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INTERNAL LININGS

by

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Introduction

The use of wall boards has increased since the war, because of their many advantages over more traditional interior linings for walls and ceilings. The main types can be roughly classified as combustible or incombustible. Fibre building boards comprise the bulk of the combustible boards others being compressed straw slabs and chipboard. Of the incombustible or near incombustible, plaster board is most widely used, other types including asbestos insulating boards and wood wool slabs.

It was realised that the introduction of large areas of combustible material as linings to buildings might increase the fire hazard and in order to classify surface finishes according to the fire risk associated with them a test was added to B.S. 476 in 1946 which has formed the basis of a number of recommendations. The test had to be introduced at relatively short notice to meet an urgent post-war requirement, and its basis was essentially arbitrary. A critical examination of the test has recently been made (1) and it has become necessary to follow this by an examination of the effects of its application, to ensure that these are neither dangerously lax nor too restrictive.

Since a high resistance to spread of flame is only one of a number of desirable properties, to put it in its proper perspective it is necessary to examine the other properties of different boards before going on to consider their uses. These are the possibility of dry process, and the large size sheets which can be easily fixed, good thermal insulation, sound absorption, resistance to moisture, structural strength, low fire hazard and low cost. Different types of board possess these attributes to different degrees and the choice of a board will therefore depend on which of these properties are desired and if the properties are not inherent in the board whether they can be easily achieved by treatment.

Cost

To give an idea of comparative costs, $\frac{3}{8}$ in. plaster board is sold to the consumer at about $3\frac{1}{2}$ d/ft^2, foil backed insulating plasterboard at about $4\frac{1}{2}$ d/ft^2 and $\frac{1}{2}$ in. fibre insulating board at about 5 d/ft^2. When the actual cost of a contract, such as lining a factory roof, is considered, the cost of the boards is probably only about $\frac{1}{5}$ or $\frac{1}{6}$ of the total cost, which would include metal fixings, labour, scaffolding etc., and in this light the relative difference between the boards would be small. However where work is being done by a "handyman", small differences in initial outlay on materials will probably be the most important factor in deciding which board is used.

Thermal insulation

With the increased cost of fuel, it is becoming more important to provide buildings with reasonable thermal insulation. The 1953 model byelaws of the Ministry of Housing and Local Government include for the first time, requirements for the thermal insulation of houses. These requirements are met by most of the traditional means of construction, and in housing there would seem to be little chance of building boards being used for added thermal insulation except perhaps for increased insulation to the roofs. However many buildings, particularly factories, are of light construction and by providing adequate thermal insulation, the heating costs can be greatly reduced. Perhaps the most typical case is of an asbestos cement roof, and the efficiency of different materials in conjunction with this type of construction, together with approximate cost are shown in Table 1.

Table 1

Efficiency of different materials in conjunction with asbestos cement roof, with approximate costs

Material used	Thermal transmittance after insulation B.Th.U. hr^{-1} ft^{-2} $0^{o}F^{-1}$	Cost per yard super*
Before insulation	1·40	-
$\frac{1}{2}$ in. fibre insulating board	0·36	17/10
$\frac{3}{8}$ in. insulating plaster board	0·35	17/10
$\frac{1}{4}$ in. asbestos board backed with 1 in. glass wool	0·18	23/7
$\frac{3}{8}$ in. plaster board backed with 1 in. glass wool	0·18	19/10

*The prices can only be taken as a rough guide, as they refer to a certain size of building, and the lowest estimate was not necessarily taken.

In general for large buildings there is only a need for thermal insulation on the outside walls and the ceiling of the top floor, since the whole building can be considered as a single unit as far as heating is concerned.

Sound control

Since most building boards are comparatively light, they cannot be expected to have any particular value for sound insulation, however as linings to walls and ceilings, provided they have the right properties, they can help to reduce noise in a room or building. Special acoustic boards, with holes or slots in the surface are manufactured, although to obtain a high sound absorption with some of the denser incombustible boards a backing of sound absorbent material such as glass wool has to be used. These special boards are considerably more expensive than the standard materials, and are generally only used for special location. Some of the standard combustible boards such as fibre insulating board have a fairly high coefficient of sound absorption, although this is appreciably reduced by painting.

At present, noise reduction in buildings is generally thought of as a luxury to be required for particularly deserving cases, but in the future it is likely to be a matter of prime concern for such buildings as restaurants, offices and schools, and a much wider field of application can be envisaged. Since some of the combustible boards are cheap and suitable it would be the obvious first choice providing their other properties were satisfactory.

Fire hazard

If a material used as a lining to the walls or ceiling of a building will spread flame, any fire which starts in the contents of the building will spread rapidly once the lining is involved. The Surface Spread of

Flame test of B.S. 476 was designed to assess the fire hazard of surface finishes and grades boards into one of four classes -

Class 1 - surfaces of very low flame spread
Class 2 - surfaces of low flame spread
Class 3 - surfaces of medium flame spread
Class 4 - surfaces of rapid flame spread.

Materials graded in Class 4 by this test can be readily ignited and when used as internal linings are likely to give rise to a continuing fire once ignited, even if there is no other combustible material in the building.

In their natural state most combustible boards fall into Class 3 or 4, and the incombustible into Class 1. The classification of the combustible boards can be raised to Class 1 by many flame retardant treatments and to Class 2 by many ordinary decorative treatments (2). Under fire conditions combustible materials which are raised to Class 1 by flame retardant treatments are not likely to behave as well in all situations as materials which have very little combustible material to contribute to a fire.

Other considerations

Other points of a technological nature which might influence the choice of board are suitability as a base for plaster, and the movement to be expected with changing humidity conditions. Although some of the combustible boards (fibre insulating board) can be plastered quite effectively, plaster board, seems to be much more widely used. A large quantity of building boards (about 30 million square yards per year) must be used as a plaster base for ceilings of houses and most of this is plasterboard.

There is no difficulty with moisture movement with plasterboard, and any difficulties with fibre insulating boards can be overcome by conditioning on site and proper fixing.

In considering the merits of different boards there is one important point which is difficult to assess, and that is the architectural possibility of the material. The final specification of materials often rests with the architect, and his main concern is often with the effect created. One of the big advantages of some of the combustible boards from this view point is their low density which permits use in large panels for suspended ceilings. Plaster board $\frac{3}{8}$ in. thick is generally used in panels 4 ft. x 2 ft. or 6 ft. x 2 ft., whereas fibre insulating board can be used up to 8 ft. x 4 ft.

Sales and uses of different boards

Consider here fibre building boards and plasterboard which are representative of their groups and for which figures are available.

The most recent figures for the sales of these two are given below.

	Amount sold per year in million square yards
Plaster board	55
Fibre building boards	60

These figures are fairly representative of the relative sales of the two boards since the war.

The majority of the plaster board production is the standard $\frac{3}{8}$ in. board, and probably something less than 5 per cent of the production is the insulating plaster board, which goes mainly to factories. Large sheets of standard board are used widely as a base for plaster although a plaster board lath is produced which is much more suitable and is recommended by the manufacturers.

As with plaster board the fibre board industries "bread and butter line" is the standard board, $\frac{1}{2}$ in. insulating board. A rough estimate of the amount of board receiving any specific flame retardant finish, as distinct from normal decorative treatments, would give a figure of about 5 per cent. Some of the main outlets for fibre insulating board are factories, schools, offices and hospitals, comparatively little going to housing.

Present recommendations on internal linings

The fire problem associated with combustible building boards is recognized by the industry as well as by Government Departments and Fire Brigades, but there seems to be considerable differences in the interpretation of the size of the problem. Although considerable amounts of combustible boards had been used before and during the early parts of the war, the particular hazards which might be associated with their use were not fully realised until the big fire at a military store in Donnington in 1943. The first recommendations on the limitations of their use followed this fire, and since the introduction of the surface spread of flame test in 1946 further recommendations from various sources have followed. It is possible to get some idea of how to weight the opinions and recommendations of the different authorities by considering what happens at the planning stage of a building. The only legally binding requirements are those of the byelaws and the Factory Department, and these generally contain no requirements for internal finishes. The use of different types of internal lining can therefore only be influenced by recommendations or advice, which might come from the Codes of Practice, the local building inspector or the fire prevention officer, who often examines the plans of new buildings, or from the fire surveyor of the insurance company who are to insure the building. The advice of these people is generally based on official recommendations such as those in the "Fire Grading of Buildings" (3), or on the current practice of Government Departments. The byelaws are not binding on Crown Property, which is the responsibility of the Ministry of Works and obviously this practise carries some influence in the outside world.

The recommendations on internal linings for houses will be considered separately from those for other buildings.

Recommendations on internal linings for houses and flats

1. Report of the Joint Committee on fire grading of buildings (3)

The British Standard Code of Practice - "Precautions against fire", is based on this report which recommends the following in terms of classification on the surface spread of flame test of B.S. 476.

Class 1	Class 2	Class 3	Class 4
May be used in any situation.	May be used in any situation except on walls and ceilings of staircases and passages.	Should be used only in living rooms and bedrooms but not rooms in the roof, and only as a lining to solid walls and partitions. Not	May be used as ceilings except in kitchens staircases and passages provided that the ceiling is at least 7 ft. 6 in. above the floor and the walls are Class 1.

2. Ministry of Housing and Local Government

All proprietary types of non-traditional houses which are to be erected by local councils are vetted by the Ministry, and their recommendations for these are, that except for the ceiling of the top storey, combustible building boards can only be used if plastered.

3. Insurance companies

There is no increase in premium in this country for houses with combustible internal linings. It is of interest that in some Commonwealth countries the premium is increased by about 9d. per £100.

Buildings other than houses

1. Byelaws

In the model byelaws of the Ministry of Housing and Local Government there are no requirements for internal finishes but in those of the Department of Health for Scotland certain buildings have limitations on the linings of escape routes. The byelaw reads - "In every corridor forming part of the travel distance in any storey, and in every room forming part of the travel distance from any other room, all continuous wall and ceiling linings shall be either -

(a) non combustible; or

(b) Class 1 combustibles, obtained without impregnation or surface treatment of a combustible board.

Similar provisions for means of escape in case of fires are made in the London Building Acts which generally require that - "Staircases, landings, corridors, passages, lobbies and doorway recesses within staircase enclosures, exit ways from staircases should be enclosed by solid incombustible material not less than 3 in. finished thickness".

2. Report of Joint Committee on Fire Grading of Buildings

The Committee made recommendations on the limitations of the use of combustible linings which were dependent on the type of occupancy, and these are summarised below.

(a) Assembly buildings

Class 1 or 2 surface finishes except in buildings which do not accommodate a closely seated audience half the wall area may be Class 3 if the other half is Class 1, and the exit facilities are increased.

(b) Trade, commercial and industrial buildings

The only restriction is that Class 4 surfaces should not be used.

(c) Hotels and Residential Schools

Wall and ceiling finishes of bedrooms to be limited to Classes 1 and 2.

(d) Institutional Buildings

All wall and ceiling surfaces should conform with Class 1, except that where bedridden patients are not normally expected Class 2 surfaces should be allowed.

(e) Escape routes

Except under special conditions all finishes to be incombustible.

Places of public entertainment

The majority of requirements and recommendations for places of entertainment are bases on the "Manual of Safety Requirements in Theatres etc." issued by the Home Office, and on the report of the Fire Grading of Buildings Committee. The Home Office manual recommends that theatre buildings containing any considerable quantity of softwood wall covering should be graded as Class C, a class for which special fire precautions are required.

3. Recommendations of the Ministry of Works

These recommendations which only apply to buildings for which the Ministry are responsible are not based on the surface spread of flame classification of materials. Where an ordinary decorative treatment does not give sufficient protection, the material would not be used. One of the reasons is that in a cavity construction there can be no removal of treatment on the unexposed face of a lining.

The use of a combustible board, however treated, is very strongly discouraged for wall and ceiling linings to "Corridors, staircases, halls or rooms which may be used by the public or large numbers of staff; or for any purpose whatsoever in workshops, storerooms and other accommodation where fire risk is above normal, or for buildings containing stores or materials capable of propagating fire". Combustible building boards are also not recommended for buildings where there are no unusual fire risks.

4. Ministry of Education's recommendations for schools (4)

For assembly halls in schools up to four storeys the recommendations are the same as those of the Fire Grading of Buildings Committee. Elsewhere they are dependent on the number of storeys. For instance, classrooms in schools from two to four storeys can have a Class 3 ceiling if the walls are Class 1, but areas of high fire risk and stores must be Class 1 throughout. In schools of 5 storeys and over all linings must conform to Class 1, and in escape routes of any type of school the linings must be Class 1.

Where Classes 1 and 2 are recommended, these apply to materials before they have received any surface treatment, and this virtually excludes all combustible boards in these situations.

5. The insurance companies views on internal linings

Most insurance companies tend to deal with each case on its merits. The tariff companies have had for a long time an extra charge for wooden linings and wood ceilings in some four or five industries which they consider to be particularly hazardous. The definition has been extended to cover combustible building boards, and applies to whatever the spread of flame rating of the board.

They consider a distinction between different spread of flame ratings as "splitting hairs", probably because the extra charge, somewhere in the region of 1/- per £100, is small.

The spacing of sprinkler systems is also tied to some extent to the type of construction. Whereas the normal spacing of sprinklers from a wall is 6 ft. with a "wooden wall" this must be no more than 4 ft.

6. The Fire Prevention Officer

The extent to which a Fire Prevention Officer can influence the use of internal linings is dependent on such things as his liaison with the Local government building inspectors, and his standing with architects.

Considering this and the fact that he can only act in an advisory capacity, the Fire Prevention Officer's influence must vary greatly throughout the country, being greatest in County Boroughs where it is easier to maintain contacts than in Counties.

Most Fire Prevention Officers are guided in their recommendations on internal linings by official recommendations and by their own experiences. It is difficult to make any generalities on their recommendations, but it is probably true to say that they would always prefer an incombustible material to a combustible material, and would recommend linings to be Class 1 or 2.

Discussion

The recommendations of the Ministry of Housing and Local Government, the London County Council, and the Ministry of Works, and the practise of the Insurance Companies are not based on the "Surface spread of flame test", and in the requirements of the Scottish Home Department, and the Ministry of Education the spread of flame classifications are qualified. This means that in the view of many authorities the test does not furnish sufficient evidence on which to base recommendations. This can lead to requirements which are not functional and may lead to the elimination of materials which are, in fact, suitable.

Although some of the differences between the requirements of different authorities depend on the special types of risk to which they apply there still seem to be wide differences in attitude towards the use of combustible building boards, and there is clearly a need for further discussion between the interested parties so that, if possible, one set of recommendations can be drawn up. This would be of tremendous help to everyone including manufacturers who would have only one set of ideals instead of so many as there are at present.

Flame retardant treatments

Present use

Only a very small percentage of all combustible boards are at present receiving any flame retardant treatment. There are two possible methods of improving the flame retardant properties of combustible boards, surface treatment and impregnation. Surface treatments, in the form of paints, are probably the only treatment applied to fibre insulating board, and the main outlets are to the services, factories and some schools; virtually none go to housing. Probably the main reason for the limited use of surface treatments is that they increase the cost of the board by something like 50 per cent, and since they are generally not washable, still require decorating.

In the field of building boards, impregnation treatments are carried out only on hardboards; the only sizeable market being for exhibition work, where most regulations call for an impregnated board. Here again the increase of cost is the deterrent to any larger market, since impregnation treatments carried out at present, involve a separate process which makes them more expensive than surface treatments.

The future of flame retardant treatments

The biggest problem is that of providing a suitable treatment for fibre insulating boards at a competitive price. There is a general tendency to favour the use of an impregnated board rather than one with a surface treatment, and this is probably due to a number of reasons. Firstly a "factory applied" treatment is generally preferred, also the treatment does not have to be renewed and the back surface in a cavity construction will not create a hazard and finally if the board is fractured the exposed edges will not ignite easily or smoulder. Any

factory applied surface treatment which is used on both sides of a board, means an addition of at least two processes at the manufacturing stage and the extra costs involved make this impracticable for large-scale production.

One possible solution is to include some flame retardant salt in the boards during manufacture. The feasability of this depends on the manufacturing process. This is likely to vary from mill to mill, but the principles are the same in all the processes. The fibrous pulp, which is the raw material of fibre building boards, is mixed into a smooth suspension with water, and it goes onto the moving belt of the production run in this form. There are various ways used to remove water from the pulp, in some cases the pulp is carried on a mesh which allows some waters to drain off and then more is removed by suction boxes under the mesh before entering the rollers which remove still more. In another process the majority of the water is removed by a series of rollers. On leaving the rollers the board still contains as much as 60 to 70 per cent moisture, and this is removed by passing through a stage heated chamber.

The flame retardant salt could be introduced at the beginning of the process, but because of the amount of solution lost during the preliminary drying before entering the heat chamber, it would obviously be necessary to have a closed circuit to save excessive waste of salt. It would seem that this would be practicable and if done on a large scale should add very little to the cost of the board.

There is however some experience on the performance and properties of impregnated boards which show that considerable work has yet to be done to find the most suitable type and amount of salt which can be included in the board without altering too much its merits as a building material. There are two main problems which are likely to be met with. Firstly, since any salts which could be included in the manufacture would have to be water soluble, these salts will take up moisture when the board is in position, and if the moisture taken up is excessive there will be considerable movement in the board and also loss of strength. Secondly, and really related to the first problem is that of decoration of impregnated boards. One of the normal decorations for fibre insulating board is an oil bound water paint, and this type of treatment would be likely to dissolve some of the salts which would probably appear in a crystalline form on the surface. A more important difficulty would probably be caused by the take up of water from the atmosphere by the salts leading to a flaking of the paint film.

These difficulties have been met with in the past, but this may be because large amounts of salts have been included in the board. It is very likely that the maximum amount of flame retardant chemical which can be included in an insulating board, consistent with it still being a useful building material, is very small and might only raise its rating on the surface spread of flame test from Class 4 to Class 3. There would at present be no market for an impregnated insulating board with a classification on the surface spread of flame test lower than Class 1, if it were more expensive than the standard board, since the call seems to be for "Class 1 or nothing". This means that there is something less than 5 per cent of all boards sold receiving any flame retardant treatment. If the standard fibre insulating board contained a certain amount of flame retardant salts which made it not easily ignitable by a small source, and prevented continuing smouldering it would be a safeguard against misuse of the board and a big advance in fire protection. Added protection could still be given for particularly hazardous situations.

Conclusions

The general properties of combustible and incombustible boards are similar in many respects, some of the combustible boards having the advantage as far as noise reduction and architectural possibilities are concerned, whereas the incombustible boards create no fire risk. At present there is no economic method of making a combustible board which can create no fire risk under some circumstances. It seems that the most promising line would be to aim at a general improvement in the standard boards by the inclusion of some flame retardant salts in manufacture. Before this could be done some exploratory work is necessary on the effect of such salts on the properties of the board. Even if a slight improvement of the flame spread characteristics of the board were not at present acceptable to many of the authorities, it would protect the manufacturers from the misuse of their product and would be a sound long term investment for the industry, since any such move would probably be reflected in a reduction in fire incidences involving combustible boards.

Architects normally specify the materials to be used in buildings and there appears to be very wide differences in their appreciation of fire protection requirements, particularly concerning the fire hazard of internal linings. This is understandable when one examines the variety of conflicting recommendations on their use, and there seems to be a need for a fresh approach to the problem which would give rise to a set of recommendations acceptable to all the authorities. It seems that the present Surface Spread of Flame test of B.S. 476 would not be an adequate basis for any such general recommendations.

References

1. National Building Studies. Special Report No. 22.
2. F.R. Note No. 165/55.
3. Post-war Building Studies Nos. 20 and 29.
4. Ministry of Education Building Bulletin No. 7.