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BREEAM/NEW HOMES: THE BRE ENVIRONMENTAL ASSESSMENT METHOD FOR NEW HOMES

by G J Raw and J J Prior

SUMMARY

The words "unhealthy housing" tend to provoke an image of old ill-maintained homes, but there are important issues to be addressed in relation to new homes. New homes, like any new buildings, have an impact on the global environment, the local environment, use of natural resources and the indoor environment. This has health implications: some of them for the future (e.g. the possible effects of depletion of the ozone layer), some of them more immediate and relating to the environment in which we now live. This paper describes an assessment method developed by BRE to promote the design of new homes which are more "environmentally friendly"; the paper concentrates on those issues which have the greatest immediate implications for health.

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BREEAM/NEW HOMES: THE BRE ENVIRONMENTAL ASSESSMENT METHOD FOR NEW HOMES

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The words "unhealthy housing" tend to provoke an image of old ill-maintained homes, but there are important issues to be addressed in relation to new homes. New homes, like any new buildings, have an impact on the global environment, the local environment, use of natural resources and the indoor environment. This has health implications: some of them for the future (e.g. the possible effects of depletion of the ozone layer), some of them more immediate and relating to the environment in which we now live. This paper describes an assessment method developed by BRE to promote the design of new homes which are more "environmentally friendly"; the paper concentrates on those issues which have the greatest immediate implications for health.

1. BUILDINGS AND ENVIRONMENTAL ISSUES

Environmental issues are becoming increasingly important and there is an associated increase in public awareness. There is generally less awareness of the contribution that good building design can make to reducing pollution and improving the environment. The environmental issues in relation to buildings can be classed as:

- the IMPACT OF BUILDINGS ON GLOBAL ATMOSPHERIC POLLUTION through, for example, the "greenhouse effect" (use of energy for buildings is responsible for half the UK's annual production of "greenhouse gases", two thirds of this from housing - Shorrock & Henderson, 1990);
- the IMPACT OF BUILDINGS ON THE LOCAL OUTDOOR ENVIRONMENT AND DEPLETION OF RESOURCES, for example aspects of local ecology such as the variety or rarity

of wildlife and the use of limited natural resources for building;

- the INFLUENCE OF BUILDINGS ON THE HEALTH, COMFORT AND SAFETY OF OCCUPANTS through the effects of, for example, indoor pollution (since the highest concentrations of most airborne pollutants are found in indoor environments and the adult population of Europe and America spends 90% of its time indoors (Moschandreas, 1981) indoor pollutants have great potential to affect health).

In addition to the effects of buildings on the environment there is the possibility of changes in the environment having an impact on buildings, for example: greater demands for domestic air conditioning if average temperatures rise sufficiently; increased erosion of porous stone due to acid rain; increased risk arising from higher wind speeds, such as wind-driven rain penetrating walls or inadequate building details and, with sufficient increases in temperature, the possibility of an increase in the threat posed by public hygiene pests such as malaria-carrying mosquitoes and verminous rats, and structural pests such as termites and house longhorn beetle. These issues are beyond the scope of the current paper.

2. THE BASIS OF BREEAM FOR NEW HOMES

BREEAM, the BRE Environmental Assessment Method, seeks to minimise the adverse effects of new buildings on the global and local environment while promoting a healthy indoor environment. Its approach is to:

- raise awareness of the very important role buildings play in global warming through the greenhouse effect, in the production of acid rain and the depletion of the ozone layer;
- set targets and standards, independently assessed, so that false claims of environmental friendliness can be avoided;

- provide a means for builders to design, and home buyers to recognise environmentally better buildings, and so stimulate the market for them.

There are several versions of BREEAM in existence or in preparation. The version described here (Prior et al, 1991) is for assessing designs of new single-household dwellings (including sheltered accommodation which has limited communal facilities).

Buildings have a long life which runs into decades and sometimes centuries, so decisions made at the design stage will have long term effects on the environment. Furthermore it is easier, less expensive and less likely to create waste if improvements to buildings are made at the design stage rather than after construction. BREEAM/New Homes therefore applies to homes at the design stage. It is based on a review to determine which environmental issues should be addressed, how buildings affect these issues and how building location, design and construction can be altered to reduce adverse environmental effects.

The assessment takes into account building materials, products and processes in which regulated use or control will benefit the environment. The issues currently addressed by BREEAM/New Homes are described in the following sections; in summary they are:

- CO_2 emissions resulting from energy use in the home;
- CFC (chlorofluorocarbons) and HCFC (hydrochlorofluorocarbon) emissions;
- use of natural resources and recycled materials;
- storage of recyclable materials;
- water economy;
- the ecological value of the site;
- ventilation;
- volatile organic pollutants and wood preservatives;
- man-made mineral fibres, asbestos and lead;

- lighting;
- smoke alarms;
- storage of hazardous substances.

There are many issues which are relevant to buildings and the environment which have not been included in the current version of BREEAM/New Homes. There are three main reasons for their exclusion: no clear improvement on current regulations could be defined, there was insufficient evidence that a problem exists or there was no satisfactory means of assessment at the design stage. The issues included in BREEAM/New Homes will be periodically updated as new information becomes available and it is likely that the issues currently included could be addressed more rigorously in the future.

It is not rational to assess all the issues on a common scale. The costs to the environment and health of occupants could in theory be assessed in, for example monetary terms, and it would be possible to devise a weighting scheme. However, such a scheme would be largely arbitrary because of the difficulty in assigning an economic cost to environmental effects as diverse as the health of individuals, ozone depletion and climate change due to the greenhouse effect.

Consequently each issue is assessed individually for each dwelling design. Credit will be given where satisfactory attention is given to each of a list of items, as described below. Credit will only be given if the building design has qualities over and above those required by the Building Regulations or other legal or normally accepted standards. Items are included only where there is authoritative evidence that a real risk is involved. Attention is paid to those things which are at the forefront of current knowledge but have yet to become standard aspects of dwelling design.

Assessments will be carried out by independent assessors appointed by BRE, initially Municipal Mutual Insurance Ltd. The assessor will obtain the necessary information from the builder, calculate the carbon dioxide emission, assess the design against the other issues and award credits where applicable. A provisional report will list the credits achieved and make suggestions for improvement. After further consideration by the designers and re-submission to the assessors a final certificate will be issued. Builders will make a commitment to achieving in practice the design features for which credit has been awarded, and construction will be subject to the possibility of random inspection.

3. GLOBAL ATMOSPHERIC POLLUTION

This heading covers the effects that buildings have on the atmosphere beyond the local region: global warming, ozone depletion and acid rain.

The provision and use of buildings probably has a greater impact on the global environment than any other human activity. Environmental damage arises as a result of, for example, energy used during building construction, energy used for heating, cooling and lighting, and the chemicals present in materials used in building services and components. In particular, measures should be taken to maximise energy efficiency and to conserve fuel because:

- burning any fossil fuel leads to the production of carbon dioxide (CO_2) and so contributes to global warming through the greenhouse effect;
- sulphur dioxide, nitric oxide and nitrogen dioxide are emitted when fossil fuels (particularly coal and oil) are burnt, thus contributing to acid rain and the problem of damage to the natural environment;
- burning fossil fuels represents the depletion of a valuable natural resource;
- an energy-efficient home should be easier to keep warm.

3.1 Carbon dioxide production due to energy consumption

Reducing the release of CO_2 into the atmosphere will reduce the rate of global warming. Related benefits will be to reduce acid rain and depletion of fossil fuels. Credit will be given, on a 6 point scale, to dwellings which are responsible for the production of less CO_2 per square metre of floor area than would necessarily be achieved by complying with the Building Regulations (DOE/Welsh Office, 1989a).

No credits are given if CO_2 production is greater than 105 kg/m^2/yr. One credit would be obtained by, for example, a house built to Building Regulations insulation requirements, with space heating supplied by a modern well controlled gas boiler. 6 credits would be awarded for CO_2 production less than 36 kg/m^2/yr, which could be achieved by a super-insulated house with heating by a gas condensing boiler, a high efficiency heat exchanger for hot water heating, a low temperature heat distribution system and energy-efficient lighting.

The energy consumption of a proposed design is calculated using BREDEM, the BRE Domestic Energy Model (Anderson et al, 1985) initially using the National Home Energy Rating Scheme. The energy consumption figures are converted to CO_2 production using the fuel multiplication factors shown in Table 1. If the program shows a warning of interstitial condensation (BRE, 1989), the builder's attention will be drawn to which building element is responsible.

TABLE 1: THE RELATIONSHIP BETWEEN PRIMARY FUEL USE AND CO_2 EMISSION IN THE UK (BRE figures (Shorrock & Henderson, 1990) updated to 1991)

FUEL	CO_2 EMISSION (kg per kWh delivered)
Electricity	0.75
Coal	0.31
Fuel Oil	0.28
Gas	0.21

Since BREEAM focuses on the environment it is appropriate to concentrate on the reduction of CO_2 production rather than the consumption of delivered energy. Delivered energy does not directly reflect CO_2 production because CO_2 production per unit of energy delivered depends on the fuel used. CO_2 production is related to the amount and type of fuel consumed. The amount of fuel consumed is in turn related to the level of insulation and efficiency of appliances. Homes receiving the highest credit for CO_2 production will have improved insulation, efficient appliances and gas as the predominant fuel.

3.2 CFC and HCFC emissions

Reducing the release of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) into the atmosphere will reduce the rate of depletion of the ozone layer and of global warming. 1 credit is given for specifying insulation materials for the structure and the services (e.g. pipes and water tanks) which do not require blowing agents such as CFCs or HCFCs which have a measurable potential to destroy ozone.

In 1986, buildings accounted for some 7.5% of the annual UK use of CFCs (Butler, 1989) mainly as refrigerants in air conditioning systems and as blowing agents for the foamed insulants used in the building fabric. Air conditioning is rarely used in UK homes at present but may be used more if the predicted consequences of the greenhouse effect are realised. Even then the need for air conditioning could be avoided by appropriate design, for example the use of thermal mass or external continental-style shutters to control solar gain.

The foamed insulation materials blown with CFCs include rigid polyurethane, extruded expanded polystyrene and phenolic foams. CFCs are used because they contribute to the thermal properties of the product, are non-flammable, stable, cost-effective, have a low toxicity and can result in closed cell structures which are resistant to water penetration. Currently, in many applications in which CFCs or HCFCs have been used they are being replaced by blowing agents which do not damage the ozone layer. There are also many alternative insulation materials which do not require a blowing agent (e.g. mineral fibres), or which already use a non-CFC, non-HCFC agent as a matter of normal practice.

4. LOCAL ISSUES AND USE OF RESOURCES

This heading covers those issues which affect the immediate surroundings of a building such as the use of a green field site for building, and the use of natural resources during construction and after occupation.

Buildings require a great variety of material resources such as wood, brick and stone. In many cases there is potential for re-using these materials or for obtaining them in other ways which are also less damaging to the environment. Buildings can also be designed in such a way that, when they are occupied, day-to-day consumables such as paper and glass can more easily be recycled and important resources such as water used more carefully.

Beyond the building itself, it is possible to develop a site in such a way that effects on local wildlife and scenery are less damaging (or even enhancing). This can be achieved directly through site selection and layout, but also through consideration of transport requirements.

4.1 Natural resources and recycled materials

It is valuable in environmental terms to maximise the use of renewable resources and to maximise the utility of non-renewable resources for use in the building structure and in fixed furnishings provided by the builder. Five credits are therefore available for specifying materials as follows:

- timber and timber products for use as an integral part of the building (e.g. structural wood, window frames, architraves) which are entirely EITHER from well-managed, regulated sources OR suitable reused timber;

- timber and timber products for use other than as an integral part of the building (for example decorative work or fixed furnishings such as wardrobes and fitted kitchens) which are entirely EITHER from well-managed, regulated sources OR suitable reused timber;
- the majority of material in roof covering to be recycled or reused, (roof covering means the tiles or slates, not the supporting elements or insulation);
- the majority of masonry material (e.g. brick, concrete block and stone) in walls to be recycled or reused;
- suitable uncontaminated demolition materials wherever appropriate in fill and hardcore.

Acceptable material may consist of reused items (e.g. bricks) which make up the majority of the element specified, or items which are composed of a mixture of new and recycled material (the majority recycled). For example, cements, mortars, tiles and aerated concrete blocks can incorporate fly ash or blastfurnace slag. All materials must be fit for their purpose, for example they must have sufficient strength and frost resistance.

4.2 Storage of recyclable materials

Encouraging recycling of domestic waste on a larger scale will increase the utility of non-renewable resources. 1 credit is given for providing a set of four containers for household waste, space for them and appropriate access for removal to a collection point. The size and type of bin would have to vary with the types of collection offered locally, therefore only the number of bins (4) and total capacity (minimum 240 litres) are specified, together with the size and arrangement of the storage space.

4.3 Water economy

The purpose of this credit is to reduce wastage of water, which is a valuable resource, and to increase awareness of its importance. 1 credit is given for specifying all WCs with a maximum flushing capacity of 6 litres or a rain water collection butt.

Water is an increasingly scarce resource with an associated increasing degree of financial and environmental cost from the development of new sources. A well designed WC can operate effectively at a capacity as low as 3.5 l, and 6 l should be achievable without significant risk. The traditional rainwater butt has gone out of favour, due partly to accidents involving butts and the difficulties of avoiding the breeding of midges and other insects. Suitable design would remove these problems.

4.4 Ecological value of site

Wherever buildings are constructed there is always a risk that, however environmentally friendly the building itself may be, it may present a threat to local ecology or areas of natural beauty. BREEAM/New Homes gives one credit for minimising damage to the local ecology, either by selecting a site of low ecological value or by developing a site in a way that protects the most important ecological attributes. Construction of homes does not have to reduce the ecological value of a site, it can be used to enhance the value and a second credit is available for doing this. This part of the assessment has been designed in collaboration with the Royal Society for Nature Conservation - The Wildlife Trusts Partnership.

Derelict sites may include contaminated land providing that adequate measures have been taken to ensure the health and safety of the occupants. The use of landfill sites which are releasing gases should be avoided. Requirements for using contaminated land should be dealt with by the normal health, safety and planning procedures. For example:

- a thorough analysis of possible soil contaminants should be made as materials such as polychlorinated biphenyls (PCBs) and heavy metals could have health implications;
- if landfill gas is a potential problem, near to landfill sites, membranes used in conjunction with some form of sub-floor ventilation would be appropriate at some sites to prevent explosions at a later date (measures must also be taken to minimise the risk of subsidence);
- contaminated land can be cleaned or the contaminants dealt with in a variety of ways using both in situ and ex situ methods; techniques to achieve this are under development but some, for example biological techniques are currently commercially available;
- contaminated waste can be excavated and replaced with clean fill (this method does not really solve the problem of contamination, it merely transfers it to another area).
- advice and guidance are available in DOE Circulars (DOE, 1987,1989), Building Regulations Approved Documents C (DOE/Welsh Office, 1989b) and Guidance Notes produced by the Interdepartmental Committee on the Redevelopment of Contaminated Land. Site investigation procedures are set out in a BSI Draft for Development (BSI, 1988).

4.5 Local public transport

Encouraging the provision and use of public transport will reduce traffic congestion, air pollution from traffic fumes and fuel consumption. No credit will be given in respect of this issue, but the builder will be asked to provide a description of the available local public transport as part of the assessment.

5. INDOOR ISSUES

Indoor issues include all those aspects of a building design which have an impact on the health, comfort or safety of the occupants, such as air quality and hazardous materials.

Many pollutants are found in the indoor environment, for example formaldehyde, other volatile organic compounds, wood preservatives, living organisms (e.g. bacteria, moulds, dust mites), particulates and fibres (e.g. man-made mineral fibres, asbestos), radon, combustion products (e.g. nitrogen dioxide), and lead. While there are now satisfactory procedures for dealing with many of these, others are increasingly causing concern.

In homes, many issues can be dealt with by good provision of ventilation and careful choice of materials and construction practice. There is also scope for improving physical aspects of the environment, and safety in the home, through simple changes in dwelling design.

5.1 Controlled ventilation

An improved level and consistency of indoor air quality can be achieved while maintaining energy efficiency through controlled ventilation. 1 credit is given for the installation of mechanical ventilation (MV) with heat recovery or a passive stack ventilation (PSV) system.

Mechanical ventilation should supply to living rooms, bedrooms and other "habitable rooms" and extract from rooms where moisture and odour are usually produced (e.g. kitchens, utility rooms, bathrooms, WCs) in order to achieve a minimum whole-home air change rate between 0.5 and 1.0 per hour. Good location of supply and extract terminals is specified in BRE Information Papers (Stephen, 1988; Stephen & Uglow, 1989).

PSV in the main kitchen would be needed (above main cooker if possible) and the main bathroom, with passive stack or extract fan in other kitchens, bathrooms, shower rooms, WCs, utility rooms. Design should be according to guidance given by Stephen & Uglow (1989) to achieve an average air extract flow rate equivalent to 1-2 room air changes per hour.

PSV is driven by the indoor-outdoor temperature difference and by wind effects and therefore does not require additional energy for fans. There is limited user control but the ventilation rate will increase with increasing temperature of the room being ventilated, for example during cooking or bathing. It is also possible that continuous ventilation at a lower rate may be more effective than ventilation at an intermittent higher rate. This is because it is likely that a significant proportion of the moisture and other air pollutants are absorbed into the structure and then desorbed over a period of some hours.

The home must satisfy airtightness criteria to ensure that the ventilation devices are effective: 7 air changes per hour (ach) at a test pressure of 50 Pascals for MV and 9 ach for PSV. These standards should be fairly easy to achieve in timber framed dwellings but less easy at present in brick/block construction. An airtight dwelling would also require trickle vents to provide adequate controlled background ventilation if PSV is used. Chimneys both reduce airtightness and provide some passive ventilation. BREEAM requires appropriate procedures to be followed to preserve airtightness while not endangering health and safety. In the case of a solid fuel fire or chimney with no heating appliance supplied, a well fitting chimney closure plate must be provided. Other heating appliances fitted with a chimney or flue must be designed so as to be inherently airtight when not in use.

5.2 Cooker hood

In order to minimise the spread of moisture, pollutants and odours within the kitchen and from the kitchen to the rest of the dwelling, 1 credit is given for installing a cooker hood extract fan ducted to the outdoor air (or PSV or MV system extract point and hood above the cooker) rather than having any of these elsewhere in the kitchen.

This would be of particular value for gas cookers, which produce water vapour and oxides of nitrogen, and would in effect reduce energy consumption because an extract fan in kitchens is required by Building Regulations (DOE/Welsh Office, 1989) and if the extract fan takes the form of a cooker hood the minimum required air flow rate is halved.

5.3 Volatile organic pollutants of indoor origin

The level of volatile organic chemicals (VOCs) in the indoor air of new homes at the time of first occupation can be reduced by ventilation prior to occupation; not using urea formaldehyde foamed insulation (UFFI) or using it only in accordance with British Standards (BSI, 1985a,b,c); and not using coal tar products, which can emit naphthalene, or using them only with product quality control accreditation. One credit is given for doing this.

Many building, insulating, decorating and furnishing materials can be sources of VOCs. For example, UFFI and some paints, varnishes, carpeting, wood-based sheet materials and furniture emit small amounts of a variety of VOCs including formaldehyde and other aldehydes. Occupant activities constitute another major source in the indoor environment, but these are not included in the assessment. While the VOC levels produced in new homes are not regarded as hazardous, they can be unpleasant and may cause minor irritation reactions in a relatively small number of sensitive individuals. One way of tackling this issue would be to specify that certain materials should not be used. Various products are available or being developed which would emit VOCs at a lower rate than materials in widespread current use, but there are problems with requiring the specification of these alternatives.

For example, British Standards (BSI, 1989a) set a maximum level of extractable formaldehyde content for particleboards (25 mg per 100 g of board). Medium density fibreboard (MDF) is covered by another British Standard (BSI, 1989b). Board which satisfies these standards would not normally cause any irritation. In fact particleboard is available which is claimed to emit no measurable formaldehyde. Such board uses an isocyanate-based glue; it has good moisture-resistance properties but it is relatively expensive and rarely used indoors. While such advances are to be encouraged, the indoor environment consequences of the changes are not clear at present, and there are probably no substitutes of equivalent performance and economy for particleboards used in construction. It is therefore not advisable to place limits on the use of particleboard at present, but builders should specify boards which comply with British Standards.

Similarly, varnishes with low solvent content, and water-based paints for interior decoration, are available and would emit lower levels of hydrocarbons. Also, UFFI can in most cases be avoided by using an alternative insulant. Care must always be taken to ensure that alternative products do not contain other materials of concern and that they have been sufficiently tested for the purpose for which they are used. The scale of any known hazard from materials currently in use is too small to justify specification of alternatives at present.

In the longer term, the European Community is drawing up guidelines for methods of testing VOC emissions from a wide variety of materials. These could be applied via European (CEN) standards to prevent the use of high emitting materials. For the present, specifiers are encouraged to discuss with suppliers the provision of low emitting materials.

Until there are accepted alternative materials, BREEAM places emphasis on reducing the levels of organics at the time the home is first occupied. In most cases UFFI would be introduced well before occupation and there should not be any problem with subsequent release of formaldehyde into the dwelling. Similarly, particleboard and MDF would normally be stored for a time before delivery and/or at the building site, and then put in place some time before occupation. Additional ventilation during the final stages of construction could help to reduce levels of VOCs still further, and would be of greater benefit in relation to decoration and furnishings, the other main sources of VOCs. In the context of VOC levels, there is little point in discouraging builders from decorating and part-furnishing new homes, since materials introduced prior to occupation should have a smaller effect on the occupants than the same materials supplied by the occupant.

Reduction of VOCs can be accelerated by means of a "bake out" before occupation. This entails turning the heating on high for a period, followed immediately by a fresh air flush with extract fans on full. This might, however, cause cracking of plaster and possibly reduce the effectiveness of building sealing. There is currently no adequate guidance on the safe and effective use of bake out in new homes and it is therefore not included in BREEAM.

The reason that naphthalene is mentioned specifically is that there have been instances of this chemical being released from bituminous cold-applied damp proof membranes containing coal tar. These are commonly used in solid floor and to some extent in suspended concrete floor (pot and beam), construction. The possible health effects of low levels of naphthalene are not well understood, but the odour is objectionable to most people, and can normally be detected at levels above 0.2 mg m^{-3}.

5.4 Wood preservatives

The unnecessary use of wood preservatives can be reduced while maintaining essential protection of vulnerable timber, by specifying no use of treated timber where it is not recommended in the relevant Codes and Standards, and all preserved timber to be industrially pre-treated ready for finishing on site.

Wood preservatives are essential to the long term integrity of some timber components for buildings and other constructions. Indeed wood preservative treatment is widely accepted as the simplest and most economic means of achieving timber durability appropriate to Building Regulations requirements for certain specific components. British Standards (BSI, 1989c,d) and specific Codes of Practice give guidance on building components where preservative treatment should be considered in the interests of satisfactory performance in service.

Wood preservative use in the UK is regulated under the Control of Pesticides Regulations (MAFF/HSE, 1986) under which it is an offence to sell, supply, use, store or advertise wood preservatives which have not been approved for safety and effectiveness. A list of Approved Products is published annually by the Ministry of Agriculture Fisheries & Food/Health & Safety Executive (MAFF/HSE). Additions and amendments are published monthly in "The Pesticides Register" (MAFF/HSE). Specifiers with particular local criteria can select from this list those products which conform with their special requirements.

Specification of preserved timber for new build should favour pre-treatment because this is carried out under controlled conditions by trained specialists. This is preferable to on-site techniques, which are often applied by non-specialist personnel. It also reduces the potential for solvent from treated timber being emitted into the building structure following completion. Timber pre-treated in controlled, industrial plants by specialist professional suppliers is readily available or can be ordered for specific construction purposes.

Use of preservative fluids on site can therefore be limited to essential operations only (e.g. certain protective decorative finishing and application to cut ends in accordance with published Codes and Standards and the instructions of the suppliers of the timber). Contractors should be directed to adhere strictly to the guidance on handling preservative pre-treated wood provided by the treaters or suppliers.

Although wood of suitable natural durability can be specified as an alternative to preservative treatment, with some species there may be cost penalties, engineering consequences and difficulties in obtaining supplies. In particular, should the selection of naturally durable timber lead to an increase in the use of tropical hardwoods, this will present a conflict with environmental concerns for their conservation and more rational use.

5.5 Non-gaseous indoor pollutants

To eliminate minor or occasional health risks which are not at present covered by regulations, two credits are available:

- 1 credit for either (a) not using man-made mineral fibre (MMMF) roof insulation or (b) preventing fibres from becoming airborne within the living space (by boarding any loft area or completely enclosing all MMMF loft insulation in polyethylene) and fine filter vacuum cleaning after building works are complete;
- 1 credit for specifying no use of asbestos or of paints which contain lead.

For safety reasons, loft boarding must include provision of a light in the loft space, which can be switched on without entering the loft using a switch with an illuminated off/on indicator. Boarding should also not compress the insulation material.

MMMF are widely used as insulation materials and the finer fibres, if they become airborne may enter and be deposited in the lungs. They are linked with irritation of the skin, eyes and the upper respiratory tract. Insulation wools and special purpose fibres are the ones most likely to cause irritation.

MMMF in the domestic situation are not believed to constitute a significant health risk, but credit is given for measures to prevent fibres becoming airborne in order to minimise the possibility of minor skin and airway irritation and to reduce dust and dirt in the home.

Asbestos is a proven human carcinogen and exposure to high levels of airborne white asbestos fibres in the work place (in asbestos manufacturing), can cause lung cancer. The risk of lung cancer from exposure to the very low levels of airborne fibres normally found in buildings is extremely small - estimated to be between 1 in 100,000 and 1 in a million (World Health Organisation, 1987). The use of blue asbestos (crocodilite), brown asbestos (amosite), and products containing them is now prohibited in the UK. The use of white asbestos (chrysotile) and products containing it is permitted although restricted. Today most white asbestos is used in asbestos cement products and in friction materials. However, alternative non-asbestos fibre reinforced materials are available (HSE, 1986) and their specification is appropriate for buildings which are designed in response to environmental concerns.

A European Directive (1991) in effect prohibits the use of lead paints in new homes. However, this has not yet passed into UK law and in any case there may be some residual stocks of lead-based paints. BREEAM therefore credits the use of lead-free paint.

5.6 Lighting

Three measures are offered to improve the level of visual comfort, security and safety produced by the lighting of the home:

- 1 credit for designing the kitchen and all habitable rooms to meet daylighting criteria (CIBSE, 1987; Littlefair, 1988);
- 1 credit for specifying high frequency ballasts with low-energy lighting in the kitchen and all the habitable rooms;

- 1 credit for an external light fitted with a compact fluorescent lamp and a remote sensor consisting of an infrared source and photocell.

Maximising the use of daylight, which most people prefer to artificial light, will reduce electricity consumption for lighting. In order to avoid increasing heating energy consumption double glazing may be necessary. There are two main criteria for achieving good daylighting indoors:

- the average daylight factor in a room (minimum 2% for kitchens, 1.5% for living rooms and 1% for bedrooms);
- no significant areas (20% or more) of each room, or any fixed work surfaces or tables, from which the sky cannot be seen from table top height (0.85 m).

In offices, headaches and eyestrain have successfully been reduced when high frequency ballasts are substituted for conventional ballasts used in fluorescent lights (Wilkins et al, 1989). No corresponding study has been undertaken in homes, but it is likely that a similar effect would be obtained.

5.7 Smoke alarms

To reduce injury, death and property damage or loss due to fires there is 1 credit for installing mains-operated smoke alarms, with battery back-up, at appropriate locations. A secondary benefit will be to reduce the probability of excessive smoke from cooking spreading around the home.

British Standards describe suitable mains-powered alarms (BSI, 1990) and appropriate locations for them in homes (BSI, 1989e). The guidance on locations is also given in a free leaflet (Home Office, 1990) available from Fire Stations. Where a dwelling covers more than one floor the system should be linked so that smoke detected on one floor sets off the alarms on the other floor(s).

5.8 Storage of hazardous substances and medicines

To help prevent accidental harm due to contact with hazardous substances and medicines kept in the home, there is 1 credit for specifying two secure cupboards, one for the storage of hazardous substances and one for the storage of medicines. It is recommended that the cupboard for hazardous substances should be located under the kitchen sink. The medicine cabinet should be located out of reach of children. Both should have a lock and key.

Hazardous chemicals are kept in the majority of homes, for example corrosive agents (e.g. paint stripper); irritant chemicals (e.g. white spirit); toxic chemicals (e.g. paraquat in weed killer) and flammable substances such as methylated spirits. Specific categories of hazardous material are defined by law and any product containing them must name them on the label and carry an appropriate warning. However, there are instances each year of children suffering injury or death because hazardous substances were stored within their reach. Similarly, medicines are introduced into most homes at some time and the measures specified by BREEAM/New Homes would help to prevent accidental ingestion of medicines which could be hazardous in excess.

6. CONCLUSION

There is considerable scope for reducing the adverse impact that buildings can have on the global, local and indoor environments, thus creating short term benefits indoors and locally and, in the longer term, a contribution to the health of the world and its people. BREEAM makes a start in this work; it will be continuously extended and improved and is already stimulating the development of similar schemes around the world.

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