduction in transmittance across the light path. This is indicated as a decrease in the observed values of the per cent transmittance. The test is continued for a duration of 20 min. Specific Optical Density of Smoke is calculated from the per cent transmittance and its maximum value, which corresponds to the minimum value of per cent transmittance, forms a basis for obtaining a relative ranking of materials.

Specific Optical Density of Smoke Generated by Lining Materials

Specific Optical Density of Smoke generated by common materials like timbers, boards, decorative laminates and some plastics are tabulated in the Table. Maximum Specific Optical Density values for a particular material have been arrived at on the basis of data obtained for a few types in each category and are therefore, considered representative for the class of materials. A range, and not a single value, is given where the variation has been found to be large.

Table : Representative Values of Maximum Specific Optical Density of Smoke Generated by Lining Materials.

Material	Thickness mm	Density kg / cu.m	Max. Specific Optical Density	
			Non-Flaming	Flaming
Timber, Kailwood	12	500	330	265
Plywood, general purpose	3	650	160	75
Fibreboard, insulation grade	12	230	300	190
Particle board, insulation grade	12	400	410	250
Partlcle board, medium density	18	890	415	235
Wood wool building slab	25	515	15	25
Decorative laminate	1.6-3	1500	30-60	80-190
Expanded polystyrene	25	20	0	25
Rubberised coir	25	135	480	450
Phenol formaldehyde foam slab	25	35	4	8
Polyurethane foam slab, rigid	25	100-450	100-200	200-280
Polyisocyanurate foam	20	50	10	60
Mineral fibre marine board	25	85	30	6
Red mud PVC sheet	1.6	1740	200	310
PVC calendered sheet	2	1450	170	510
Glass reinforced plastic sheet	3	1330	20	180
PMMA sheet	3	1100	75	65

Interpretation of Results

The Maximum Specific Optical Density of Smoke generated by materials can be used to identify the likely tendency of lining materials to generate smoke during a fire. A material of higher Maximum Specific Optical Density of Smoke can be considered to generate more smoke during a fire and results in a greater reduction in the visibility than the one of a lower value.

Both the values of the Maximum Specific Density, i.e. for the Flaming Exposure mode and the Non-Flaming Exposure mode are important and are taken into account separately while making a comparative assessment of fire hazard due to smoke generated by different materials.

Conclusions

The lining materials available for different applications and occupancies can be fairly large. For making a proper choice of a material from the fire safety point of view, the Specific Optical Density of Smoke Generated by these materials can serve as a useful guide.

The value of the Specific Optical Density to be considered for any particular product or a material, shouid be the specific one determined for that particular product or the material. However, the representative value included here can be used as a preliminary indication of likely tendency of a material, of the particular category, to generate smoke.

The standard facility for the evaluation of Specific Optical Density of Smoke from lining materials is available at the Central Building Research Institute and should be used to determine the hazard of a material to generate smoke during fires, prior to its actual use in a building.

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Printed at :
Jain Printing Press, Main Bazar, Roorkee
Copies 2500

Published by : Central Building Research Institute
Roorkee (U.P.) INDIA
July, 1991