

Design and Detailing for Toxic Chemical Reduction in Buildings

SEDA Design Guides for Scotland : No. 3

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Note:

- It is the responsibility of the reader to ensure that designs comply with current regulations.
- The details shown are for demonstration purposes only, and are not intended as proposed working drawings.
- The views expressed in this publication are entirely those of the authors and do not necessarily reflect the views of the Scottish Executive or SEDA.
- The Authors have made every attempt to ensure that the text is accurate at the time of publication, but can not guarantee this.
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Front Page image:- Pfennigäcker A Healthy School. Architect Joachim Eble Architects. Photo Howard Liddell

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1 Introduction

This guide is one of a series commissioned by The Scottish Ecological Design Association (SEDA) on design and detailing for more sustainable construction.¹ It targets the use of chemicals in our built environment and offers guidance on designing and detailing to reduce toxic loads in buildings.

The guides result from the award to SEDA, in 2004, of a Sustainable Action Grant from the Sustainable Development Directorate of the Scottish Executive.² Previous guides offer guidance on

- designing and detailing for deconstruction (2005), which aims to assist in reducing the vast waste stream for which the Construction Industry is responsible.³
- design and detailing for airtightness (2006), which aims to assist in reducing the energy wasted through infiltration in typical construction.⁴

This guide seeks to help all involved to minimise the toxic loads in construction, products, buildings and the built environment and to create buildings that are healthier for occupants and enhance the environment.

The issue of chemical toxicity is not trivial. In 2002, 2.17 megatons of toxic chemicals were released into the environment by US industry alone. Many of them were known or suspected carcinogens.⁵ They arise from building materials, paints, finishes, furnishings, cleaning fluids, cosmetics and a range of other means. Less than 3% have been tested for carcinogenicity. Many people believe that this represents an unacceptable, uncontrolled experiment on the environment. The construction industry has an important role to play in changing behaviour and in changing attitudes.

Awareness and management of chemical toxicity in built development is, at least in principle, now recognized as good practice in terms of site health and safety, but we are still a long way from establishing toxicity as a life-cycle concern that embraces manufacture to end-of-life, and beyond. This is despite a substantial body of evidence to indicate that many construction materials are potentially hazardous to health and deleterious to the environment throughout their life-cycle.

The design of buildings that do not impose a toxic load on constructors, users or the environment is a crucial aspect of policy implementation if Scotland is to meet its commitments to enhance well-being, health and biodiversity.⁶ In regulatory terms this is a relatively new area but there are a number of recent studies that include extensive referencing in respect of policy and legislation.⁷

Footnotes:

1. SEDA www.seda2.org/
2. Now the Greener Scotland Directorate of the Scottish Executive: www.scotland.gov.uk/Topics/SustainableDevelopment
3. Designing and detailing for Deconstruction (2005) www.seda2.org/dfd/index.htm
4. Designing and detailing for Airtightness (2006) www.seda2.org/dfa/index.htm
5. U.S. EPA Toxics Release Inventory www.epa.gov/tri/
6. Royal Commission on Health and Pollution (RCEP) Study on Urban Environments, Well-being and Health (2003) www.rcep.org.uk/urbanenvironment.htm
7. Halliday, S.P and Stevenson, F. (2003) Sustainable Construction & the Regulatory Framework, Gaia Research, Edinburgh ISBN 1-904680-19-4



Design and Detailing for Deconstruction



Design and Detailing for Airtightness



Design and Detailing to Reduce Chemical Load in Buildings

There is a huge resource of contemporary research on chemical toxicity. This is summarized here with extensive guidance on the sources of further information. However, importantly, the basis of this guide is merely a presumption for chemical avoidance rather than a scientific analysis. It aims to enable those who wish to err on the side of caution to do so. Details and specifications are included covering five typical construction types. These are for illustrative purposes only and are not proposals. A discussion on costs is also included.

It would be wrong to limit guidance such as this to only describing toxics and the alternatives, and leave out the “higher order” guiding principles. It is through an overall approach that inroads are most likely to be made in design offices, and in the design and manufacture of goods. The overall wisdom of simplification replaces, or renders unnecessary, certification schemes and specification sheets.



The best known woodstain products contain chemicals which are a significant health hazard. There are now a number of alternative mineral paint products available, with good health and environmental credentials.

Source: H Liddell



Health warnings on woodstain and paint stripper containers highlight the danger of the chemical toxicity contained within.

Source: J Gilbert



The Earthship projects have as one of their core materials recycled tyres. However, used tyres are contaminated with benzene and represent a health risk to both the constructors handling them and potentially also those living within this containment.

Source: Sandy Halliday

2 The Context

Key Principles

1. The use of chemicals in modern buildings is widespread yet very few have been comprehensively tested for carcinogenicity or other health threats.
2. Responsibility for the level of toxicity in the indoor environment falls to specifiers in the absence of more prohibitive, building regulations.
3. That the use of toxic chemicals has an impact on health is evidenced by a number of research projects into building related illnesses.
4. Adopting the precautionary principle relates to the practice of the removal of materials from the indoor environment, where a specifier has concerns that there is insufficient proof to determine that a material is safe for use.

2.1 Aim of the Guide

To increase uptake of benign construction techniques and thereby reduce chemical loads on humans and the environment.

2.2 Objectives

- To highlight the potential risks to building users and the wider environment associated with chemical toxicity in buildings and building products;
- To highlight the benefits of benign specification which can improve the indoor environment, contribute to well-being of occupiers, improved performance, staff retention and reduction in building-related ill-health (also known as sick building syndrome);
- To promote an overall approach of simplification that replaces, or renders unnecessary, certification schemes and specification sheets;^{8, 9}
- To reduce the burden placed on the environment due to chemical toxicity in construction waste;
- To promote cost effective design solutions that eliminate the use of chemical toxins as the norm;
- To enable those who wish to adopt the precautionary principle to do so.

Building Case Study #1

"Non-Toxic" House,
Stavanger, Norway
Architects - Gaia Lista, Norway



Photo source: Gaia Lista

The 'Gifftti' (toxin-free) house in Stavanger
Environmentally sound and healthy house.

Key Design Features

- Breathable Construction with Limecrete + lightweight locks for moisture regulation.
- Internal wood panelling treated with lime wash that bleaches but preserves moisture regulating properties.
- Kitchen and bathroom in limecrete to prevent mould.
- Non-toxic silicate paint preserves moisture regulating properties.
- Flooring is either wax/oiled timber, or loose laid brick tiles.
- Cellulose fibre insulation in all walls + roof.
- Expanded clay aggregate and foam glass are used at ground level.
- Sheepswool used for draught sealant around windows.

8. Liddell H.L., (2002) Ecominimalism www.seda2.org/articles/Ecominimalism.html

9. Select Committee on Science and Technology www.parliament.the-stationery-office.co.uk/pa/ld200506/ldselect/ldsctech/21/4111706.htm

2.3 How to use this Guide

Sections One, Two and Three of this guide cover an overview of the issues, and Section Four looks at approaches to minimising chemical loads and provides sources of good information.

Section Five discusses cost issues with reference to case studies.

Section Six provides a selection of details for a variety of construction types. It includes an indication of the basic problems with existing specifications and identifies the reason for alternatives on the materials used. These are provided in order to illustrate discussion and are not in any way intended for replication. Any solutions need to be designed for their unique context.

At the end of this Guide there is an annotated list for further reading, which is separated into a short guidance list and background reading, as well as a list of useful contacts and websites.

Toxicity can be an issue at every stage from extraction to disposal of a material or product. This publication prioritises the building user and the indoor climate. It also addresses the total life cycle of a material such as when it is toxic in its manufacturing (e.g. PVC) or its installation (e.g. timber treatment spray) or if it becomes a problem at the end of its useful life (e.g. Composite panels).

PVC

Many finishes, decorating and bonding materials - paints, lacquers, adhesives and sealants - can off-gas a range of chemicals.

Risks

- During manufacture: ingredients such as the vinyl chloride monomer emit dioxin and other persistent pollutants present both acute and chronic health hazards.
- During use: PVC products can leach toxic additives, for example, flooring can release softeners called phthalates (recognised asthma triggers also linked to genital deformities, premature births, hormone disruption and cancer).
- In disposal: leaches toxic additives when disposed of in landfill; emits dioxin and heavy metals when incinerated.
- In fire: emits hydrogen chloride gas and dioxin.

Possible PVC alternatives

- Stainless steel conduits;
- PE, PP or rubber sheathing to wiring;
- Copper or PE water pipes;
- PTFE (Polytetrafluoroethylene) non-reactive pipework;
- Cast iron rainwater goods;
- Linoleum or rubber in lieu of vinyl floor coverings.

There are a number of websites giving detailed guidance on alternatives to pvc and on suppliers.^{10,11}

10. Greenpeace <http://www.greenpeace.org/international/campaigns/toxics/polyvinyl-chloride/pvc-alternatives-database/>

11. Healthy Building Network <http://www.healthybuilding.net/pvc/alternatives.html>



PVC Pipe routinely used inside and out.
Source: H Liddell



PTFE is an economic substitute for PVC.
Source: H Liddell

2.4 Target Audience

This Guide will help all those who wish to reduce the toxic chemical loads in buildings and thereby to reduce the environmental damage and minimise the risks to users and the wider environment associated with their projects, including:-

- clients, building owners and users
- architects
- architectural technicians
- health professionals
- voluntary agencies
- project managers
- builders
- interior designers
- structural engineers
- building service engineers
- building surveyors
- quantity surveyors/cost consultants
- maintenance/facilities managers
- planning officers
- building control officers
- funding bodies/professional advisors
- government agencies
- lobby groups

2.5 Justification

“Of the 75,000 synthetic chemicals which are now in common commercial use, less than 3% have been tested for carcinogenicity. In 1994, 2.26 billion pounds of toxic chemical were released into the environment, of which, 177 million pounds were known or suspected carcinogens. Most testing of chemical toxicity is undertaken on the basis of exposure at work by adults. We are ignorant of the effects on children and other species which might be vital to the ecological make-up of the planet. No one knows the cocktail effect. It is permitted only because the victims are anonymous.”

Steingraber in Living Downstream¹²

There is substantial evidence to indicate that a proportion of construction materials are potentially hazardous to health and deleterious to the environment. They continue to be used for lack of evidence of their toxicity. The Royal Commission on Environmental Pollution (RCEP) highlighted this in a report in 2003.¹³

“...The current system for managing the risks from chemicals fails to secure public confidence and is overloaded by the massive backlog of chemicals waiting to be assessed. ... A more inclusive, precautionary and effective approach is urgently required.”¹⁴



Rauli Kindergarten (2005) by Gaia Lista was designed with 100% benign materials in the indoor climate.
Source: B Berge



The UK Off site construction (OSC) industry is heavily chemically laden. This is in contrast with OSC in Austria, Switzerland and Germany. (Image UK)
Source: F Stevenson

12. Steingraber, S. (1997) “Living Downstream” Virago Press, London

13. Royal Commission on Environmental Pollution (2003) “Chemicals in Products” TSO

14. Ibid

Considerable amounts of time, expense and effort have been spent on the detailed numerical analysis of the environmental impact of building materials and components. The work has come up against real practical and philosophical difficulties and there is little information of direct day-to-day value to manufacturers and specifiers. The picture is also clouded. It is not unusual for manufacturers to seek to find fault with competitor's products whilst looking to show their own in the best possible light.

Changes in attitudes towards the impact of construction have taken place in Europe recently, in part prompted by the disturbing results of research into pollution of the environment. There are abundant water, land and air-borne pollutants and there are numerous reports on a wide range of them including carbon dioxide, ozone, dioxins, heavy metals and Polychlorinated biphenols (PCBs). Impacts are evident at all life-cycle stages from manufacturing to leaching of waste materials in landfill.^{15, 16}

The international response has led to serious attempts to reach agreements to limit pollution.¹⁷ This is leading to more stringent legislation and changes in economic policy to reverse unsustainable trends. The climate change levy, WEEE regulations, changes to building regulations and landfill tax are some examples. It is notable that these policies are leading to changes in construction activity, and in the use of materials. European regulations are being introduced including a directive on VOCs and controls on chemicals through the REACH regulations.^{18, 19}

The World Wildlife Fund (WWF) has undertaken research on chemical loads on people. They conducted monitoring surveys of human blood, to identify hazardous man-made chemicals that contaminate our bodies. The alarming results highlighted a wide range of chemicals in human blood originating in buildings.²⁰

There is increasing attention to minimizing waste arising from construction, and increasing pressure on primary resource conservation is leading to reuse and recycling of construction materials. However, many materials in our buildings have embodied toxicity. This may be intrinsic to the material, as is the case with asbestos or occur largely as a result of manufacture, as in PVC. It is also possible for toxicity to accumulate during the product life, as is the case with bricks next to a busy road. Builders and specifiers need to be aware of the potential hazards posed by this embodied pollution and act accordingly to avoid exposure to future risk and liability.

Building Case Study #2

Sunnmoeregata, 1, Oslo, Norway
Architects - Alice Reite

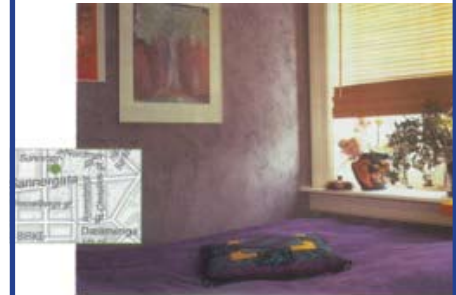
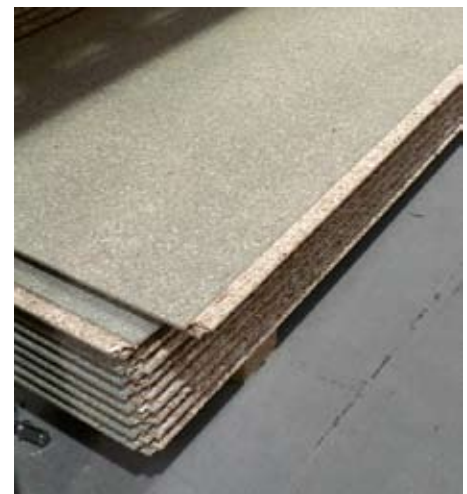


Photo source: A Reite

Project aim:-
Non-toxic renovation in inner-city flat in Oslo.

Key Design Features

- Natural materials throughout inc. clay, eco-paints, oils and woodwork.
- Humidity controlled without fans.
- Heating cables in walls to reduce dust circulation.
- Plastic materials completely avoided.



Chipboard is a ubiquitous flooring material. It is usually bonded together with Phenol formaldehyde resin (formaldehyde is one of the most virulent triggers for allergic reactions). In addition it is sometimes treated with preservatives of a type banned in the USA since 2002.

Source: H Liddell

15. www.defra.gov.uk/environment/statistics/

16. www.scotland.gov.uk/Publications/2005/08/15135632/56452

17. Brenton T., (1994) The Greening of Machiavelli RIIA

18. http://www.defra.gov.uk/environment/ppc/old-consultations/vocs-transpose/consult_doc.pdf

19. REACH - http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

20. <http://www.wwf.org.uk/chemicals>

Given the trend towards improving health & well being, enhancing biodiversity and waste minimisation there will be increasing attention to the toxicity of materials in the future. The burden of responsibility increasingly lies with designers to use materials that can be safely re-used and can withstand future, more stringent, regulation. The use of outputs from other industries as inputs to the construction industry demands that we use extreme caution to ensure that these materials do not introduce a toxic burden to buildings.

There is growing concern about indoor air quality and other adverse factors within buildings, highlighted by 'Building Related Illness'. Indoor air quality is now legislated for in many countries.^{21, 22} This guide limits its remit to construction and fixtures, but not the ventilation, fit-out, furnishings and finishes that are also implicated. They are highly likely to introduce or contain toxic materials and have cleaning and decoration regimes that are potentially chemically hazardous. There can also be a risk that inappropriate construction can lead to biological toxicity for example through mould growth. Whilst this study is focussing on chemical toxicity, the authors feel that it would be an artificial boundary not to refer to this significant risk. Designers and specifiers should discuss these issues with clients and users.

Radon and radiation are also recognized as significant in relation to indoor air quality but are outwith the scope of this publication. We have provided references to further information.

Radon emissions from the ground, and their seepage into buildings are of serious concern in some geographical locations.

Radiation and electro-magnetic smog is an area of increasing concern and speculation.^{23, 24, 25, 26}

"The Health Protection Agency acknowledges that little study has taken place on electric fields and that links between electromagnetic fields and cancer are not ruled out, with further research required. They advise a precautionary approach which minimises people's exposure to certain types of electromagnetic radiation. The building regulations do not take account of electromagnetic radiation but do require housing to be protected from radon gas, where it occurs at significant levels."²⁷

Legal Case Studies

There have been a number of legal cases brought against landlords, homebuilders and insurers over health problems originating from poor indoor air quality. Four are highlighted in this publication.

Most examples are from the United States where legal action on indoor air quality is common, and often results in the payment of large damages.

A large number of cases in the US concern toxic mould growth and associated health problems. Toxic mould is widely regarded as a medical hazard and is more open to litigation, than other indoor pollutants such as dust mite allergens and VOCs where medical research is complex and less conclusive.

In the US the number of claims has increased rapidly with 7143 cases being reported in 2001 compared to only 3 cases a decade before. Substantial sums have been awarded to plaintiffs in a trend that has seen contractors placing exclusions in their contracts and insurance companies raising premiums or adding exemptions to their policies.

21. www.hse.gov.uk/LAU/lacs/75-1.htm

22. www.unison.org.uk/safety/doc_view.asp?did=181

23. Saunders, T. (2002),

24. BRE publication BR376 (1999) Radon: guidance on protective measures for new dwellings in Scotland BRE

25. www.hse.gov.uk/radiation/ionising/radon.htm

26. Scottish Building Standard 3.2 Site preparation – protection from radon gas, in the Domestic and Non-domestic Technical Handbooks.

http://www.sbsa.gov.uk/tech_handbooks/th_pdf_2007/Section_3_Domestic_2007.pdf

http://www.sbsa.gov.uk/tech_handbooks/th_pdf_2007/Section_3_Non-domestic_2007.pdf

27. Health Protection Agency, offers testing and guidance on Radiation Protection www.hpa.org.uk/radiation/

2.6 Policies and Regulation

2.6.1 Key Policies

Since 1990 there has been a succession of policies that have evolved to promote sustainable construction.

The UK policy paper A Better Quality of Life – A Strategy for Sustainable Development in the UK²⁸ included the following:-

“Effective protection of the environment. We must act to limit global environmental threats, such as climate change; to protect human health and safety from hazards such as poor air quality and toxic chemicals; and to protect things which people need or value, such as wildlife, landscapes and historic buildings.”

EU and International Policy on the environment includes the Construction Products Directive, promotion of the precautionary principle and implementation of policy to enforce the polluter pays principle, such as the WEEE regulations.²⁹

- **Precautionary Principle**³⁰

Wherever there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. This is very relevant to the question of chemical toxicity because of the lack of scientific proof.

- **Polluter Pays**

The ‘polluter pays’ principle requires those people who cause pollution to be responsible for paying the cost of remediation. The recently introduced Waste Electrical and Electronic Equipment Directive (WEEE) makes producers responsible for financing the collection, treatment, recycling and recovery of waste electrical and electronic equipment. This type of regulation initially targeting the most hazardous and widespread pollutants is having, and will continue to have, wide-ranging impact. The chemical toxicity in building products is going to be less easy to ignore. These are also part of international agreements on the environment, the latter in the generic context of internalizing external costs. In addition international policy relates to the rights of future generations, all sectors of the current generation and our responsibilities to enhance biodiversity.

- **Protection of Biodiversity**

There is significant evidence of the value that people place on biodiversity and the contribution to human well-being.³¹ However the issue extends beyond well-being to survival. Reducing biodiversity diminishes the gene pool and impairs the robustness of natural systems. This increases the risk of exponential failure of natural systems, which can in turn jeopardise human life. Protection of biodiversity requires us to be attentive to the lifetime impact and the final destination of construction materials and products.

28. A Better Quality of Life – A Strategy for Sustainable Development in the UK
<http://www.sustainable-development.gov.uk/publications>

29. EU Sustainable Development Strategy
http://ec.europa.eu/sustainable/welcome/index_en.htm

30. http://europa.eu/scadplus/glossary/precautionary_principle_en.htm

31. Royal Commission on Health and Pollution (RCEP) Study on Urban Environments, Well-being and Health www.rcep.org.uk/urbanenvironment.htm

Legal case Study #1

Call vs. Prudential (Settled 1992)

This first major IAQ case argued before a jury in the US generated important IAQ related law.

The main charges of negligence brought by the plaintiff included:

- The use of building materials that off-gassed formaldehyde and other noxious chemicals.
- Failure to notify that the building was not suitable for occupancy due to noxious fumes and chemicals infiltration.
- Failure to supply adequate levels of fresh air.
- Failure to act on reports of tight building syndrome (TBS) and sick building syndrome (SBS).
- Failure to provide information on the health effects of TBS and SBS.

Liability for problems with the HVAC system was extended to the manufacturers and sellers of the system as well as everyone involved with the construction and design of the system including architects, engineers and installers.



Prefab sheets for playhouse.

Oriented Strand Board (OSB) – contains formaldehyde and is being used e.g. for a pre-fabricated kit playhouse for children.

Source: H Liddell

Whilst we have an abundance of sustainability policies representing the stated priorities, aims, aspirations and objectives of national governments, international bodies, professions and companies – we have little by way of regulation or controls to enforce improvements at the design stage. However, ‘end of pipe’ measures to treat pollution or charge polluters are driving changes in the supply chain.

In reality it is widely recognised that the value of regulation remains in minimising bad practice. Driving forward changes in practice that are desirable and necessary often falls to committed leaders prepared to innovate, from whom others then take the lead.

It is for this reason that this guide promotes the higher order EU and International requirements of precaution, responsibility and good sense. It is an overall approach of simplification and good sense that is necessary in the first instance, in order to produce the new generation of affordable buildings with reduced chemical load that can provide the evidential base and momentum to facilitate moving legislation forward.

2.6.2 The Role of Regulation

The issues which have prompted this guide have come to the fore in recent years, as yet such policy that exists is very generalised due to the lack of detailed research in to the area. Where policy has been translated into regulation to date it has only looked at specific ‘end of pipe’ issues – such as with the control of asbestos.

The Building (Scotland) Act 2003 led the UK by introducing the powers to make building regulations to further the “achievement of sustainable development.” In 2004 the agency initiated a review of the Building (Scotland) Regulations 2004 and the associated Technical Handbooks in order to identify any barriers to sustainable development and possible strategies to enhance sustainability.

Research into sustainable construction and the regulatory framework for the Scottish Executive included an appraisal of building regulations in other countries.³² It indicated that there was significant opportunity proactively to set objectives and to develop the appropriate mechanisms for achieving them. It identified examples of promotion of sustainable development objectives through a Building Regulatory Framework in Norway, Sweden and Germany.

In Scotland the current position is that, in the absence of detailed investigative research into individual toxins and groups of toxins, the current regulations concentrate on controlling air quality through guidance on ventilation. It is vitally important that adequately funded research is undertaken and that the results are used to minimise toxic loads through stricter Building Regulations.



Paint finishes need to be both moisture permeable and avoid off-gassing. The last 10 years has seen a wide range of benign options come onto the market in the UK.

Photo taken in The Green Shop, Bisley, Stroud
www.greenshop.co.uk
Source: H Liddell



WHAT IT SAYS ON THE TIN

Paints and preservers now come with warning labels attached and explain the harmful toxins that they contain.

Source: H Liddell

32. Halliday S.P., and Stevenson F. (2004) Sustainable Construction and the Regulatory Framework, Gaia Research, Edinburgh, ISBN 1-904680-19-4

2.7 Responsibilities and Roles

The responsibility for toxicity in building materials in Scotland lies between a number of organisations – SEPA (Scottish Environmental Protection Agency), HSE (Health and Safety Executive), British Standards Institute (BSI) and Local Authority Environmental Health Departments.

SEPA covers the cradle and the grave – i.e.

- Cradle:- the process surrounding the initial gleaning of the raw material - through mining, extraction, harvesting, etc. and
- Grave:- the waste stream that ends up in the ground, in water or in the air.

The HSE covers the area of occupational hazards and is responsible for any identified risks at a factory, assembly plant or building site. They also overlap with Local Authority Environmental Health Departments in terms of any clearly identifiable Sick Building Syndrome factors.

The EU Construction Products Directive embodies the idea of life cycle responsibility.

“The environmental impact of construction products and materials is subject to standards set by the International Organisation for Standardisation (ISO) EU harmonised standards (CEN) and European Technical Approvals (ETA). Under the EU Construction Products Directive 89/106/EEC (CPD) section on “hygiene, health and the environment” construction work must be designed and built in such a way that it will not be a threat as a result of any of the following:

- The giving-off of toxic gas
- The presence of dangerous particles or gases in the air
- The emission of dangerous radiation
- Pollution or poisoning of the water or soil
- Faulty elimination of waste water, smoke, solid or liquid wastes
- The presence of damp in parts of the works or on surfaces within the works

From ISO 14040:2006 and ISO 14044:2006 ³³



A number of relatively benign products are entering the insulation market including sheepswool (See spec note 23 in Appendix F)
Source: F Stevenson

33. www.iso.org Also <http://www.eota.be/http://ec.europa.eu/enterprise/construction/internal/intdoc/id3/explanid3.htm>

3 The Issues

Key Principles

1. Growth in the use of modern building materials, decreased ventilation levels and fluctuating moisture levels have introduced increased levels of allergens in the indoor environment.
2. Poor indoor air quality can have a significant effect on health.
3. Volatile Organic Compounds pose a number of risks to health.
4. Care needs to be taken with all material types and attention given to treatments and processing in product manufacture.
5. Designing with benign materials benefits the environment, economy and community. In some cases, prices may be higher than standard products but it is often possible to make trade-offs, and additional costs will decrease as market share and competition increases.

3.1 Construction Related Chemical Pollution

Throughout the 20th century – but especially post-war – the construction industry has changed both its construction methods and its building materials. This has contributed to changed heat and moisture retaining capacities of buildings. As a consequence, fluctuations in moisture content in buildings are greater and so are the problems caused by moisture, which serves as a medium for chemical reactions and microbial growth. An increasing dependence on a high content of mechanical services in seeking to mitigate this is also a major cause for concern.

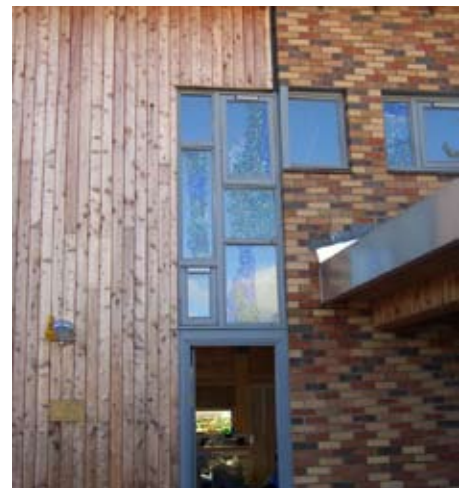
Modern buildings are less well ventilated than in the past (it is not unusual to find air changes of less than one per hour in modern, well insulated buildings). Whilst this is a trend necessary for environmental and energy benefits, it can lead to a build up of triggers in the air and to excessive moisture levels.

At the beginning of the 20th century, about 50 materials were used in buildings. Now, about 55,000 building materials are available, and over half are man-made.³⁵ There has also been a dramatic upsurge in pollutants such as synthetic chemicals in furnishings, fabrics and finishes.

Solvents (chemicals commonly used in paints and adhesives).
Risks range from: irritation & headaches to dermatitis, colour blindness, brain damage, cancer and even death.

Possible solvent free alternatives:

- Natural water-based emulsion paint;
- Linseed oil-based gloss paint;
- Avoidance of materials containing or requiring glues, e.g. manufactured wood products, wallpaper;
- Where use of glues is unavoidable, (e.g. for installation of linoleum or rubber flooring) use solvent & formaldehyde free glues;
- Avoidance of timber treatments through detailing.



This recycling centre in Bute by Chris Stewart Architects, made from recycled materials is ingenious, however, not all recycled materials have good toxicity pedigrees.
Source: F Stevenson



Standard wood preservers come with a serious health and environmental warning.
Source: H Liddell

35. Roalkvam D., (1997) Naturlig Ventilasjon NABU/NFR

There is evidence of a relationship between modern building materials, the increase in indoor allergens and an increase in allergic reaction.^{36, 37} Some studies have implicated building materials including PVC, some paints, varnishes, insulation materials, timber treatments and wood composites; many furnishings are also implicated.³⁸ There is increasing evidence of the role that toxicology plays in pre-disposing people to asthma. Evidence is appearing that particulates of elements such as cobalt, nickel, cadmium and mercury have a profound effect on the immune system.^{39, 40}

The US Timber industry agreed to phase out use of Copper Chrome Arsenate (CCA) timber treatment, which has been a source of concern, provided that by agreeing to do so they were immune from future prosecution.⁴¹ (and spec.note 17 in Appendix F)

Product information relating to health is usually derived from tests conducted on otherwise healthy people, under laboratory conditions, using the substance in question only. The affects on those potentially most vulnerable to such toxins, such as the elderly, children and the unborn are rarely considered. Also, the risk to health from the 'cocktail effect' of the many chemicals present in buildings is very rarely considered, so information on health risks from specific substances may be insufficient.

3.2 Scientific Uncertainty

"The reason for scientific uncertainty is that the widespread introduction of suspected carcinogens into the human environment is itself a kind of human experiment... The tools of science do not work well when everything is changing all at once!"⁴²

There is significant activity at a government level to address concerns about, and to establish controls on, chemicals. However the proliferation of chemicals exceeds the capacity of scientific appraisal methods to assess the impacts. The US national toxicology programme estimated in 1995 that 5-10% of the 75,000 chemicals in current use might reasonably be considered to be carcinogenic. Of these at present we regulate only about 200. Eco-labelling systems are emerging, but cannot give attention to chemical toxicity because the basic testing has simply not been done. Current labelling requirements put the onus of voluntary declaration on the manufacturer.

36. Andrae S., et al (1988) Symptoms of bronchial hyper-reactivity and asthma in relation to environmental factors Arch Dis Child 63 473-478

37. Abramson M., et al (1991) Ambient Air Pollution and respiratory disease Med J Aust 154 543-551

38. Oie L., (1998) The role of indoor building characteristics as exposure indicators and risk factors for development of bronchial obstruction in early childhood NTNU Trondheim

39. PM2.5 particulates: man-made particles smaller than 2.5 microns. These have increased dramatically in recent years at least in part due to the shift from coal to waste oil mixes in incinerators, factories, etc.

40. <http://www.epa.gov/>

41. Lumber Companies agree to Arsenic Ban St Petersburg Times February 13th 2002

42. Steingraber.S (1997) "Living Downstream" Virago Press, London



The green colour tinge in sawn timber indicates CCA treatment. This was voluntarily restricted by the US Timber industry on the basis of research from the American Environmental Protection Agency (EPA) in 2004.

Source: H Liddell

Legal case Study #2

DuPage County Courthouse v. Hellmuth Obata & Kassabaum

Staff experienced symptoms of SBS shortly after moving into the new courthouse in Illinois, with reports of over 400 occupants suffering from headaches, nausea, dizziness and respiratory irritation.

In March 1992 the building was evacuated with several building occupants requiring ambulances. Later that year, several of the occupants filed personal injury lawsuits against the architect and contractors (including the HVAC contractor) alleging that the design of the ventilation system and presence of VOCs were responsible for the illnesses they were experiencing.

The County also filed a lawsuit against the architects and contractors seeking \$3 million for fixing the ventilation system. The County failed to win damages, the final verdict stating the County was responsible, attributing the problems to the measures taken in response to earlier concerns over IAQ including the chemicals used to clean furnishings and alterations to the mechanical systems.

Only minor damages against the architect and contractor were awarded due to faults in the air handling systems. However a number of individual suits were settled out of court.

The publicity that this generated played a key role in insurers and others taking SBS more seriously.

Defra's chemicals pages provide a source of information on what the Government is doing to protect the environment and human health from the risks posed by exposure to hazardous chemicals.⁴³

Despite the lack of an adequate system of appraisal, designers still have a duty of care to ensure that their specifications are fit for purpose in terms of their performance in a construction. Designers failing to apply the precautionary principle will be at increased risk of liability.

SEDA positively supports material testing and content declaration.

3.3 Indoor Climate

It has now been demonstrated that the contemporary indoor environment is a significant source of risk in relation to health. In a study of 15 office buildings in Copenhagen, it was found that only 12% of the pollution of the internal air originated in the occupant metabolism:- 25% derived from smoking, 20% from materials & furnishings and 42% from the ventilation equipment. The basis of this work was the complex 'olf' unit - invented by Fanger for the amount of pollution into the indoor climate emitted by an average adult. Much that followed from it transformed perceptions of the impact of the indoor environment on health, and has major repercussions in relation to behaviour, servicing strategies, choice of finishes and legal requirements.

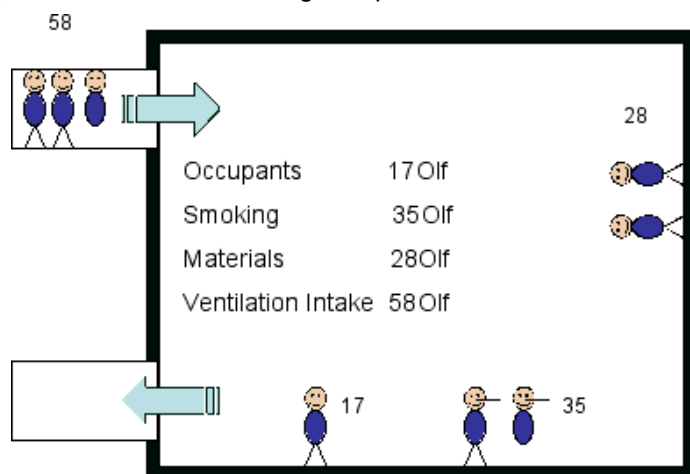


Figure 1: Average Pollution Sources in 15 offices in Copenhagen. An average of 17 occupants worked in each office. Source: P O Fanger.⁴⁴

More recent studies have identified that concentrations of more than 35 VOC's [including vinyl chloride, benzene, formaldehyde and toluene] are typically up to 10 times higher indoors than outdoors.⁴⁵ They are associated with a wide range of detrimental health effects in humans and animals, [including cancers, tumours, irritation and immune suppression]. Many have been identified as emanating from building products. The WWF study (referred to above) found many instances of fire retardant in human blood and tissue samples. Exposure limits are often set for the work environment, but there are no controls to limit exposure to harmful agents in the home. Given the time we spend in domestic buildings, pressure is building to address this.

43. <http://www.defra.gov.uk/environment/chemicals/index.htm>

44. Fanger O.L (1998) Hidden Olf's in Sick Buildings ASHRAE Journal

45. www.epa.gov/iaq/voc.html



The breathing (moisture transfusive) wall is now commonplace. The need to deal with interstitial moisture realistically - has led to the increase in its use.

Source: F Stevenson



Rauli Kindergarten it is built without the use of paint, except for lime wash on interior surfaces and additional linseed oil on the floor.

Source: B Berge

There is a clear connection between VOC concentration in the air and indoor temperature. The higher the temperature, the more VOCs appear in the gaseous phase. It has also been shown that concentrations of many VOCs increase as humidity falls. [Though this is not the case for formaldehyde]. Information is available on sources of VOCs, the extent of emissions and assessing indoor air quality, although avoidance is the best strategy.⁴⁶

Nobody in the UK yet markets a formaldehyde-free particleboard. OSB uses less resin binder than particleboard due to the removal of fine particles. Some OSB has less formaldehyde emission than particleboard (2 to 4.5 mg per 100g as against 3 to 7 mg per 100g) because the binder used is the more stable phenol formaldehyde, and is locked in. Particleboard uses the less stable urea formaldehyde. Both products meet the class E1 requirements of BS EN 300 1997, but a readily available UK "living board" as currently manufactured in Germany is awaited. There is a variation of emission with temperature.

A number of schemes are now in place for classifying low emission rates. There is presently no limit for VOC emissions in the European Product Standard, although schemes exist in a number of countries and there are plans to introduce a scheme. Recent research indicates that indoor air moisture content can best be tackled with the right choice of materials and surface treatment.⁴⁷

There is evidence to suggest that adequate ventilation can reduce the impact of allergy triggers existing in the home. Also, appropriate choice of low emission materials helps to reduce the off-gassing that contributes to poor indoor air quality and triggers allergenic reactions. It can therefore be compatible with reducing ventilation requirements. This is an accepted trade off under the Norwegian building regulations.⁴⁸

Sick Buildings

In 1971 the state laboratory for the control and inspection of foodstuffs in Geneva was given a new, state of the art building with all the latest in sophisticated technical installations. After occupation all the food tests started to register excessive toxicity levels. When control measures were made back in the previous building the toxicity levels were found to be 'back to normal'.

Ultimately it was discovered that the 'high-tech' materials in the new building were the cause of the high toxicity levels in the foodstuffs, and that it was occurring after only a short storage time in the building.

Toxic emissions were found to be leaking from paints, plastic materials, varnishes, flooring and furniture and were poisoning both the room air and the foodstuffs waiting to be tested." Hubert Palm⁴⁹



Play equipment made in Norway uses CCA treatment for the UK market and is untreated for the German market.

Source: H Liddell

46. "Volatile organic chemical (including formaldehyde) in the home", Medical Research Council, Institute for Health and the Environment (2000)

47. Technical University of Denmark (2005) "Moisture Buffering of Building Materials" BYG-DTU R-126

48. National Office of Building Technology and Administration, Norway, Guidelines to the Technical Regulations under the Planning and Building Act (1997) (English version available from: <http://www.be.no/beweb/english/englishtop.html>)

49. "Das Gesunde Haus" Hubert Palm, (1968) Verlag Gesundheitsdienst. (second ed. 1974)

(VOCs)

Volatile organic compounds are chemicals that are emitted as gases from certain solids or liquids at room temperature. There are 50 – 300 chemicals that can be classed as VOCs in the average indoor environment. The main sources in domestic environments are paint, floor sealant, vinyl and furnishings.

VOC levels have been shown to be a lot higher during and after construction. This is often apparent in the smell of a new building, or where a new carpet has been fitted. Off gassing of the VOCs from the materials may occur over a prolonged period of time. Formaldehyde is the most common VOC in indoor air, and is emitted from carpeting, particleboard, furniture and new clothing. It is colourless but has a distinctive odour. Certain VOCs, such as formaldehyde, are often absorbed onto surfaces and textiles reducing peak concentrations but prolonging overall exposure. The most vulnerable are pre-toddler infants, who spend significant amounts of time in close proximity to the floor.

Exposure to VOCs is primarily through inhalation, although some VOCs are ingested through food, or liquids. Exposure to VOCs can result in irritation to the nose, throat and eyes; they can cause headaches, nausea, dizziness, and can aggravate asthma. Chronic health effects linked to VOC exposure include cancer, liver damage, kidney damage and central nervous system damage. The majority of studies have focussed on occupational exposure, where VOC levels are often higher and on the impact of one specific chemical over a relatively short period. Little is known about the effect of combined exposure or of the effects of low level long term exposure. It has been repeatedly shown that working as a painter increases the risk of lung cancer by 40% - however, it has not been possible to identify the causative chemical due to mixed exposures.⁵⁰

Common VOCs are listed below:

• Formaldehyde	• Benzene	• Toluene
• Methylene	• Chloride	• Xylene
• Ethylene glycol	• Texanol	• B1,3-butadiene

There is some information connecting the use of plastics in the home and respiratory illness. A Finnish study that investigated the presence of PVC based wall materials in the home and the respiratory health of children indicated that there might be adverse health effects on the lower respiratory tracts of small children from emissions from indoor plastics.⁵¹ It also concluded that there was an increased risk of pneumonia in children exposed to plastic wall materials.

Many of the water based paints used in the home still contribute small amounts of VOCs to the indoor environment and have been linked to the exacerbation of asthma systems. Due to these medical concerns a number of 'VOC free' paints have appeared on the market.

Formaldehyde

Formaldehyde is present in significant quantities in a wide range of house furniture, insulation and floor and wall fittings. It is used in hundreds of industrial processes including the manufacture of particle boards, MDF, chipboard and plywood, thermal insulation foams, adhesives, glues and resins.

A study into the domestic exposure of young children to formaldehyde in Australia suggested that it increases the risk of childhood asthma.⁵² An Austrian report distinguishes between the levels perceived as safe for occupational exposure and the levels that should be present in the home – infants spend a large portion of their time indoors.⁵³

Risks

- Exposure to high levels or long-term low levels of formaldehyde may cause cancer (emissions still occur after installation).
- Formaldehyde is recognised as an asthma trigger.

50. Lynge, E., Anttila, A. and Hemminki, K., (1997) Organic solvents and cancer. Cancer Causes Control, The Harvard-Teikyo Program Special Issue, Vol. 8, No. 3, pp. 406-419

51. Jaakkola, J.J., Verkasalo, P.K. and Jaakkola, N., (2000) Plastic wall materials in the home and respiratory health in young children. American Journal of Public Health; Vol. 90 pp. 797-799

52. Rumchev, K.B., Spickett, J.T., Bulsara, M.K., Phillips M.R., and Stick, S.M., (2001), Domestic exposure to formaldehyde significantly increases the risk of asthma in young children, European Respiratory Journal Vol. 20 pp. 403-40849. Wankte et al. "Exposure to gaseous formaldehyde induces IgE-mediated..."

53. Wankte, F., Demmer, C.M., Tappeler, P., Gotz, M., Jarisch, R., (1996) Exposure to gaseous formaldehyde induces IgE-mediated sensitization to formaldehyde in school-children, Clinical & Experimental Allergy, Vol. 26 Issue 3 pp. 276-280

Possible formaldehyde alternatives:

- Cellulose insulation in lieu of foamed insulation;
- Water-based paint in lieu of wallpaper and associated glues;
- Timber in lieu of MDF and chipboard (Note: timber naturally contains formaldehyde, but at levels that are acceptable in terms of minimum health risk).

3.4 The Wider Environment

Many products used in construction have widespread unregulated environmental impact. Those containing VOC's for example impact on the ozone layer and there is a wide range of water, air and land impacts from many substances in common use. The most serious chemical pollutants include the Chlorinated hydrocarbon pesticides such as DDT, aldrin and dieldrin, the polychlorinated biphenyls (PCBs) that have been used in a variety of industrial processes, and metals such as mercury, lead, cadmium, arsenic and beryllium. All these substances persist in the environment and are toxic to life if they accumulate in any appreciable quantity. Production of PCBs was halted at the beginning of the 1980s because of their accumulation in the food chain, but they are still found today in trace concentrations in the sea and in the fatty tissue of marine animals.

As an example, to demonstrate the range of effects, the subject of leachates is an increasing area of concern and is considered here.^{54,55}

Leachates

These are apparent in landfill and arise from a wide range of construction materials and products including concrete, plastics, paper and electrical goods. Heavy metals, such as chromium and stainless steel, used in the construction industry manufacturing process, are a particular concern as are treatments and finishes that leach from buildings in use. Another area of concern is the final destination of unrecoverable, non-biodegradable wastes from building sites, such as plastics and plasticisers that release chemicals which are disruptive to ecosystems over time.

The potential adverse impacts on biodiversity are evident. Biodiversity is a key requisite of sustainable development as set out in "Meeting the Needs".⁵⁶ The Scottish Executive is beginning to acknowledge the importance of biodiversity as a neglected area in relation to sustainable construction. It is a big challenge, requiring more inter-departmental working, research and policy development to create a feedback loop within the Executive. There is a lack of data on the environmental impact of construction but this area of concern is related to - but outwith - the scope of this publication.

54. SEPA "State of the Scottish Environment 2006" www.sepa.org.uk

55. Amlo S et al Identification of PCB and decontamination of PCB-containing buildings in Norway.

Andersson, Åse., (2002) Harmful compounds in paint leached from wooden facades, The 3rd International Conference on Sustainable Building, Oslo 2002

Andersson, Åse., (2002) Long-term leaching of environmentally hazardous substances in admixtures, emitted from concrete, The 3rd International Conference on Sustainable Building, Oslo 2002

Christensen, N.T. et al. (2002) Harmful substances in building waste in the future – inventory and prediction of twelve substances. The 3rd International Conference on Sustainable Building, Oslo

56. Choosing our Future – Scotland's Sustainable development Strategy (2005) www.scotland.gov.uk/Publications/2005/12/1493902/39032

Legal case Study #3

515 Park Avenue, New York

515 Park Avenue is known as the world's most expensive condominium building, where the cheapest units sell for \$8 million and require a \$40,000/month maintenance fee. However, cracks in the foundations, poorly insulated pipes and improperly sealed walls allowed water to seep into the building resulting in toxic mould growth. Eight of the building's 38 apartments had to be evacuated and many common areas had to be sealed off over potential health concerns. Residents and the buildings board of managers started litigation against the building's sponsors and contractors in late 2002. A second case asking for a phenomenal \$2 billion in damages was also filed by one resident against the building's board of managers as well as against the building sponsors and contractors.



The Reception building and shop at CAT in Wales is an exemplar of the use of healthy materials – including rammed earth and untreated timber.

Source: H Liddell

3.5 Materials

For the purposes of this study it is convenient to use the system of classification of materials used by Bjørn Berge in “The Ecology of Building Materials”, which identifies materials used in buildings as inorganic, organic and composites of these.⁵⁷ The meanings of these terms in this context are explained below and are slightly different from their use in other disciplines.

Inorganic

This group includes many of the most traditional and ubiquitous of building materials that tend to be robust, re-useable or recyclable. Although they may be organic in origin, they are mainly manufactured from materials commonly regarded as minerals and are in a form that is not subject to biological decay. Some (especially the metals) are subject to slow chemical decay.

Many metals and their alloys are subject to leaching by even slightly acidic rainwater and this can give rise to pollution. Many naturally occurring elements can be dangerous and metals are often highly toxic to humans and animals even in small quantities.

These may be present as impurities or as a necessary part of alloys of the commoner metals. Radon emission may be a problem with some of the non-metals and dust may be a problem in the manufacture and use of any of this group.

Lime, cement and their derivatives are corrosive and care is required in applying materials that contain them.



Cement is not just high in embodied energy it can also have a health impact.
Source: H Liddell



40% of the world's houses are made of unburned clay. We should think twice before replacing them with less healthy alternatives.
Source: J Gilbert
Dalhousie house by ARC Architects

	Ferrous metals	secondary metals
Stone	Iron	Arsenic
Earth	Steel	Cadmium
Brick		Chrome
Ceramics	Non-ferrous metals	Cobalt
Aggregates	Aluminium	Lead
Glass	Copper	Manganese
Cement	Zinc	Nickle
Concrete		Titanium
Lime + Limecrete		Gold
Plaster/render		Alloys

Organic materials

Organic materials in this context are materials which come directly from either plant or animal sources and are subject to biological decay. Some of these are dangerous, but the ones listed here are generally considered healthy and will biodegrade benignly if they have not been



Not all stone is risk free. Granite is a known radon source.
Source: M Wolchover

57. Berge, B. (2000), The Ecology of Building Materials, Architectural Press, Oxford

over-processed or treated. However, they are often treated with a wide range of potentially dangerous chemicals to prevent decay. Examples of these include organophosphates in wool, weed killer in hemp and tannins in leather.

Vegetable products	Animal products
Timber	Hide
Timber products	Hair
Straw	Wool
Rubber	Wax
Linoleum	Glues
Coconut fibre	

Synthetic materials

Synthetic materials in this context are either not naturally occurring or are naturally occurring but have been subject to significant chemical or mechanical processing. They therefore tend to have significant levels of embodied energy and many are specifically designed to resist chemical and biological decay. Unless clearly certified as benign and environmentally responsible they need to be regarded as needing to be treated with caution. The best current source of information on potential hazards is in "The Ecology of Building Materials".⁵⁸

Plastics	Paints	Solvents
Synthetic Fibres	Preservatives	Formaldehyde
Synthetic Fibre reinforced products	Sealants	CFCs/HCFCs
Industrial by-products	Glues and resins	
Fossil oils	Asphalts + bitumen	

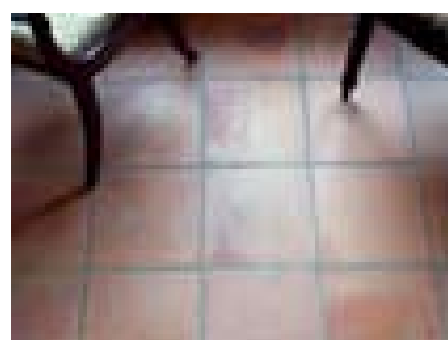
Composites

Most building products are composite elements made up of a number of different materials each of which will have different environmental credentials. The use of composite materials in general greatly reduces the possibility/viability of later recycling or re-use. Reinforced concrete is an example. It is possible to separate out the steel but it is noisy and expensive. Earlier floor techniques with, for example, steel beams or brick vault in the compression zone and concrete on top kept the materials separate.

A window will tend to have a large number of different components: timber, glass, glue, aluminium, sealant, gas. The potentially toxic content in all the elements should be a consideration as well as any life cycle issues for maintenance and management.



Sample of 500mm cellulose Insulation – Austrian standard
Source: H Liddell



A real clay tile floor Architects Simpson + Brown
Source: J Gilbert



Often marketed on the basis of being easy to clean, Vinyl floors emit phthalates.
Source: H Liddell

58. Berge, B. (2000), The Ecology of Building Materials, Architectural Press, Oxford

3.6 Benefits of Benign Specification

3.6.1 Increasing Market Share

Environmental issues are increasingly used in specification choices to discriminate between products and frequently only imports are available to meet the required performance specification. Transportation of imports adds to pollution, but this is currently justified by improved performance in the building lifetime. With increasing demand for healthy and energy efficient buildings this is already applying to a small but growing market of whole buildings being imported.

Many environmental products lack competitors and so can be expensive, making sustainable construction potentially more expensive than unsustainable alternatives. If appropriate agencies were to identify readily available and cost effective opportunities for reducing environmental impacts, it would result in a whole range of benefits.

3.6.2 The Triple Bottom Line (environment, economy, community)

Designers and specifiers need to become more aware of benign product choices.

There is an overriding assumption that construction activity is optimized with respect to cost and hence that change imposes an unnecessary burden. (This assumption is challenged in section 5.) This view fails to take account of widespread waste. Reduction in chemical loads should be adopted for the wider economic, social and environmental benefits. If governments are serious about addressing environmental pollution then economic drivers are likely to make this increasingly easy. The convergence of environmental and economic policy is helpful. For example the increasing requirement for recycled materials means that reducing chemical loads will add value should design for deconstruction be more widely adopted.

Specifying healthy materials is a means of cutting unnecessary use of financial resources on, for example, sickness at work, environmental mitigation and remediation issues and enabling money to be spent more productively on other things. Ultimately we all pay for the NHS/health insurance premiums to treat the consequences of building toxicity, and the taxes that are needed to deal with cleaning rivers, bunding landfill and remediation of polluted land. Yet prevention is usually cheaper than cure. (see cost case study 5.5)



The Glencoe Visitor Centre roof from Scottish Heartwood of larch and following a centuries old Norwegian construction tradition.
Source: H Liddell



A window is made up of many materials with varying environmental credentials.
Source: Gaia



A new, healthy floor / wall / roof product popular in Europe – Brettstapel is a prefabricated massive timber construction system made from a low-grade timber species. Untreated planks are joined via dowels removing the need for glue.
Source: H Liddell

4 Benign Construction

Key Principles

1. Green appraisal schemes do not always give priority to issues of embodied toxicity, usually placing a greater emphasise on embodied energy and as such cannot be used as the only source of guidance.
2. It is often necessary to adopt a creative approach to design to deal with toxicity risks.
3. Attention to toxicity needs to be given during all stages of the RIBA Plan of Work.
4. Toxicity effects the whole life cycle of a material from extraction/creation to disposal.
5. Guidelines on materials to control the design and specification process have proved successful for many European local authorities, councils and municipalities.

4.1 Design Approach

Many practices are eager to know more about materials and their effects. However, the tools available in the UK to satisfy the interest are either in an early stage of development or of limited value. Very few specifically address the issues of chemical toxicity because of the dearth of information. The BRE Green Guide to Specification for instance awards an “A” rating to a very high percentage of appraised elements with significantly varying chemical make-up and cradle to grave toxic impacts.⁵⁹ This statistically skewed distribution inevitably raises concerns. Clearly chemical toxicity is not a significant aspect in its scoring system.

Notably, products tend to be appraised, rather than creative design solutions. Hence a well-detailed, locally procured, solid timber, untreated roof – which has potentially very little adverse impact over its life - does not appear amongst the elemental options of roofing material because no-one has yet paid for it to be appraised. This is probably inevitable for a commercial scheme but highlights the problems faced by designers looking for a truly wide-ranging and independent view.

It is incumbent upon designers to seek creative design solutions to environmental problems regardless of the certification schemes that exist.

Building Case Study #3

Allergy House
Bonn, Germany
Weberhaus Gmbh & Co. KG

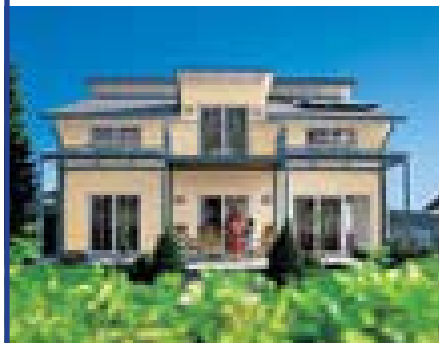


Photo source: Weberhaus Gmbh & Co. KG

Project aim:-
Kit built low-allergy house in Bonn, Germany developed for a family of allergy sufferers provides basis for ALLOKH certification.

Key Design Features

- A low allergy plot: suburban with few trees and south facing to maximise solar gain.
- Use of untreated timber and low emission paints.
- Wall to wall tacked carpets avoiding the use of glue.
- Plumbing & fittings free of nickel or non-ferrous heavy materials.
- Pollen filters on windows.
- Walk in cupboards in front of bedrooms to allow removal of ‘contaminated’ outdoor before entering the sleeping area.
- Central vacuuming system.
- Whole house ventilation system.
- Use of fold-down radiators for cleaning behind.
- A hobby room with a separate entrance has been located in the cellar of the house providing an isolated space for activities that may create a health issue if carried out in the main house.



The Reception Building at CAT Machynlleth. (Architects Borer and Lea) The roof is made from untreated oak strips.
Source: H Liddell

59. Anderson et al., (2002) Green Guide to Specification, BRE.

4.1.1 Plan of Work

The RIBA Plan of work provides a framework for the design and construction process, the table (below) outlines issues relating to toxicity at each Work Stage to indicate a sequence of decision-making.

RIBA Plan of Work	Actions regarding toxicity
Work Stage	Action
A Appraisal	Establish level of toxicity avoidance to be aimed for. Identify appropriate site context if critical to occupants.
B Feasibility / Briefing	Audit Site/ existing buildings for any existing items of note. Prepare action plan for dealing with any issues of significance.
C Outline proposals	Consider the materials and form of construction at an early stage for any implications related to an established policy on toxicity levels. Identify areas of special concern in the indoor climatic zones
D Detailed Proposals	Confirm all materials and products in specification and audit for toxicity levels. If necessary establish a Risk Register of suspect materials/ products. Use third party review and specialist advice for areas of uncertainty. If necessary request certification from suppliers.
E Final Proposals	Confirm the credentials of materials/products on the Risk Register. Consider alternatives for any not resolved. Double check final specification acceptable to client/ users.
F Production Info	Maintain vigilance on materials and products; especially where changes are made. Check items for cost to ensure their survival if tender should require schedule of reductions. Prepare statement for tender documentation on toxicity. Ensure complete documentation on products is available.
G Tender Documentation	Include clear statement at front of tender documentation indicating importance of pricing against the specified materials, and why, and that no substitutes should be assumed. Consider a pre-tender seminar to emphasize the significance of the specification and the reasons for it. Also seek to identify the appropriate supply chain routes in order to keep costs down, and to avoid the 'fear factor' affecting prices.
H Tender Action	Ensure that Contractor is fully signed up to the specification. Identify aspects of site operations where toxicity and chemical risk might occur and produce method statement, for Health and Safety File.
J Mobilisation	Brief all site personnel as to the nature of the specification and why. Include areas where site operatives might be at risk, + where the alternative strategy removes previous risk.
K Site Works	Establish and implement a vetting procedure for materials and products. Continue training and information inputs to site personnel all through the contract and as part of site induction procedures.
L Post Completion	Monitor Indoor Air quality post occupancy. Test any suspect samples prior to the end of the defects liability period. Get Contractor to sign off the specification. Ensure information on all products is passed onto clients and maintenance team. Brief clients / maintenance team on any special procedures.

4.1.2 Roles and Responsibilities on Site

Designer / Design Team

Briefing of key personnel on the site is crucial as they will not be aware under normal circumstances of the importance of the specification and will be used to a constant trade-off of one material/product against another.

Clerk of Works

In the case of the employment of a Clerk of Works it is essential to undertake an extensive induction exercise, as it will often be at his/her behest that a change of specification is initially approved. The best policy is one of zero substitution, however supply chains are not totally reliable and there will almost certainly be cases for specification change. The Clerk of Works should always refer back to the Design Team for approval.

Contractor

The Main Contractor's principal responsibility is to deliver the non-toxic specification overall and the coordination between the sub-contractors will be his/her biggest challenge. It is advised that this is wrapped into the site induction process so that nobody can avoid being informed of the issues. It is also worth identifying the health and safety benefits of a non-toxic specification to the site operatives themselves.

Building Case Study #4

Kitchen for a Chemically Sensitive Client
Medina, Washington State, USA
Architects: Rob Harrison



Photo source: M. A. Moore (Courtesy Rob Harrison Architects)

Project aim:-

Renovation of kitchen and two bathrooms for client with multiple chemical sensitivity (MCS)

Client tested all the materials to be used in the renovation to ensure no adverse reaction, 120 materials tested, five rejected.

Key Design Features

- All materials/finishes with very low toxicity levels.
- Cabinets made from formaldehyde-free Medite II, with low toxic glues and finishes.
- Kitchen floor cork, with a low-toxic adhesive and finish.
- All joints were bonded with a low toxic compound.
- Natural wool carpet fixed with tacks and placed over a hair and jute pad.
- Water filtration system.
- Ducted fresh air intake to cooker hood to prevent back draft.
- Materials containing CFC's, urea formaldehyde, benzene, toluene, carbon tetrachloride, styrene-butadiene, or trichloroethylene were excluded.
- Ban on site petrol-fuelled generators and heaters: smoking and use of fragrances; pesticides, herbicides and noxious cleaning products.

4.2 Life Cycles

Toxicity can be an issue at every stage from extraction to disposal of a material or product.

Whilst this publication prioritises the building user and the indoor climate, material toxicity is relevant from cradle (manufacturing) to grave (disposal).

The recycling and re-use of building products and materials is generally regarded as an environmentally positive activity. However, in a study carried out for Scottish Homes in 1994 the subject of embodied toxicity was raised.⁶⁰ The research highlighted a concern that recycled products and materials might increasingly include a toxic component (e.g., a timber floorboard beneath a polluting industrial activity). There are still no mechanisms in place to vet the toxicity of recycled materials, despite the ratcheting up of requirements for their use. This tendency for quantity issues to precede, and then dominate, over issues of quality places thoughtful designers in a difficult position in relation to some perceived good practice. Guidance on assessing a material's pedigree would be helpful if the changing requirements are to have a genuinely positive result on health and the environment. Designers need to look to their own future liabilities.

Selecting and designing details that minimise chemical load at the outset minimises risks during the project life and also more readily facilitates the materials being a valuable resource at the end of one lifespan. Given that control of environmental pollution is likely to become more stringent, this makes healthy building an increasingly attractive strategy.

4.3 Labelling and Assessment

There are many ways of providing information on materials.⁶¹ Manufacturers make their own claims about products, and they can also participate in voluntary labelling schemes designed to highlight a special feature of a product. In some cases, companies are legally obliged to state certain information on products in prescribed formats.

There are green labelling schemes for almost every type of product. There are also schemes for different types of environmental impacts, and for combinations of products and impacts. Good schemes provide an excellent way for companies to advertise to their customers and potential customers that a product has achieved demanding environmental standards. However, given the potential marketing advantages it is not surprising that some schemes may be less than thorough in their appraisals.

Assessment tools can emphasise criteria such as embodied energy, longevity or recyclability, which tends to skew the picture and undervalue the issue of toxicity. As there are few comparative measures of toxicity it is rarely addressed.

60. Liddell H.L., Kay T., and Stevenson F. (1994) From New to Old: The Potential for Re-use and Recycling in Housing, Innovation Study No.1, Scottish Homes, Edinburgh

61. Halliday S.P (2004) Appraisal Tools and Techniques Gaia Research



Photo of the Rauli Kindergarten. MDF Board is now available with a zero formaldehyde content.

Source: B Berge



Fly tipping - building construction waste – much of which is toxic to the environment as well as playing children

Source: H Liddell



This wall section from BedZed involves both new products and new construction methods.

Source: F Stevenson

A number of organisations, local authorities, councils and European municipalities are using guidelines on materials to control the design and specification process. The Tübingen model shown below is the type of model increasingly discussed because its precautionary approach has been shown to be readily achievable in a sizeable development.

When the City of Tübingen in South Germany decided to undertake the development of a derelict French Barracks into a new City Quarter they developed a number of innovative strategies for procurement and for environmental protection. Rather than selling the land to a developer they determined to set the guidelines and to oversee the development themselves. In this way they have been able to maintain control and to recycle the profits into the infrastructure, including transport and landscape. They decided to go beyond the regulatory framework in setting environmental guidelines for the development. The following is the contractual agreement that forms the basis for environmental protection.

Municipal Building Department Tübingen Supplement to Architect Contract/ Engineer Contract

Regarding: Compliance with the conditions for environmental protection

The Architect/ engineer commits

- To include the following regulations in planning and tendering and
- Guarantee the compliance of the following regulations in the submission as well as in the project monitoring. This commitment is part of the contract.

1. Protection of Wood

On principle the use of wood preserver is not allowed. If the construction necessitates wood preserver (see examples in DIN 68 800 Part 3, April 1990), the following products are allowed: inside the building only pure boric salt products and outside the building beech distillates or CKB-salts (chromate/ Potassium/ boric acid).

2. Paint, varnish, adhesives (for carpets, coverings...)

Only non-solvent materials respectively materials signed with RAL-UZ 12 (Blue Angel, Environmental Label No. 12) are allowed.

3. Halogen-free Materials

Exceptions are admitted in the field of electric cables as well as tubes for the sewage system. In the last case the tender must include the following sentence: "The contractor is committed to recycle PVC-waste from the building site separately".

4. Materials containing CFC

The use of materials containing totally halogenated Chlorofluorocarbons (for example R11 and R12) is not permitted.

The use of partly halogenated chlorofluorocarbons is exceptionally allowed, but reasons must be given for each individual case.

5. Tropical Timber

The use of tropical timber is not allowed.

6. Mineral Fibrous Insulating Material

Only mineral fibrous insulating material with carcinogenic index lower than 40 is allowed. (Carcinogenic index in the meaning of technical guideline for hazardous materials 905).

7. Resolution of the City Council to the use of grey water

8. Resolution of the City Council the low energy standard

9. Consideration of the accident prevention regulations

Sometimes the architect or engineer may think in inevitable to use material not according to the numbers 1-5. In this case the deviation must be explained in detail and the municipality must agree before tendering. The valid alternatives must be nominated precisely in the tender.



Woodfibre sarking at Greenock by John Gilbert Architects. MDF Board. Is now available with a zero formaldehyde content.

Source: John Gilbert Architects



Plywood with an FSC label tells only of the source not its subsequent gluing and treatment.

Source: H Liddell



Loretto, Tübingen – a city quarter built under a strict non-toxic materials code.

Source: H Liddell

4.4 Life Cycle Analysis

There are hundreds of systems of Life Cycle Analysis. However, because the identification and quantification of the pedigree, history and likely destination of a material or product is very complicated, it has been difficult for analysis to be simplified to a point that is user friendly for the design and specification part of the construction process.

The more inclusive the analysis becomes in terms of the number of criteria they assess, the more complicated they turn out to be. There is also a risk of them rewarding things which can be very accurately calculated (e.g. embodied energy) and avoiding those things that are more subjective (e.g. exploitative child labour). Most systems are by necessity simplified to a simple 3 point scale or “traffic light” system.

The majority of information on materials and health is based on US and middle European data. These vary in terms of quality and scope of issues but are worthwhile investigating to get an understanding of the range of issues.⁶² As well as assessment schemes listed below there are also valuable discussion forums, such as the AECB, where designers and builders can exchange information on materials and products.⁶³

4.5 Assessment Schemes

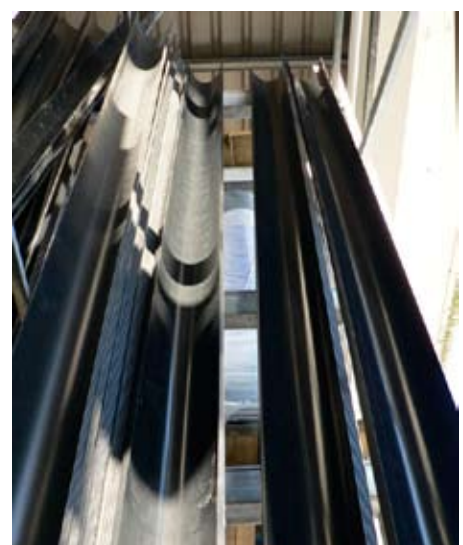
Government and NGO's are active in promoting assessment and appraisal and in setting guidelines on environmental claims. Defra produces detailed advice for business and consumers about using green claims.^{64, 65} The Green Claims Code and subsequent Green Claims - Practical Guidance has no statutory force. However, it is supported by trading standards and industry bodies, so it is reasonable for regulatory or formal, self-regulatory authorities (the courts on trades descriptions and the ASA on media advertising) to take it into account. Defra cannot take enforcement action against incorrectly used claims and labels, except in respect of labelling schemes for which Defra itself is responsible, like the European Ecolabel.



Recycling low-toxicity bricks is only possible if built with lime mortar that can be brushed off before re-use. Cement mortars are too strong.
Source: J Gilbert



Reclaimed bricks in a caisson
Source: J Gilbert



PVC pipes and gutters will probably continue in use for some time. Meanwhile priority should go to addressing the indoor impact of PVC materials
Source: H Liddell

62. <http://www.buildingforhealth.com/>

63. www.aecb.net

64. A Shopper's Guide to Green Labels - a leaflet explaining the meaning of some of the green labels and logos commonly found on products.
<http://www.defra.gov.uk/environment/consumerprod/shopguide/index.htm>

65. Green Claims Code - best practice advice to business and consumers on making environmental claims
<http://www.defra.gov.uk/environment/consumerprod/gcc/index.htm>

4.6 Ecolabels

There are many different labelling systems currently operating in the EU with labels appearing on a wide range of products, however, in the UK there is no system which specifically represents the construction industry. Standards set by each label differ and are subject to change, and therefore must be checked before specification.



The EU Flower is currently the most common ecolabel in the UK. It was established in 1992 and is administered in the UK by Defra.⁶⁶ The label represents many products ranging from detergents to hardwood flooring. As yet, very few UK products carry the EU flower but the system is popular in mainland Europe. The EU Flower aims to be the most recognised ecolabel in Europe and incorporates environmental issues and the precautionary principle into its criteria.



Established in 1989 by the Nordic Council the Swan ecolabel is also a useful resource.⁶⁷ Although the label has been developed for the Scandinavian market, the website contains useful information in English, such as a list of registered products as well as criteria relating to the standards each product must achieve before being certified. The Swan ecolabel certifies a broad range of products including many of relevance to the construction industry.



Nature Plus is an international eco-label for sustainable building products.⁶⁸ Founded in Germany by a number of specialist building materials suppliers and trade co-operatives, they only certify products that are comprised of a minimum of 85% of renewable raw material, or are from mineral based materials. There are strict limits placed on the use harmful substances ensuring that no health risks are posed from the building materials. Life Cycle analysis is accounted for through visits to the production facilities and through consideration of durability/life span of the product. Initially, only limited sections of the website were in English, however, this is gradually being updated and when completed the site will prove a useful resource.



The German Blue Angel label also contains a vast range of products and an information resource on its website.⁶⁹ However, although the Blue Angel Label was the first ecolabel, criticism has been levelled at it and other systems (such as BRE's Green Guide to Specification) that they have become devalued and watered down through too much trade influence.

66. <http://ec.europa.eu/environment/ecolabel>

<http://www.defra.gov.uk/environment/consumerprod/ecolabel/>

67. <http://www.svanen.nu/Default.aspx?tabName=aboutus&menuItemID=7069>

68. <http://www.natureplus.org/en/>

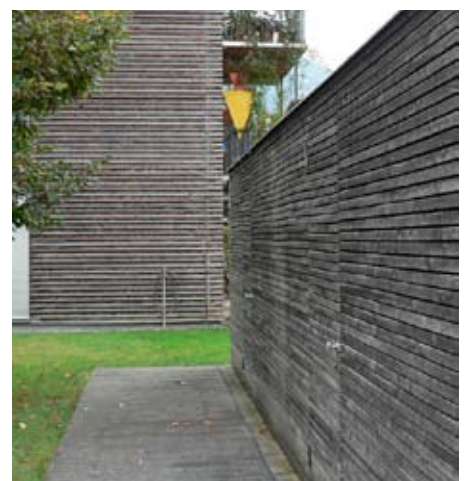
69. http://www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm



For many years European product manufacturers have been replacing environmentally challenged materials in composite products with more benign substitutes. These woodwool slabs are bonded with magnesite instead of cement, and finished with a mineral paint.
Source: H Liddell



Sønmoregate Oslo – a healthy indoor climate using benign materials that score high on the Nordic ecolabelling systems
Source: A Reite



Austrians find the weathering of timber attractive. The idea of painting or 'treating' timber is not even a consideration. Yet their wooden buildings can go without major repair for centuries.
Source: H Liddell



The Austrian Institute for Building Biology and Building Ecology (Österreichisches Institut für Baubiologie und Bauökologie – IBÖ) administers what is considered by most European ecological designers and specifiers, to be the ultimate ecolabel manufacturers to acquire.⁷⁰

They set very strict standards for building products and furnishings which incorporate environmental impact, health and lifecycle. All the materials used in the Town Centre development in Ludesch (see section 5.4.1 of this report) were assessed by IBÖ. Unfortunately, at the moment, their website only appears in German, however, it is worth checking out the site as this may change in the future.



Green Seal is a US based label that also has an expanse of information and a high level of transparency.⁷¹

Although there are many other European ecolabels, not many have resources in English. There are organisations aimed at promoting the use of ecolabels such as the Global Ecolabelling Network and ecolabelling.org that provide useful information on ecolabels and keep a catalogue searchable by country and industry.^{72, 73} The Healthy Building Network is useful resource providing information on toxicity and environmental justice.⁷⁴ A number of organisations also supply 'green' building products⁷⁵, however, not all products necessarily have low toxicity and further details should always be sought - unless the product has an appropriate ecolabel.



Prefabricated eco-building waiting to be transported to site to be erected in 2 days. Traditional materials can adapt to modern construction methods.

Source: H Liddell



Apart from changing timber into toxic waste once it is coated with polyurethane, it also can no longer behave like timber – i.e. it cannot breathe.

Source: H Liddell



OSB board has made very fast inroads into the European market and is a known emitter of formaldehyde. Given that there are now whole house systems made from this material it needs to address its use of formaldehyde adhesives as a matter of urgency.

Source: H Liddell

70. <http://www.ibo.at/de/produktpruefung/index.htm>

71. <http://www.greenseal.org/>

72. <http://www.gen.gr.jp/>

73. <http://ecolabelling.org/>

74. <http://www.healthybuilding.net/>

75. <http://www.sust.org/tgd/>

<http://www.natural-building.co.uk/>

<http://www.constructionresources.com/>

<http://www.greenspec.co.uk/>

4.7 Culture Shift

There are four key areas where a culture shift is required: -

1. Amongst clients who need to be asking for healthy buildings.

The demand from clients for a shift in the product supply chain can happen overnight – a hard-hitting piece of journalism or a test case at court can have an immediate and drastic effect on a product. UK industry is at risk of complacency in not seeking to protect itself against this kind of circumstance.

2. Amongst designers who should be specifying healthy buildings.

The Duty of Care and health and safety justify a culture shift, beyond any moral obligation. Designers need to inform themselves not just in terms of the materials and products but also the way in which these come together to create an indoor climate, where most people in the UK spend 90% of their life.

3. Amongst manufacturers who need to be supplying healthy products and substituting toxic materials for benign ones.

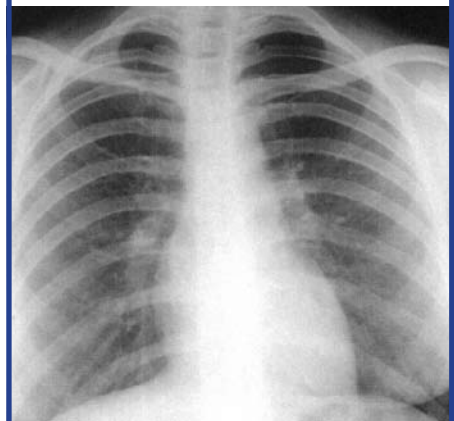
Product manufacturers in the UK seem to have responded to the increased demand for green products in general and toxin free products in a less fulsome manner than most of their north and middle European counterparts. In countries such as Germany, Austria, Switzerland and Sweden the building product industries have tended to subject their products to appropriate third party review and then made changes in order that they can market them with confidence. There are few examples of UK products that have changed their specification in order to ensure that they are free of suspected toxins.

4. Amongst CDM Coordinators

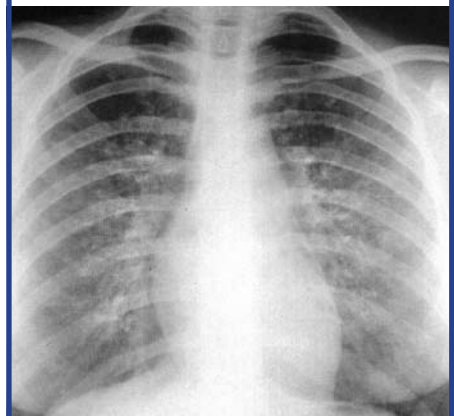
With the new CDM Regulations (2007) there is shift of a larger amount of the onus of responsibility for the design and construction Health and Safety agenda onto the design team. This represents an opportunity for them to state any products or materials which they regard as suspect and therefore a risk unless positive proof is available to the contrary. It would be a very positive use of their new role if the CDM Coordinators made this clear to design teams, and invited them to register any concerns. It would also place pressure on manufacturers actively to seek third party accreditation, in order to give specifiers the confidence that their products were benign.

Medical Case Study

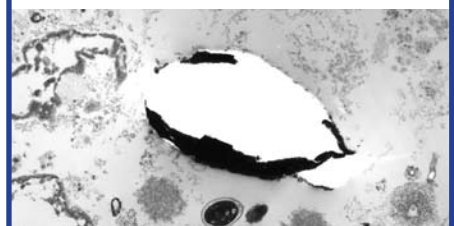
Illustrated are chest x-rays of a breathless young woman referred to a chest clinic 3 months after redoing a bathroom in her Victorian house. She stripped plaster over two 12 hour sessions over a weekend when concerned that contractors were not progressing work. Windows could not be opened for ventilation. Shortness of breath developed 2 days later - particularly after climbing a flight of stairs. The chest x ray (scan 2) shadowing was investigated by lung biopsy which showed cells loaded with particulate material. This dust is shown on the electron micrograph (scan 3), and was similar in constitution to a 'sweepings' dust sample taken from the bathroom floor. 6 months later, the chest x ray (scan 1) had almost returned to normal, and the patient was symptom free. Lung function tests initially detected abnormal gas transfer within the lung, which returned to normal over 18 months.



Scan 1



Scan 2



Scan 3

As reported in specialist respiratory journal Thorax -Pulmonary infiltration after home-renovation dust exposure : histopathology and microanalysis. KAnderson, et al, Thorax 1996; 51: 654-655.

5 Costs

Key Principles

1. It is possible, through trade offs, to provide a non-toxic specification to the majority of buildings – unless building prices are already at rock-bottom.
2. Trade offs can come from adding value through design, reduced service costs or through attention to the supply chain.
3. Immediate financial benefits can be realised through improved health (reduced medication), increased productivity, and reduced absenteeism levels in healthy buildings.

5.1 General Context

It is important to note that there are very few studies which have looked at the costs of green buildings. A comprehensive search has identified only one (from Austria) that has looked rigorously at the cost of third party (vetted) healthy materials.

Most of the studies have looked at the criteria which are of most relevance to the BREEAM and LEED labelling schemes and healthy materials have a low priority in both, compared to energy issues.

The studies do not isolate the health credentials of the materials and associated costs.

It is misleading to seek to take single elements from the details in section 6 (which are for illustrative purpose and not proposals) and price them out against alternatives as this ignores the trade-off options.

“Estimation procedures can often be found wanting when looking at individual green features, which can be picked off one by one as not cost effective, while they would hang together as a package”⁷⁶

5.2 Definitions

Cost, price, value and **affordability** are ubiquitous terms in the Construction industry. They all have different meanings yet they are too often used interchangeably.

Cost discussions, in terms of sustainability, have tended to introduce cost-in-use (process) as well as first-cost (product) as part of the debate. In the case of a developer the cost of buying the site and constructing a building will be different from the **price** it is sold at (routinely by about 20%).

The issue of **value** is significant, because quality is a sustainability issue – in terms of fitness for purpose, robustness, longevity and health – which may or may not be delivered for the same price, depending on the skill and intent of the individual developer.

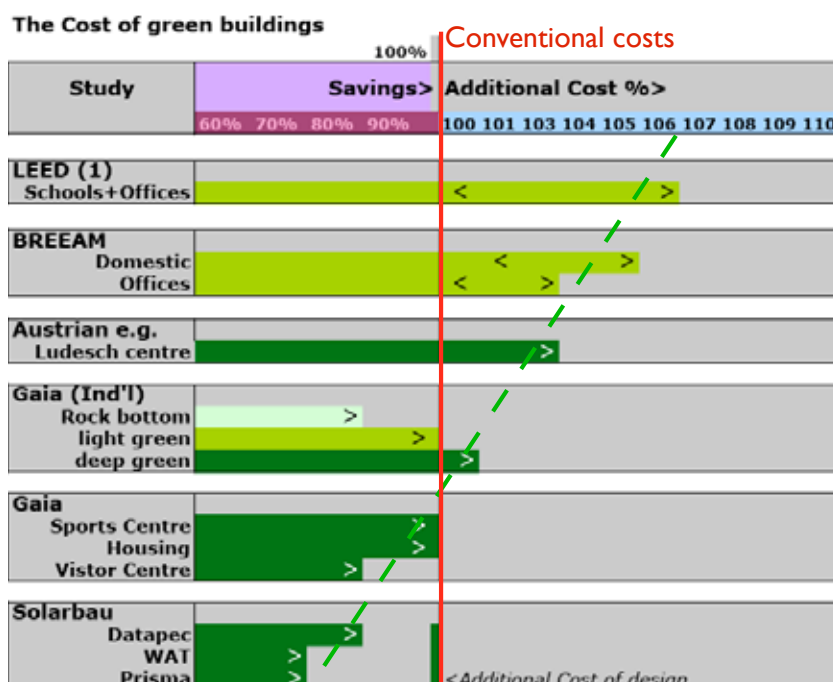
Affordability is now virtually synonymous with building more cheaply and at a lower quality than preferred. Importantly those on the lowest incomes are the most vulnerable to poor quality indoor climate.

76. Bordass, B. (2000) Cost and value: fact and fiction, Building Research & Information Volume 28, Issue September 2000

5.3 Trade-offs and the Lowest Option

The debatable perception that green buildings cost more, in capital terms, dominates the public domain. Therefore, the tendency has been to seek to argue the case for green buildings on a 'cost-in-use' basis, where the consensus is that they do indeed pay back, even in narrow financial terms, and that this pay-back can be even greater where social and environmental costs are also accounted for.

The reality from a range of studies seems to be that, for low budget buildings, incorporating green specification without cost penalty is indeed very difficult. Nevertheless, for the vast majority of buildings above the lowest cost threshold, there are sufficient trade-offs available to specifiers to bring green buildings into line with conventional yardstick costs. These trade-offs vary but include adding value through design, reducing servicing costs or simply attention to the supply chain. Where these trade-offs are not taken account of then capital costs are generally found to increase by 1 – 7 %. Most of the studies summarized in the illustration, are looking at the whole range of green specification and not just the cost of healthy materials. Further inspection of the data indicates that the additional cost of non-toxic materials on its own would be likely to account for less than half this figure – in the case of the Ludesch project (see over) this was found to be below 2%.



The Cost of Green Buildings (above) is set against a 100% norm line, which represents the conventional building cost benchmarks, set individually by each of the studies.⁷⁷

77. References for this table are:-

LEED - The Costs and Financial Benefits of Green Buildings. A report to California's Sustainable Building Task Force, Greg Kats October 2003.

BREEAM - Putting a price on Sustainability, Cyrill Sweet BRE trust 2005

Ludesch - "Neubau ökologisches Gemeindezentrum Ludesch" (New ecological community centre Ludesch) Wehinger, Torghele, Mötzl, et. al. for the Austrian Federal Ministry for Transport, Innovation and Technology, 2006

Gaia Industrial - Cost Study for Forfar Eco-park, Gaia and Ralph Ogg for Scottish Enterprise 2002

Gaia - In-house feedback studies vetted by Ralph Ogg & Ptnrs.

Solarbau Study - per Joachim Eble Architects, Tübingen, Germany 2000.

Legal case Study #4

Mackenzie vs. Glasgow City Council & Glasgow HA

In the first case of this kind in the UK, Linda MacKenzie, a Glasgow mother, is taking the local council and housing association to court over damp conditions in her home. Her seven year-old son developed asthma and it is claimed that the damp conditions are responsible. High levels of exposure to dust mite faeces have been identified in the claim as being responsible for the development of the child's asthma. Dust mite samples taken from the mattress in the child's bedroom found 1,400mcg of Der p1, 700 times higher than the World Health Organisation safety levels. The case is aiming to prove that the landlord failed to carry out repairs that might have improved the conditions within the house and are therefore responsible for the child developing asthma. Although the damages sought are modest when compared to the cases in the US (£50,000), it is hoped that if causality is found it will lead to landlords reviewing poor living conditions.

5.4 Case Studies

5.4.1 Town Centre Local Municipality Mixed-use Building, Austria

In the case of the £3m Town Centre development in Ludesch, built in in the Vorarlberg area of Austria in 2005, the clients commissioned a parallel study, during the construction period, to establish the additional cost of adopting a very high quality of Passive Design and a Healthy Building materials specification (see illustration for key materials choices). The research report identified the additional costs for the vetted healthy building materials (third party reviewed by IBÖ, the Austrian institute for Building Biology) to be a maximum of 1.9% over conventional costs, with a cost-in-use benefit that paid for itself in the first few months of occupation. (This sum does not include for the cost for the third party vetting of the materials for their health credentials). Given the nature of the materials identified in the table and their availability in the UK, as at January 2008, the percentage additional costs are transferable and equivalent to UK costs.



Ludesch Town Centre
Source: H Liddell

Ludesch Town Centre Eco-Building		
Cost issues	Extra cost for eco materials	
	Euro	GBP
Builderwork structural		
Construction Carpenterwork		
plywood instead of OSB	6507	£ 4,555
Hemp instead of mineral wool	3447	£ 2,413
Cellulose instead of rockwool	724	£ 507
sheepswool instead of hemp	869	£ 608
extra for knot-free wood	7298	£ 5,109
Builderwork technology		
heating system		
piping in stainless steel	2977	£ 2,084
higher pipe lagging standard (natural material)	861	£ 603
Sanitary system		
piping in stainless steel	3326	£ 2,328
higher pipe lagging standard (natural material)	1010	£ 707
low voltage electrics		
Cable for energy monitoring	3990	£ 2,793
EMF isolation installation	6390	£ 4,473
trunking and support	19870	£ 13,909
Building fitout		
Joiner work		
Walls + floors Sheepswool instead of mineral	4026	£ 2,818
Movable cross walls massive wood erection	2944	£ 2,061
dry lining sheepswool instead of mineral wool	18000	£ 12,606
Sheepswool caulking to wooden windows	888	£ 622
Total extra cost of ecological Materials	83127	£ 58,196

"Neubau ökologisches Gemeindezentrum Ludesch"

Wehinger, Torghele, G. Mötzl, et. al. Bundesministerium für Verkehr, Innovation und Technologie May 2006

5.4.2 Two Sports Centres

Two £3m sports facilities, each with a 20 metre swimming pool and a three court sports hall, were constructed simultaneously during 1995-6 in central Scotland within 40 miles of each other. One was built to a high standard, but without regard to green principles; the other was built to an equally high standard but incorporating dynamic insulation, hygroscopic finishes and a healthy materials specification (mid to deep green) including mineral paints, linoleum and clay tile finishes. The centre with the green specification included for PVC, formaldehyde and VOC free materials and products, and was less expensive than the centre with the conventional spec. by £10/m². This was achieved not by reduction in standard, but by careful trading-off of the more expensive items of specification in 1995 (insulation material, dynamic insulation system, paint finishes, etc) against a specification with a reduced services content. The above comparative information on construction costs for these two projects is via the QS company that was involved in both projects.⁷⁸



McLaren Community Leisure Centre. Callander, Scotland:- £875/m² in 1995
Source: Gaia Architects

5.4.3 A Visitor Centre

A £2m visitor centre was built in West Scotland in 2002 and, by careful design and selection of materials, including home grown timber, biomass fuel heating, natural ventilation, breathing floor, walls and roof construction, demountable (nail-free) detailing new British slate roofing, low flush wc's and waterless urinals, was delivered on a par with similar facilities. Its M+E content was reduced via a strategy of passive design, superinsulation and airtight construction to 9% of the capital cost (as against a norm of around 25%). The 16% trade-off in unused heating, ventilation and electrical technology was used for the higher quality fabric, including a high standard of healthy building materials. The healthy specification included for zero PVC, formaldehyde and VOC content in materials. It included natural and untreated timber inside and out, mineral paints, cellulose fibre insulation, sheepswool caulking around windows and linoleum floor covering. Unlike the Ludesch building no detailed analysis or third party vetting of materials was undertaken. The above information has been derived from the architects and QS.⁷⁹



Glencoe Visitor Centre. Argyll, Scotland:- M+E Costs 9.2%
Source: Gaia Architects

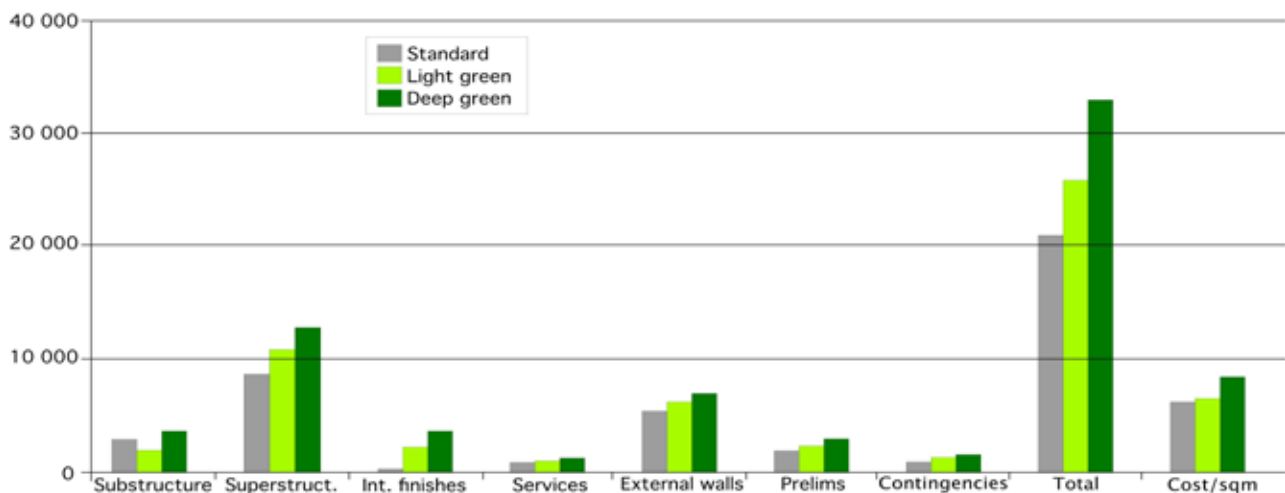
5.4.4 Industrial Eco-Park

Scottish Enterprise commissioned research into the provision of sustainable light industrial units. The design team considered four options, standard, light green (minimal green spec.), mid green (moderate green spec.) and deep green (high level of green spec.) The resultant study established that the deep green option was 20% more expensive than the standard (low-cost) option, as there was very little to be traded off. The developer, who was being reimbursed only a proportion of the additional cost, perhaps surprisingly and somewhat bravely, chose the deep green option and the eventual build costs bore out the research. All of the units were let immediately, upon completion, to companies operating their businesses in a sustainable manner. This may well have been a tertiary benefit of the specification in a location where light industrial units were not in particularly high demand.

78. Ralph Ogg and Partners

79. Ibid

In looking back at the study for the purposes of this publication we have estimated that those additional costs that can be assigned strictly to materials and products, probably account for about 50% of the total additional cost. However, even here there were options for potential savings (eg cellulose fibre instead of the sheepswool that was installed). This would probably bring the additional costs, even in this low budget situation, to around 5%.



Histogram Forfar Eco-Park. The left hand column is in £ sterling for totals and one tenth of these figures for the Cost/m²

5.5 The Secondary and Tertiary Benefits

“While the environmental and human health benefits of green buildings have been widely recognized, this comprehensive report confirms that minimal increases in upfront costs of about 2% to support green design would, on average, result in life cycle savings of 20% of total construction costs – more than ten times the initial investment.”⁸⁰

Adams

A study into Healthy Indoor climate design and productivity has indicated dramatic reductions in:-

- Acute Respiratory Illness (ARI) of 23%-76% (worth \$6bn to \$14bn a year in the USA.)
- Allergies & Asthma of 8%-25% (worth \$6bn to \$14bn a year in reduced health costs and \$1bn to \$4bn in economic gains)
- Sick Building Syndrome (SBS) of 20%-25% (worth \$10bn to \$30bn a year)
- Direct Productivity gains 0.5%-5% (worth \$20bn to \$200bn a year).⁸¹

80. Kats G., et. al. (2003) The Costs and Financial Benefits of Green Buildings - A Report to California's Sustainable Building Task Force

81. William F.J., (2000), Health and Productivity Gains from Better Indoor Environments and Their Relationship with Building Efficiency, Annual Review of Energy and the Environment, Vol. 25 pp. 537-566

5.6 Summary and Conclusions

The skilled practitioner will trade off the higher price of certain sustainable materials by moving towards passive design and away from highly serviced buildings by use of careful orientation, massing design, and detailed specification. The use of passive design, breathing wall construction, hygroscopic finishes, natural ventilation, the elimination of air conditioning and similar measures can all be used to reduce prices.

The foregoing is of course going to be affected by the type of building in which the detail is used. It should also be born in mind that the initial cost of a building is relatively small in relation to its whole life cost and as such increased costs of construction will not be particularly relevant over the life of the building unless they are of considerable magnitude. Costs require also to be considered holistically, as the tertiary benefits (improved health, reduced absenteeism) will accrue to the building owner and/or society as a whole.

“We are pleased to report that most healthy materials now cost no more (and sometimes less!) than conventional products, thanks to increased demand and production. Labor costs may rise slightly if the builders are not familiar with the materials or with healthy building techniques, but even then the total increase is typically just 1-3% of total cost to build.”

(US Web advertisement February 2008)⁸²

Building Case Study #5

Allergy Free Housing - Fairfield

Toll House Gardens, Perth

Architects - Gaia Architects, Edinburgh



Photo source: H Liddell

Project aim:-

To acknowledge that allergic responses to buildings are a Disabled Access issue and seek appropriate design solutions

Key Design Features

- Applied research comprising fourteen low allergy, affordable dwellings for Housing Co-op with strict budget.
- ODPM sponsored research to develop affordable low allergy building specification, avoiding known and suspected building related allergens and minimising the conditions for adverse impact.
- Healthy building design, through use of hygroscopic + low emission materials.
- 3 ventilation systems:- dynamic insulation, heat recovery and natural.
- Guidance given to the prospective tenants on the ventilation and opportunities for avoiding import of allergic materials, plus guidance on flooring materials and bedding.
- Post occupancy evaluation included in the houses with assessed critical levels from other research.

82. http://www.architecturalhouseplans.com/healthy_homes/

6 Details

Key Principles

1. Different materials off-gas VOCs at different rates and therefore each can have a different impact on the indoor climate.
2. Benign design has been categorised here into priorities depending on the type of construction and subsequent use of materials and their impact on indoor air quality.
3. The use of surface finishes/chemical treatments and particle board/MDF can be significant sources of toxicity in all design types.

General

When it comes to internal air quality, it is wrong to believe that “natural” products are necessarily better for internal air quality than synthetic products. Many toxic substances occur quite naturally, including arsenic, asbestos, formaldehyde, radon and moulds. Also quite a number of “natural” materials may have been treated in the manufacturing process (such as wool, cellulose, wood).

VOC contents can be quite low in some materials such as particleboard, but emission of VOCs can last several years. Whilst some paint finishes can have high VOC emissions but may only emit VOCs for a short period. (1) (Note: The reference numbers in (brackets) for this section refer to Appendix F - Specific Notes found on pages 65-72)

Such a wide range of VOCs can be emitted from building materials that it can be difficult for any specifier to find adequate information about a product or to assess the health risk on the internal air quality. VOC exposure from building products is likely to be highest over the first two years of a building’s life. Indoor VOC levels in older buildings and homes are typically about 7 times as high as outdoor levels (sources include dry cleaned clothes, air fresheners, cleaning materials). A new building will often have VOCs 100 times higher than those outdoors, falling to 10 times the outdoor level in about 2 to 3 months. Different materials will absorb and give off VOCs at different rates. In one German study complaints of the internal air quality started two years after occupancy. Studies found a number of new VOCs which rather than being released at an early stage, were emitting for a smaller but steadier rate over the years (37). Materials with large surface areas such as wall and floor surfaces, potentially have a strong impact on internal air quality, so paints, wall and floor finishes (38) are important when making choices to reduce VOCs and formaldehydes.



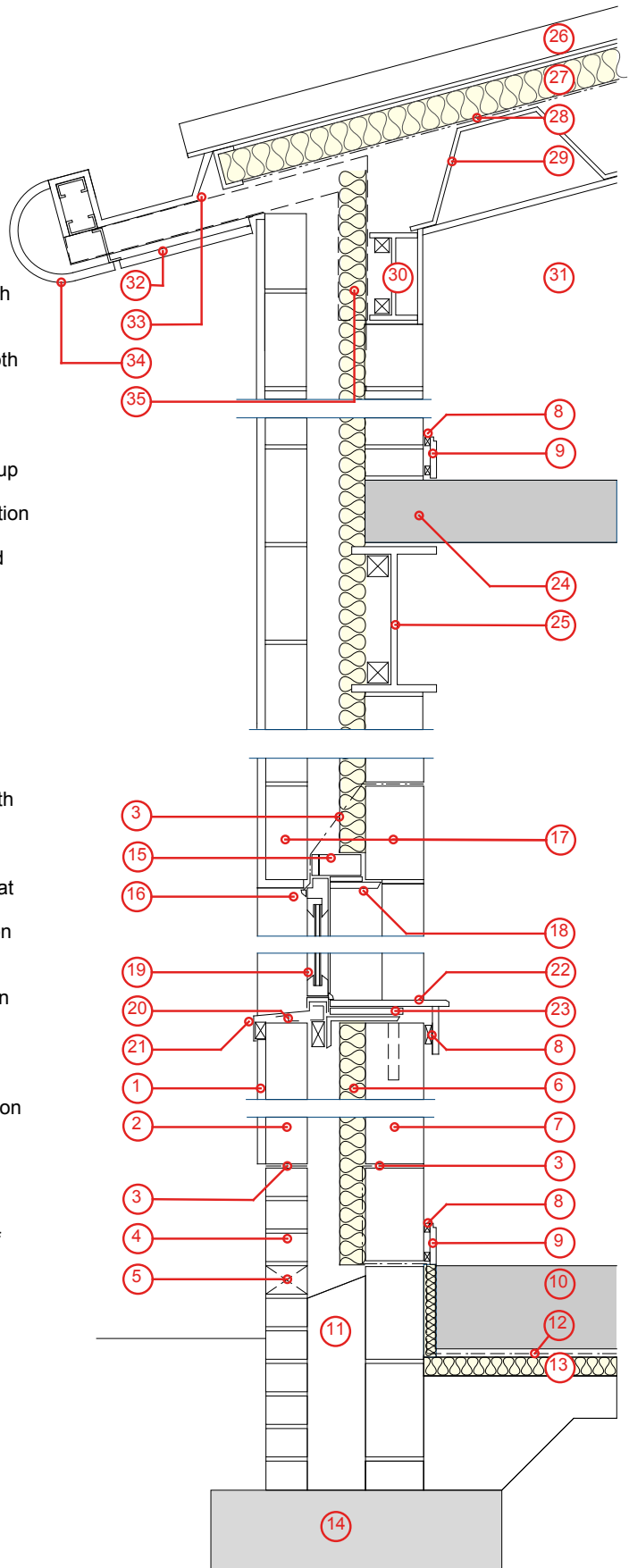
Despite an EU directive in 2002 for the 5 year phasing out of the production of PVC as supply material for the construction industry nothing has been done in the UK. Indeed the industry commissioned a study from Natural Step - to map out a 20 year strategy to increase its life-span.

Source: H Liddell

6.1 Steel Frame and Concrete Block Cavity Wall

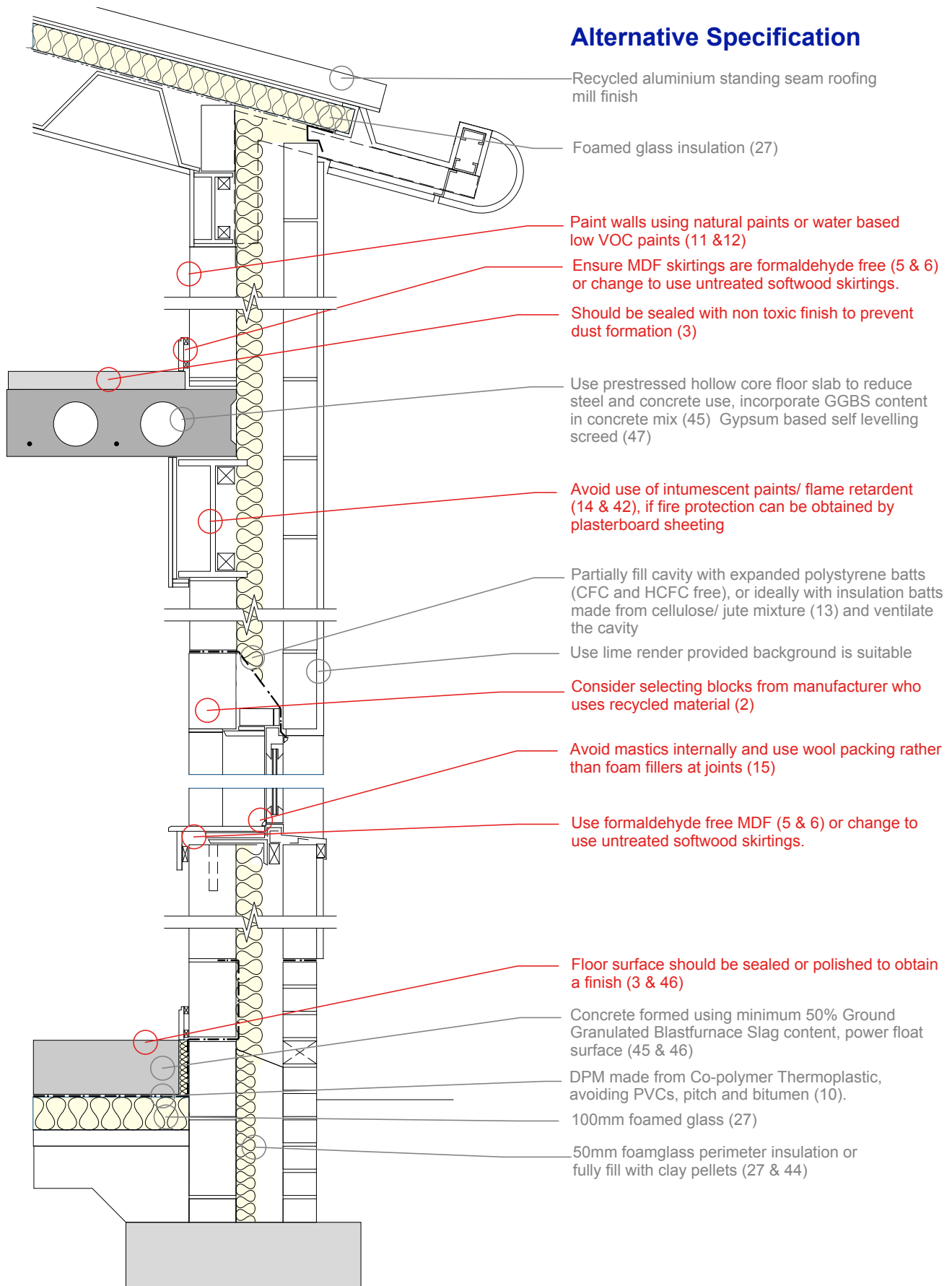
Typical Specification

1. Drydash, cement: lime: sand render (2:1:9) in two coats
2. 100mm dense concrete blockwork in 1:1:5 mortar
3. PVC damp proof course
4. 100mm facing brickwork in 1:1:5 mortar
5. Perpend weep slot @ 900mm centres
6. 60mm butt jointed mineral fibre slab insulation held to wall @ 600mm centres. Wall ties as required, not shown
7. 140mm concrete blockwork in 1:1:5 mortar with 2 coats matt emulsion paint finish
8. Soft wood timber packer nailed to wall
9. 15mm MDF skirting board nailed to packer, both with 2 coats satin emulsion paint finish
10. 200mm Insitu concrete reinforced slab with float finish
11. 140mm wide standard mix ST2 concrete fill
12. Polyethylene damp proof membrane dressed up and lapped with DPC
13. 50mm rigid polystyrene eps butt jointed insulation
14. Trench foundations
15. 40mm mineral fibre slab insulation compressed into void
16. Polysulphide sealant
17. Reinforced Concrete lintols to structural engineers specification
18. 15mm MDF surround nailed to packer, with 2 coats satin emulsion paint finish
19. Proprietary aluminium double glazed window unit screwed to masonry or support steelwork
20. Mastic tape
21. PPC pressed metal cill glued to packer
22. 15mm MDF cill and apron nailed to packer, with 2 coats satin emulsion paint finish
23. Secondary steel support angle to structural engineers specification
24. 150mm insitu reinforced concrete slab with float finish
25. Steel beam to structural engineers specification
26. Standing seam roof mechanically fixed to support structure
27. 100mm butt jointed mineral fibre slab insulation mechanically fixed
28. Reinforced polyethelene vapour barrier laid loosed with lap joints
29. 200mm structural metal deck
30. Eaves beam to structural engineers specification
31. Raking rafter to structural engineers specification
32. PPC metal soffit bolted to outrigger
33. Prefomed gutter and single ply lining mechanically fixed
34. PPC bullnose gutter mechanically fixed to roof structure
35. Cranked mild steel outriggers bolted to eaves beam



Standard, durable and economic heavyweight construction applicable to commercial projects

6.1 Steel Frame and Concrete Block Cavity Wall



6.1 Steel Frame and Concrete Block Cavity Wall

This type of construction is robust and provides a high thermal mass although it does contain a lot of high energy materials. Whilst cement producers are major emitters of CO₂, the products do not necessarily lead to the contamination of the internal air quality in the building, except through the possible generation of dust particles. The reduction of cement content is beneficial ecologically and substitution is generally practical. More ecological concrete blocks are now available which make use of recycled content rather than virgin aggregates (2).

Providing flat self finished floor surfaces which can be easily sealed(3) can also avoid the need for additional floor finishes which often add more chemicals. Although concrete is relatively inert once cured, any admixtures, curing compounds and sealers may emit VOCs. Try to specify water based, zero or low VOC additives (4)

The alternative detail shown highlights with emboldened text those elements which present the greatest risk to air quality, other recommendations will reduce the chemical load of the building but only have a minor effect on internal air quality.

High Priority

Floor Finishes

As noted above, self finished concrete floors can provide a clean low VOC surface. The floor surface can be polished using grinders and polishers to produce a smooth finish(46). Alternatively the concrete surface can be sealed with a low VOC finish (3).

If a finished surface is applied, try to avoid vinyl flooring and vinyl composite tiles as these are manufactured from a variety of hazardous chemicals including ethylene dichloride with unplasticized polyvinyl chloride (uPVC). In its chemical form, PVC (7) is a registered and persistent carcinogen which can cause damage to liver, lungs, skin and joints. It is poisonous to water organisms and emits toxic compounds throughout lifetime. The main problem is at the production plants where workers can be exposed to the chemical Vinyl Chloride through inhalation. A study of VOC emissions identified vinyl flooring as emitting n-tridecane, phenol and phthalates. Seam sealers emitted tetrahydrofuran and cyclohexanone and the adhesives emitted toluene (8). The main problem lies in the plasticizers used to make the product pliable. When Vinyl flooring is burned it releases hydrogen chloride, metal chlorides and dioxins. However whilst sheet vinyl itself does offgas formaldehyde slightly, it emits less than particleboard, plywood or wood veneers(51).

Alternatives such as linoleum, rubber, cork (9) should be considered but in all instances glues need to be selected to avoid formaldehyde (57).

Wall and Ceiling Finishes

Paint products contain a variety of VOCs some of which do not dissipate for many months after application. 'Low odour' paints may have reduced VOCs but they can still give off harmful formaldehyde and acrolein. Not all emulsion paints are benign, some pigments can cause problems including irritation and damage to respiratory system and provide allergy triggers. Some are carcinogenic.

The underside of precast (and insitu) concrete may be sealed to prevent dust from the concrete (3). The underside of metal deck roofs may also require painting, or will come with a self finish. This can be preferable to finishing on site but some coatings make recycling materials more difficult (for example, mill finished aluminium is better because it can be recycled at a lower temperature, whereas coatings need to be burnt off at higher temperatures).

Use solvent free emulsion with reduced acrylic-vinyl polymer content for skirtings and facings (11). Mineral organic paints are also available and preferable, suitable for block walls (12).

MDF Skirtings, Facings, Finishes

MDF is popular with builders because it is dimensionally stable and can be easily worked. However it does present a dust hazard when cut, and MDF boards do contain formaldehyde which is considered a probable carcinogen (5).

Formaldehyde free MDF is available(6) and other substitutes are possible such as untreated softwood skirtings. Any skirtings or facings should be mechanically fixed rather than glued to avoid VOCs released from the glue as well as to ease dismantling and recycling (56). Consider also the paint treatment of internal cills, facings, doors, windows and skirtings (12)

Medium Priority

Wall Construction

Concrete is not very vapour permeable so this type of construction does not allow the natural migration of water vapour through the walls. It is thus less tolerant of changes in humidity which can lead to moisture build up. Indoor air quality will be improved using a breathing wall system.



Fire Protection

Intumescent paints will vary in their chemical mix and can be both water bourne and solvent bourne releasing VOCs. They will also contain fire retardants which accumulate in the body (14). Where possible fire protection can be provided by sheeting with plasterboards to obtain the required resistance.

Mastics

Mastics such as polysulphides, silicones and polyurethane mastics contain several chemicals such as chlorinated hydrocarbons (15). Where possible they should be avoided indoors. However, perhaps a greater problem is the increasing use of polyurethane foam fillers (expanding foam) used to fill up construction joints prior to mastic applications. Alternatives such as hemp and wool fibres can be used for this purpose.

Low Priority

Concrete floors and ceilings

If left unfinished, cement dust particles can be given off, so surfaces should be given a non toxic sealing finish to prevent dust formation (3)

If the surface is finished with a sheet material then try to select a material that does not require glueing or at least uses a low VOC adhesive (57)

Concrete blockwork

Reducing the amount of cement in a building is always a good ecological aim although some concrete blocks have a lower embodied energy than brick(2). Using Hollow clay blocks as an alternative should reduce the risk of dust on wall surfaces (16).

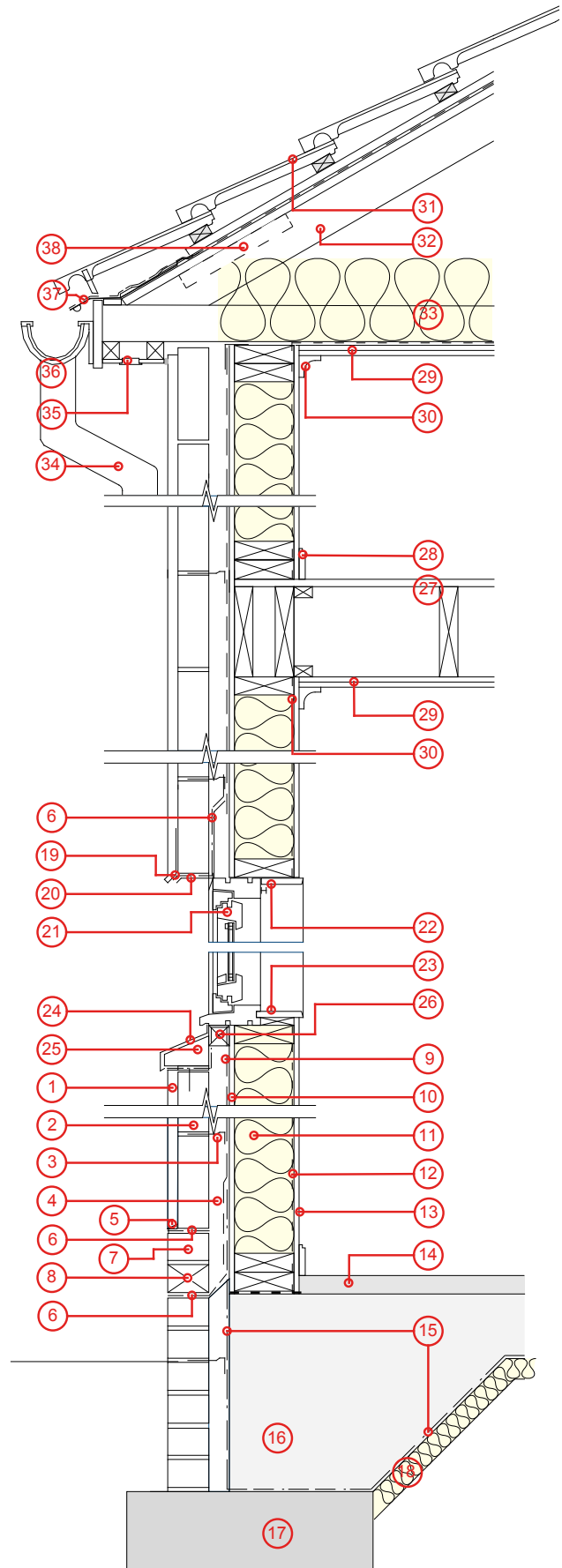
PVC membranes and DPCs

As they contain PVC (7) they should be avoided where possible. PVC vapour barriers may not be in direct contact with the inside, but we think it best to minimise any risk. Alternative DPCs exist which utilize copolymer thermoplastic (10)

6.2 Timber Kit Construction

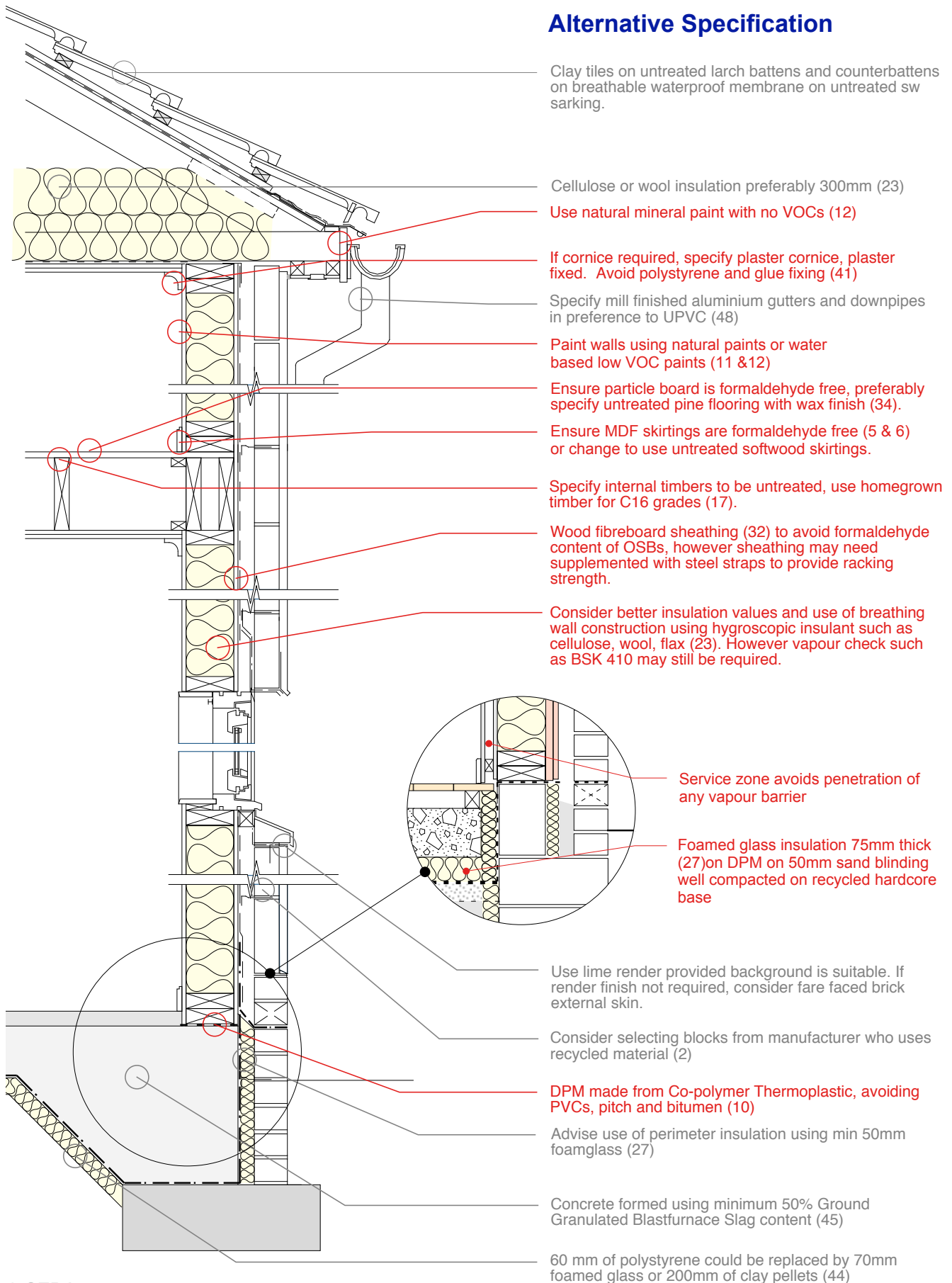
Typical Specification

1. Drydash, cement: lime: sand render (2:1:9) in two coats
2. 100mm dense concrete blockwork in 1:1:5 mortar
3. Cavity wall ties mechanically fixed @ 900mm centres horizontally and 450mm vertically - all staggered
4. 50mm ventilated cavity
5. Expamet render stop bead mechanically fixed @ 600mm centres
6. PVC damp proof course
7. 100mm facing brickwork in 1:1:5 mortar
8. Perpend weep slots @ 900mm centres
9. Breather paper fixed to ply
10. 12.5mm sheathing ply nailed to studs
11. 145 x 44mm soft wood studs @ 600mm centres - nail fixed to form frame with 100mm mineral fibre quilt insulation held in cavity by frame construction
12. Polyethylene vapour barrier stapled to interior side of studs
13. 12.5mm plasterboard
14. cement based self levelling screed.
15. Polyethylene damp proof course dressed up edge of slab and tucked behind dpc / breather paper
16. 150mm insitu reinforced concrete slab with float finish
17. Trench foundations
18. 50mm rigid polystyrene eps butt jointed edge insulation beneath slab
19. Render stop nailed to blockwork at 600mm centres
20. Galvanized steel lintol and cavity closer to structural engineers spec
21. Proprietary pine tilt and turn double glazed window unit screwed to masonry or support framework
22. 15mm MDF nail fixed internal surround
23. 15mm MDF nail fixed cill
24. Aluminium ppc flashing mechanically fixed to frame
25. Precast concrete cill on 1:1:5 mortar
26. SW packer cavity closer
27. Timber joists @ 450mm centres fixed at perimeter support by mechanically fixed steel joist hangers, overlaid with 18mm particle board flooring
28. 75 x 15mm MDF skirting board nail fixed to frame
29. Vapour barrier and 2 layers 12.5mm plasterboard nailed to underside of joists
30. Extruded polystyrene cornice glue fixed - 1 coat satin emulsion finish
31. Concrete roofing tiles on 25 x 38 treated battens on 19 x 38 treated counterbattens on type 1F roofing felt on 18mm OSB sarking.
32. Proprietary timber roof truss with bolted joints
33. 200mm glass wool insulation
34. UPVC down pipe
35. Vents within soffit
36. UPVC gutter mechanically fixed to fascia board by brackets
37. Mechanically fixed PVC angle flashing
38. Insulation stop



6.2 Timber Kit Construction

Alternative Specification



6.2 Timber Kit Construction

Timber kit has the potential to be largely chemical free, however this is not true of the present industry where nearly all the timber used is chemically treated. CCA treatment is still in use in the industry and most of the alternatives, such as permethrin, have some sort of negative effect on the environment (17). Even boron, which has been seen as the benign alternative, has now been deemed as unsuitable in the home environment by Norway (39). The preferred option is to design kits which do not require treatment, or at least where treatment can be kept to a minimum.

Other timber board materials such as plywood and OSBs will often contain formaldehydes (5). As these board finishes are rarely of a finished quality, the floors will often be carpeted or covered with a range of floor finishes which themselves may contain further chemicals. If floors could be provided with self finished surfaces, then floorcoverings would not be necessary. Carpets can be a major source of VOC and carpet are also likely to harbour dust mites, increasing the risk of asthma (58).

Plasterboard is used extensively as a dry lining board in timber kits. These boards differ in their use of adhesives but it should be understood that VOCs may be emitted from the binding adhesive used for fixing papers to the plaster substrates (18). Absorbed solvents from the coatings of plasterboard can release steady concentrations of VOCs into indoor atmospheres over long periods of time. Alternative board materials formed from clay or cellulose should be considered (20).

High Priority

Particleboard flooring

Particleboard flooring (also known as chipboard flooring), some fibreboards and OSB are formed from chipped low grade timber bound in urea-, phenol formaldehyde or resorcinol adhesive. Formaldehyde is carcinogenic (5). Chipboard is one of main culprits in toxifying indoor and board materials can offgas for long periods. Some of these board materials also contain Benzaldehyde, Ethylbenzene and Benzene. In the UK, alternatives for particle board flooring are limited. A German manufacturer produces a formaldehyde free particleboard but they have no UK stockists. UK manufacturers make an OSB flooring board which uses a formaldehyde free binder but does use polyurethane (19). Untreated softwood flooring and hardwood flooring (33) are likely to be the best alternatives at present and as they can be self finished, avoid the need for any carpeting.

Paint finishes

Paint finishes contain a variety of chemicals which increase VOC content. New buildings would be expected to require 6 months to a year to decline to the VOC levels of older buildings. For paints, the dominant VOC's are usually the solvent component ethylene glycol, or propylene glycol and Texanol. A variety of aldehydes and carboxylic acids have been detected by BRE in chamber tests of VOC emissions from paints. These emissions can add to the pollution load on the internal environment, increasing the health risk for occupants. Oil based paints and varnishes contain white spirit or other mineral spirits such as petroleum distillates, releasing a complex mixture of aliphatic and aromatic hydrocarbon compounds (11).

Solvent free emulsion paints and mineral organic paints are preferable but VOC emissions will vary with the substrate as well as the ventilation rates in the building (12).

Medium Priority

Timber Treatment

Timber treatment should be reduced as far as possible. CCA (copper, chrome and arsenic) is being phased out in residential buildings and has been banned in play areas, however it is still in use for fencing. Alternative, slightly less harmful treatments are available such as Tanalith-e (based on copper and triazole) and copper, chromium and boron (CKB salts). Permethrin is also used in preservatives as a common insecticide (it can also occur naturally but is also carcinogenic). All of these treatments require light organic solvents as carriers (often implicated in health problems) and the chemicals will slowly 'out-gas' from the timber over the building's lifetime (17). Designing and detailing a building to avoid the need for timber treatment (by ensuring adequate ventilation and protection) and selecting timbers which are well seasoned or have higher durability classifications, can help avoid the need for treatment (40).

Cornices

Polystyrene (21) cornices are formed by polymerisation of styrene. Styrene (22) irritates air inhalation routes, and can damage reproductive organs. However cornicing may be encapsulated, in which case the adhesive used to fix them into place may be a greater problem. If cornices need to be installed, plaster cornices are available and adhesive can be gypsum based rather than glue based (41).

Low Priority

PVC

PVC is a registered and persistent carcinogen which can cause damage to liver, lungs, skin and joints. It is poisonous to water organisms. PVC Emits toxic compounds throughout its lifetime (7). PVC materials are found in a large number of internal finishes and trims, including items such as light switches and electric wiring. The main risk internally is likely to be from PVC flooring materials, PVC windows and doors or fabrics containing PVCs rather than PVC pipework. However there remains the risk of toxins released from PVC when there is a fire.

When used externally there should be no effect on internal air quality. Alternatives are easier to find for external use, such as aluminium gutters (48) and downpipes. Doors and windows can be timber, pipework can be HDPE and LSHF cables can be used (28).

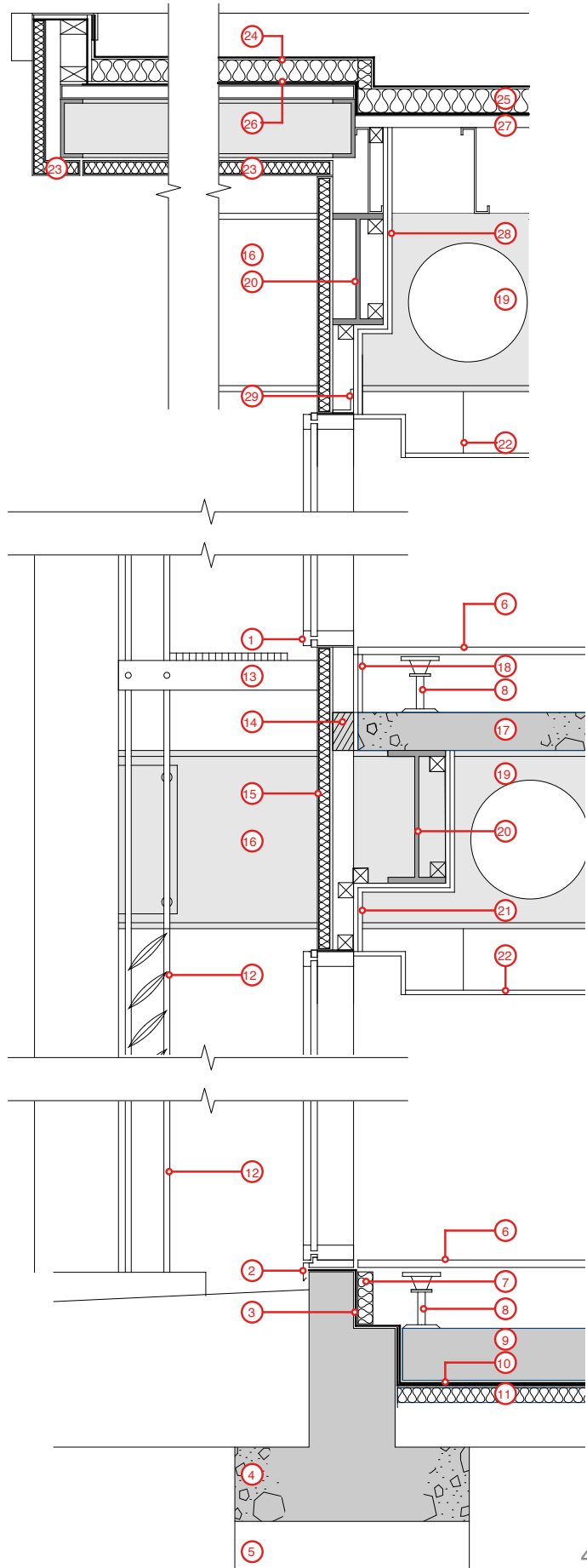
Fibres

Insulation with mineral fibre quilt followed by a polythene vapour barrier should not lead to chemical of-gassing, but care needs to be taken to ensure such insulants are sealed as small fibres can be released by the insulant which can irritate the lungs (13). Walls which allow the absorption and release of water vapour (through the use of hygroscopic insulants) are alternatives (23).

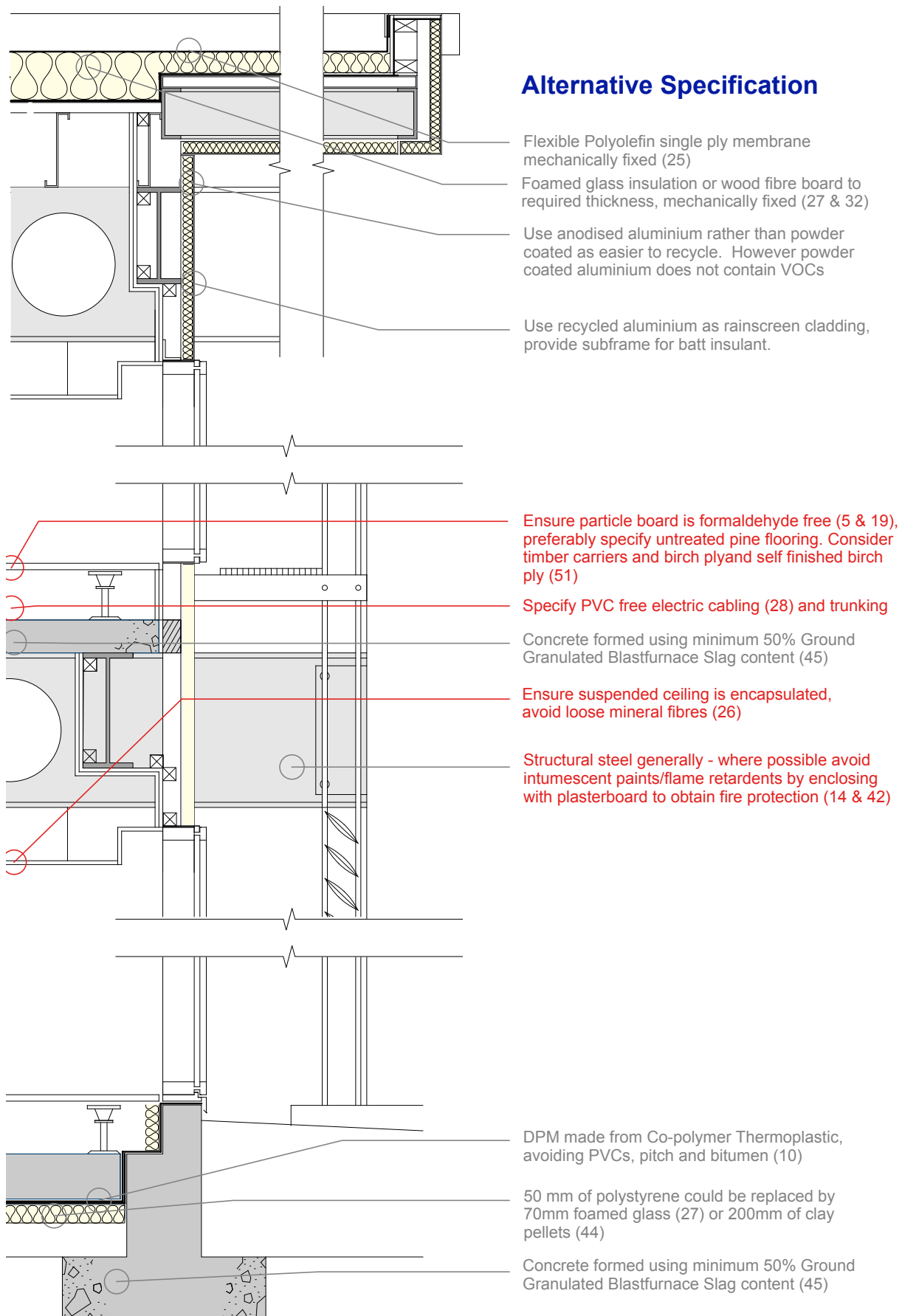
6.3 Steel Frame Construction

Typical Specification

1. 175mm deep overall ppc aluminium curtain walling system spanning from ground floor slab to secondary steel at roof level, tied back to steel structure at intermediate floors levels
2. Mechanically fixed flashing and infill between curtain walling and upstand
3. PVC damp proof course
4. Concrete strip foundation spanning between pad foundations with 295mm wide upstand, reduced to 150mm to suit curtain walling
5. Pad foundation to external column running to roof level to support steel
6. 225mm deep overall proprietary access floor system
7. 50mm rigid polystyrene eps butt jointed insulation glued to DPC
8. Raised access floor pedestals mechanically fixed to concrete slab @ 600mm centres
9. 175mm insitu reinforced concrete slab with float finish
10. Polyethylene damp proof membrane dressed up and lapped with DPC
11. 50mm rigid polystyrene eps butt jointed insulation
12. Aluminium louvre blade sun shading on tensioned steel rods spanning from roof steel to fixing point at ground level
13. Steel maintenance walkway, with mansafe anchor points, on cantilever steel arm, fixed to secondary steel and tension steel rod
14. 1 hour stopping at floor slab edge
15. Insulated aluminium ppc panel glazed into curtain walling horizontally and vertically @ 1500mm centres
16. Projecting beam with bolted fin plate connection to external chs column
17. 125mm insitu concrete floor slab with float finish
18. 2 layers 15mm wallboard infill below raised access floor
19. Cellular beam
20. Steel I section beam
21. 2 layers 15mm wallboard infill between curtain walling and floor slab
22. Proprietary suspended ceiling system fixed as per manufacturers recommendations
23. Insulated aluminium pp cladding panels fixed to secondary steel framing to soffit
24. Single ply roof membrane mechanically fixed
25. 80mm butt jointed mineral fibre slab insulation mechanically fixed
26. Reinforced polyethelene vapour barrier lapped and sealed
27. Profiled metal deck with Z purlins mechanically fixed @ 600mm centres
28. 2 layers 15mm wall board infill between curtain walling and roof deck
29. Insulated aluminium ppc flashing, glazed into curtain walling horizontally, with cassette panel joints vertically @ 1500mm centres
30. Secondary steel support angle



6.3 Steel Frame Construction



6.3 Steel Frame Construction

The main problem with steelwork is the need to fire protect it, although lots of other materials also require protection (such as the surface spread of flame to timber surfaces and many fabrics and furnishings). Intumescent paints are used extensively on steelwork and these paints carry expanding agents and flame retardants (14).

Finding the chemical content of intumescent paint is not easy and usually not given by the manufacturers. The flame retardant decaBDE, recently deemed to be safe following an EU risk assessment, has been found in high levels in lake sediment (54), the eggs of british birds(55) and in human blood (14). The chemical has been shown to cause changes in behaviour and brain function of mice (53) and it's use is under review. PentaBDE, a brominated flame retardant and DeBDethane are also contaminating the environment.

Brominated flame retardants

- A collective term for a large group of organic chemicals that retard flame development.
- Some of the chemicals have attracted attention due to the fact that they do not degrade well in the environment. They can be concentrated in the food chain, and have been identified in living organisms and breastmilk.
- A number of the chemicals, including polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDD) have proven hazardous to health and the environment (24)

High Priority

Flame Retardants

Avoid use of flame retardants where possible and if required, fully investigate chemical compounds, use water based retardant (42). Ideally box in steelwork with fire resistant plasterboard to required thickness, this avoids the need for any fire retardant treatment.

Particle Board

Select formaldehyde free floor panels and finishes. Particle board contains formaldehydes which are carcinogenic. Chipboard/ particleboard is one of main culprits in toxifying indoor air. Also some floor panels are laminates requiring more glue and formaldehyde content (5). Consideration should be given to using a cellulose board system.

Ventilation

Openable windows ensure ease of internal ventilation for occupants. Make use of natural ventilation where possible.

Medium Priority

Ceiling Tiles

Ensure ceiling tiles are sealed, some use mineral wool and edges are not sealed (that is, fibres are exposed at the edges). Also if insulation such as mineral wool is carried in the suspended ceiling, small fibres can leak into the atmosphere (13). Consider installing margins around perimeters to avoid cutting of tiles which could lead to disturbance of any fibres. Whilst paints used in ceiling tiles are low VOC water based paints, some may be vinyl faced tiles using PVC (26)

PVC sheathing to electrical cabling.

Most houses today are wired using PVC sheathed cables and in a serviced building like this, significantly high levels of PVC are present (7). PVC cabling releases toxic fumes during fires. In high risk buildings like airports, "low smoke halogen free", LSHF cables are used. These use sheathing materials like polythene and polyolefin (28).

Low Priority

PVC

Avoid PVC membrane on single ply roof (7). Although this does not necessarily affect indoor air quality, the avoidance of PVC is important because PVC is a registered and persistent carcinogen which can cause damage to liver, lungs, skin and joints. It is also poisonous to water organisms and emits toxic compounds throughout lifetime. Use Flexible polyolefin single ply membrane (24) mechanically fixed into fibreboard insulant base.

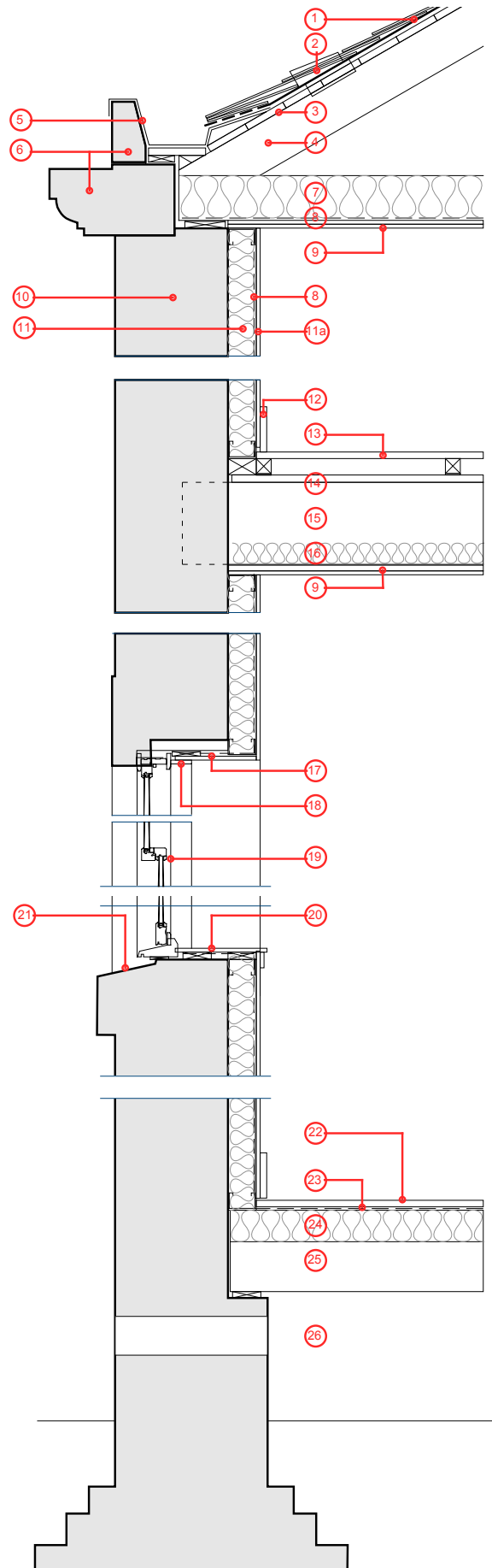
PVC DPC. As noted above, PVC should be avoided and alternative materials such as copolymer thermoplastic DPCs should be used (10).



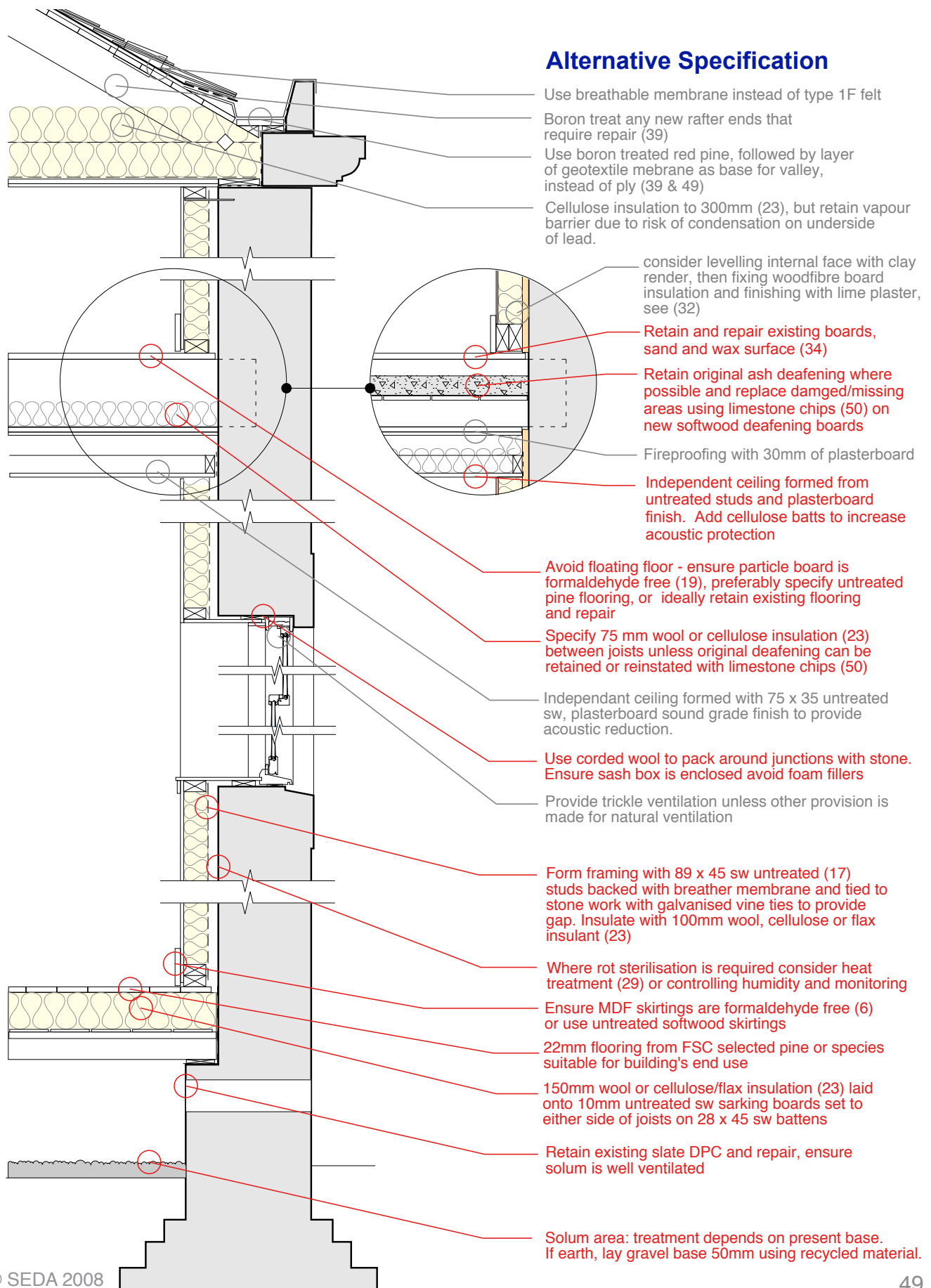
6.4 Rehabilitation

Typical Specification

1. Existing slates taken up and replaced, nailed through Type 1F felt with stainless steel nails.
2. New slate vent and flashing to ventilate attic space.
3. Existing 100x20mm softwood sarking on
4. Existing 165x75mm softwood rafters.
5. New lead sheet gutter laid on marine ply sole and dressed under breather membrane
6. Ashlar facing stone naturally bedded.
7. 150mm Rockwool insulation within existing 150mm ceiling joists.
8. Vapour Control layer
9. 1 layer of 12.5mm plasterboard, one layer 19mm plasterboard nailed to underside of existing ceiling joists (lath and plaster removed) 2 coat satin emulsion finish
10. Existing Stone External Wall.
11. 100mm rockwool between 95mm proprietary metal studs fixed to existing external wall (existing lath and plaster removed)
- 11a. 1 layer of 12.5mm t+f plasterboard screwed to metal studs thru' vapour control layer
12. MDF skirting glued to plasterboard, 3 coat gloss finish
13. Raised 22mm type III chipboard floor screwed to cushioned timber battens 50x50mm at 400 centres, 50mm mineral wool infill.
14. Existing 25mm thick floor boards.
15. Any rotten joists removed and replaced with new treated joists, old deafening and deafening boards removed.
16. 75mm acoustic grade mineral wool between joists.
17. Plasterboard returned to form soffit, vapour control layer continuous over treated softwood or ply packers
18. MDF Soffit lining tacked and glued to window frame and plasterboard, silicon sealed with 3 coat gloss finish.
19. Double glazed replacement timber sash and case window. Silicon sealant all around externally.
20. MDF Cill into frame groove and over vapour control layer and packers, silicon sealed and with 3 coat gloss finish.
21. Existing shaped stone cill.
22. 22mm type III chipboard floor glued tongues and grooves, secret nailed to joists
23. Vapour barrier
24. 100mm Rockwool insulation within existing joists, supported by netlon.
25. Existing softwood joists, resting on packers.
26. Existing ventilated solum, base make up 50mm fine hardcore and cold asphaltic finish.



6.4 Rehabilitation



6.4 Rehabilitation

In Scotland, older properties can be tenemental or cottage type. The detail shows a typical section through a stone tenement wall where the height may vary. It is not uncommon to find a mixture of brick and stone in the outer walls.

Timber joists usually span from front to rear of these properties and joists are usually embedded in the outer walls, helping to tie the structure together. However if gutters, downpipes and the stone fabric are not maintained, moisture can build up in the wall and lead to rot in the joist ends. Rot eradication treatments are therefore a part of the rehabilitation process and clients and funders alike often request 'guarantees' for rot eradication works. Specialist firms will often decide to saturate the walls and new timbers with chemical preservatives leading to an unhealthy internal environment (17). Alternatives exist to try and avoid chemical treatment altogether. In Denmark, rot eradication is carried out using the heat treatment method where the complete structure is tarpaulined and the temperature is raised to 50°C (slowly, to avoid shrinkage). This ensures all of the fabric is treated and avoids the use of chemicals altogether. However if the cause of the dampness can be located and removed (essential to any treatment), then localised heat treatment of the wall fabric can also work. Provided the temperature and humidity of the wall can be maintained, then further rot outbreaks can be avoided. Monitoring devices can be planted into vulnerable areas to check dampness and humidity levels (29).

Because of the fear of hidden dry rot outbreaks, there is a tendency to strip out all the old timbers and deafening between the joists, as well as dropping the old ceilings. This creates an incredible amount of dust which can be dangerous to workers. Outbreaks of dry rot can be located by using trained 'rothounds' to sniff out dry rot. This allows resources to go to where they are needed and avoids the undue stripping out of the old fabric (30).

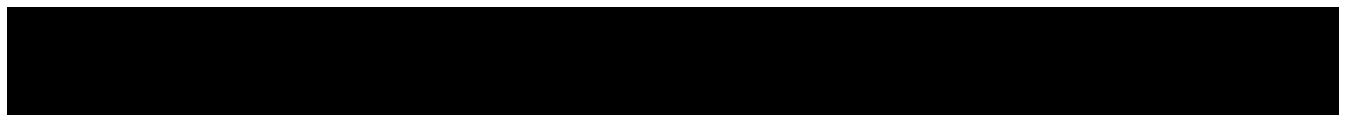
Regarding the insulation, this has to be installed internally if the stonework is to remain fronting the building. Whilst stonework is generally vapour permeable, the degree of permeability will vary, and if brick and cement rather than lime have been used then the fabric may be fairly impermeable. Installing a vapour barrier may be the best way of ensuring the internal face of the stonework remains free of condensation. If timber, rather than metal studs are used, then it is common practice to isolate the timber from the external wall, as we have shown in the detail. If the timber studs are left untreated, then this void space should be ventilated. However we are also showing in our 'inset detail', where the stone wall is considered to be vapour permeable then a hygroscopic (vapour permeable) insulation could be used fixed directly to the wall, once the walls surface has been levelled. If clay or lime plaster (43) is used this should result in a formaldehyde free and comfortable internal environment.

High Priority

Reduce Chemical Treatment

Reduce chemical treatment to walls and timbers by careful surveying of structure, identifying sources of moisture and removing them, maintaining a stable internal temperature and humidity to prevent outbreaks. If whole building affected by dry rot, consider heat treatment of fabric (29)

Where timbers are already buried in wall fabric and require treatment consider inserting Boron rods (31).



Use well seasoned timbers rather than treated timbers when replacing joists.

Boards and Finishes

Select formaldehyde free particle board if a board material has to be used (6). Otherwise the best approach is to specify 22mm FSC red pine flooring which is untreated. If a self finished floor is required use an FSC hardwood floor (33) and wax finish (34).

Select formaldehyde free MDF or use untreated soft wood (5).

Paint Finishes

Finish wall and ceiling surfaces with natural pigment paint with low VOC emissions. (12). Specify water based latex primers and acrylic glosses for timberwork finishes (11)

Medium Priority

Loft Insulation

Use blown cellulose fibre in loft, although if eaves is well ventilated the fibres can blow about. Alternatively consider cellulose/recycled jute insulation batts (23).



Low Priority

Mastics

Avoid two part polysulphide mastics and foam fillers around window reveals. Use jute or wool fibres and silicone or linseed oil mastics (15). In sash and case construction draughts can be reduced by ensuring the counterweight case is fully boxed in.

Ventilation

Openable windows ensure ease of internal ventilation for occupants.

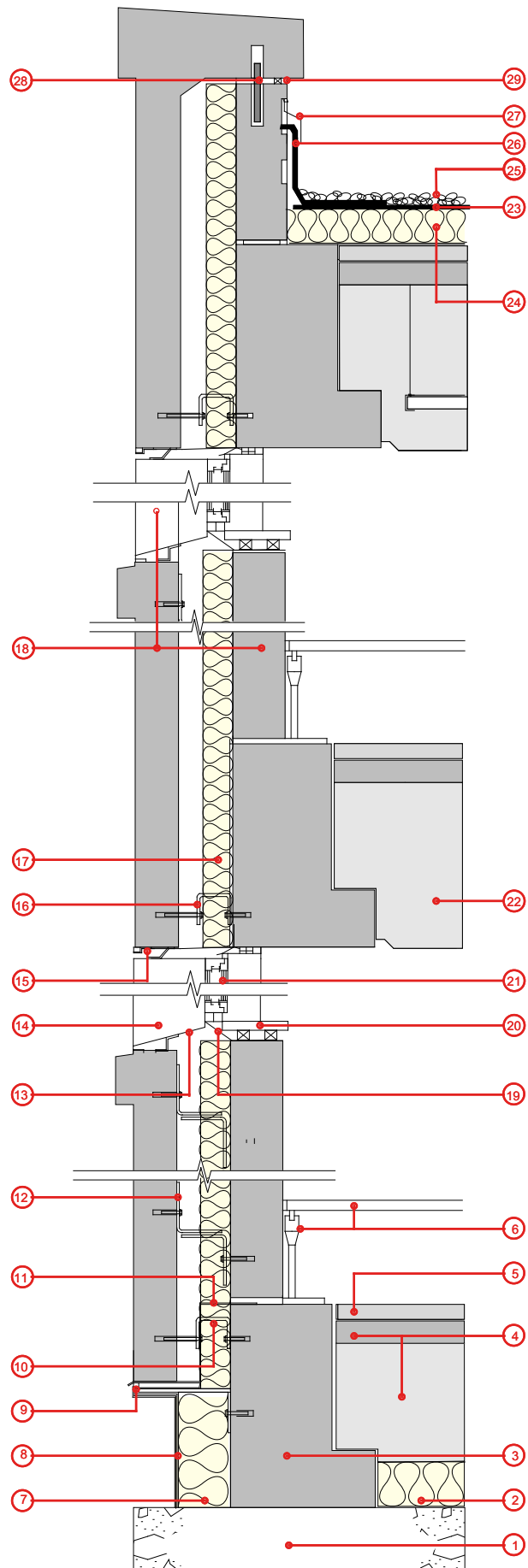
Special Plasterboards

Generally the use of plasterboard should not cause any problems. However additives used to produce waterproof and fire resistant gypsum board may contain VOCs. Absorbed solvents from the coatings of plasterboard can release steady concentrations of VOCs into indoor atmospheres over long periods of time (35)

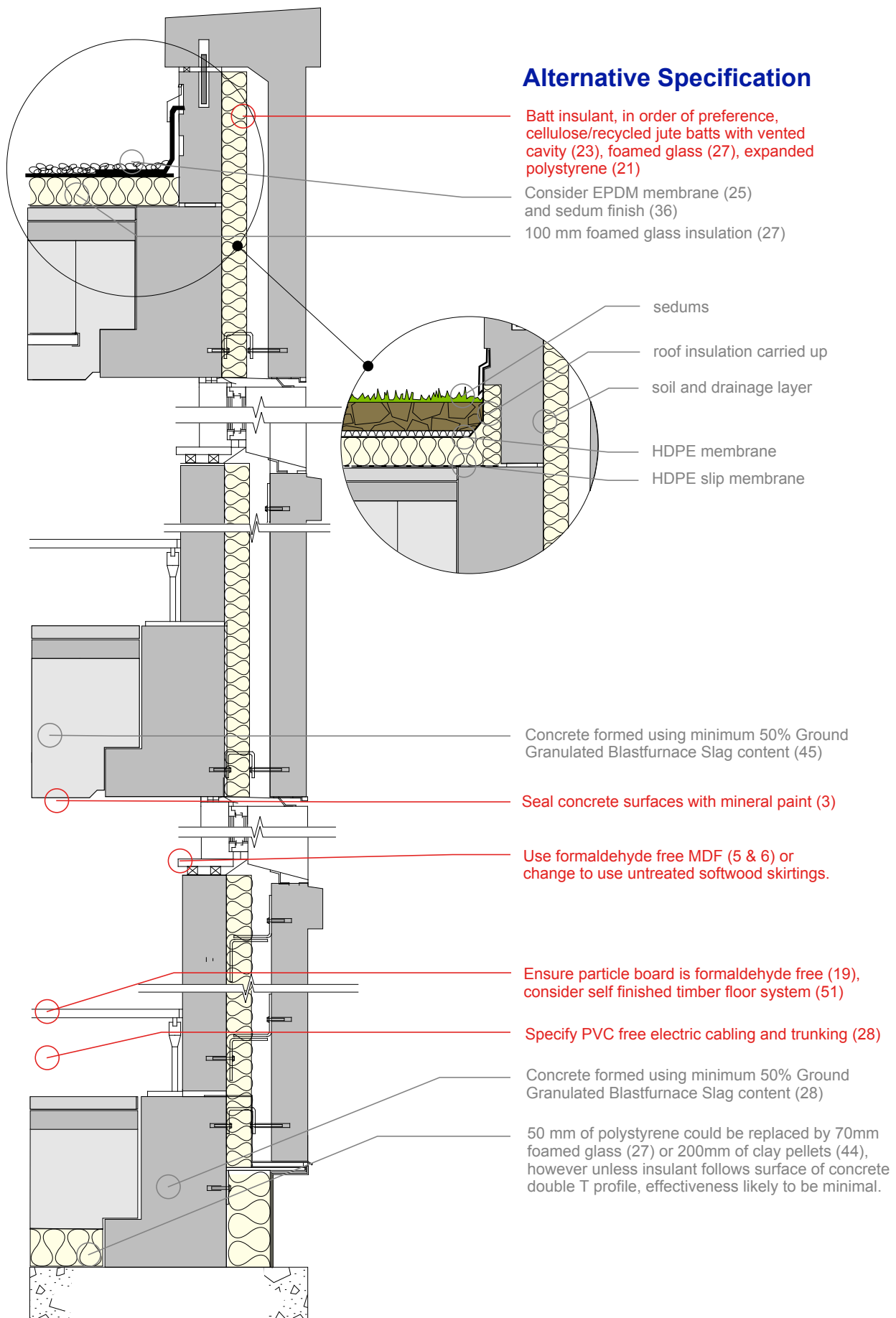
6.5 Precast Concrete

Typical Specification

1. Pad foundation
2. 50mm rigid polystyrene epps butt jointed insulation
3. 690 x 350mm pre-cast concrete beam
4. Pre-cast concrete double T-unit spanning between beams
5. 50mm structural screed
6. 300mm deep access floor system
7. 175mm expanded polystyrene insulation
8. Mesh and waterproof cement render
9. Bond breaker and sealant
10. Stainless steel shelf angle attached using wedge anchor insert with 10mm gusset centrally welded
11. Continuous aluminium flashing
12. 140 x 180 x 10mm stainless steel angle
13. PPC aluminium sill with silicone sealant
14. PPC aluminium window trim sealed with silicone
15. Weephole in recessed joint
16. 135 x 115 x 215mm stainless steel channel
17. 100mm expanded polystyrene insulation
18. 150mm sandstone coloured pre-cast panel
19. EDPM membrane locked into window
20. Treated timber window sill
21. Thermally broken triple-glazed window
22. Metal tile as suspended ceiling system
23. 20mm asphalt roofing
24. Non-compressible extruded polystyrene insulation
25. Stone chippings as ballast
26. Asphalt up-stand on high-bond primer
27. Aluminium flashing mechanically fixed into rebate in panel
28. Dowel fixing
29. Silicone seal



6.5 Precast Concrete



6.5 Precast Concrete

Concrete is by its nature, very dense and impermeable. It does not allow the passage of water vapour and does not absorb (or release) moisture. This was one of the downfalls of large panel system buildings, where moisture that was not absorbed by the walls was driven into the joints, making them more vulnerable. Their poor levels of insulation only added to the risk of internal condensation. However precast concrete does have advantages, combined with good insulation it can provide thermal mass and externally, a variety of prefinished surfaces are available. As a structure which has little tolerance over the movement of water vapour, internal conditions will often be controlled by mechanical ventilation and air conditioning systems, which can also pollute the internal air quality because of poor air intakes, lack of maintenance on filters etc.

Surface finishes which could absorb and release changes in humidity would help to create a better internal environment. In approaching the typical detail we consider that floor and ceiling finishes, paints and insulation are likely to be the main contributors of VOC and formaldehydes.

High Priority

Particleboard Floor Panels

Select formaldehyde free floor panels and finishes. Particle board contains formaldehydes which are carcinogenic. Chipboard/ particleboard is one of main culprits in toxifying indoor air. Also some floor panels are laminates requiring more glue and formaldehyde content.

Paint Finishes

Finish wall and ceiling surfaces with natural pigment paint with low VOC emissions. (12). Specify water based latex primers and acrylic glosses for timberwork finishes (11)

Medium Priority

Polystyrene

Avoid use of polystyrene if possible (21). Formed by polymerisation of styrene. Styrene irritates air inhalation routes, damages reproductive organs. Benzene, used in the production of polystyrene, is a known human carcinogen. Studies have yet to confirm that there is a health risk, but we believe avoidance is preferable and would recommend using a foamed glass insulation where loadings are required. In cavity walls we suggest the use of cellulose/recycled jute insulation batts (23).

Cement Dust

To prevent the spread of cement dust from the concrete surfaces we suggest that surfaces should be sealed with a water based mineral paint (12).

PVC Wiring

Avoid PVC sheathing to electrical cabling.

In a serviced building like this, significantly high levels of PVC may be present from the electrical cabling. PVC cabling releases toxic fumes during fires. In high risk buildings like airports, "low smoke halogen free", LSHF cables are used. These use sheathing materials like polythene and polyolefin (28).

Low Priority

Asphalt Roofing

Asphalt roofing is not very healthy for the applicators as Benzene is given off. Low fume asphaltic make ups are available but other solutions should be considered such as a green roof system which can help contain rainfall surges and will add to the environmental quality provided sedums are selected to suit the local climate (36).

MDF skirtings

Use formaldehyde free MDF (5)

Appendices

A Definitions

B Acronyms

C References

D Further Reading

E Useful Contacts

F Specification Notes

Appendix A Definitions

This guide focuses on the design of appropriate detailing for minimising toxic loads of building projects based on Scottish building practice and climate.

Allergy - A condition in which the body has an exaggerated response to a substance (eg food or drug). Also known as hypersensitivity.

Allergy Trigger - The substances that trigger allergy are called allergen. Examples include pollens, dust mite, moulds, danders, and certain foods.

Building Related Ill-Health –A combination of ailments associated with people’s place of work or home, also often referred to as Sick Building Syndrome. A 1984 WHO report suggested up to 30% new & refurbished buildings worldwide may give rise to ill-health.

Chemical Pollutants – Pollutants presenting a hazard to health and the environment of natural or synthetic origin, essentially chemical in nature.

Chemical mutagens - Agents that may give rise to mutations resulting in an increase in the incidence of congenital defects in future generations.

Dander – Tiny scales shed from human or animal hair or skin. Dander floats in air & settles on surfaces. Cat dander is a significant contributor to allergic reactions.

Ecological Footprint - Estimate of the area of Earth’s productive land/water required to supply the resources an individual or group demands, and absorb their wastes. By calculation extent a person uses more/ less than their fair share of world resources.⁶⁹

PCB - Polychlorinated biphenyls - a class of commercially produced organic chemicals which were developed in the 1930s and were mainly used in the electricity supply industry and mining. They have been proven to be toxic to both humans and animals.

Toxicity - A physiological or biological property that enables a chemical to do harm, or create injury, to a living organism by other than mechanical means; or the ability of a chemical to cause poisoning when the chemical is administered to a living organism.

Toxic Release Inventory - A US database of toxic releases. Manufacturers must report annually the amounts of almost 350 toxic chemicals and 22 chemical categories that they release directly to air, water, or land, inject underground, or transfer to off-site facilities. EPA supplies information to the public under the “Community Right-to-Know” law.

Reclamation and reclaimed - material is set aside from the waste stream for future reuse with minimal processing.

Reuse - the use of reclaimed materials for their original purpose.

Recycling and recycled - the manufacture of a new product using reclaimed materials, scrap or waste as feedstock.

Synthetic - substance formed by a chemical process or chemical change from substance extracted from naturally occurring plant, animal, or mineral sources. The term does not apply to substances created by naturally occurring biological processes.

69. www.gdrc.org/uem/footprints/wwf-ecologicalfootprints.pdf

Appendix B Acronyms

AECB – Association of Environment Conscious Builders
ASA - Advertising Standards Agency
BSI – British Standards Institute
BPEO - Best Practical Environmental Option
BRE - Building Research Establishment
CEN - European Committee for Standardisation
CFCs – chlorofluorocarbon
CIBSE - Chartered Institute of Building Service Engineers
CIRIA - Construction Industry Research and Information Association
CKB -
CPA Construction Products Association
CPD - Construction Products Directive
DEFRA – Department for Environment, Food and Rural Affairs.
EC - European Community
ECOHB - The European + Global Network of Organisations for Environmentally-Conscious and Healthy Building
EPA - Environmental Protection Agency
EPD – Environmental Product Declarations
ETA - European Technical Approvals
EU - European Union
HBN – Healthy Buildings Network
HCFCs – hydrochlorofluorocarbon
HSE – Health and Safety Executive
HVAC - Heating, Ventilation, & Air Conditioning
IAQ - Indoor Air Quality
IBN – Institute of Building Biology
ISO – International Standards Organisation
LCA – Life Cycle Analysis
M&E - Mechanical and Electrical (services)
NBS - National Building Specification
NBT - Natural Building Technologies
NGO - Non-governmental Organisation
NGS – National Green Specification
NIOSH - National Institute for Occupational Safety and Health
ODPM - Office of the Deputy Prime Minister
OSB - Oriented Strand Board
OSC - Off site construction
PCBs – Polychlorinated biphenyls
PE - Polyethylene
PP - Polypropylene
PTFE - Polytetrafluoroethylene
PVC - Polyvinyl Chloride
REACH - Registration, Evaluation and Authorisation of Chemicals
RCEP – Royal Commission on Environmental Pollution
RIAS - Royal Incorporation of Architects in Scotland
RIBA - Royal Institute of British Architects
SBS - Sick building syndrome
SEDA - Scottish Ecological Design Association
SEPA - Scottish Environmental Protection Agency
TBS - Tight building syndrome
VOC – Volatile Organic Compounds
WEEE - EC Directive on Waste Electrical and Electronic Equipment (WEEE)
WHO - World Health Organisation
WWF – World Wildlife Fund

Appendix C Main References

Abramson M., et al (1991) Ambient Air Pollution and respiratory disease Med J Aust 154 543-551

Andersson, Åse., (2002) Harmful compounds in paint leached from wooden facades, The 3rd International Conference on Sustainable Building, Oslo 2002

Andersson, Åse., (2002) Long-term leaching of environmentally hazardous substances in admixtures, emitted from concrete, The 3rd International Conference on Sustainable Building, Oslo 2002

Andrae S., et al (1988) Symptoms of bronchial hyper-reactivity and asthma in relation to environmental factors Arch Dis Child 63 473-478

Berge, B. (2000) The Ecology of Building Materials, Architectural Press, Oxford

Generally regarded as Architects' main source of robust information. Deals with materials rather than products and avoids conflict with individual manufacturers.

Bordass, B. (2000) Cost and value: fact and fiction, Building Research & Information Volume 28, Issue September 2000

Carson. R (1962) Silent Spring, Houghton Mifflin Company, Boston.

Everybody's original source. It is impossible to read a book on the topics of environmental pollution without this ubiquitous, meticulous and mould breaking piece of work from a victim of environmental pollution.

Christensen, N.T. et al. (2002) Harmful substances in building waste in the future – inventory and prediction of twelve substances. The 3rd International Conference on Sustainable Building, Oslo

Gaia Research and Gaia Architects (2005) Affordable Low Allergy Housing – A Guidance Note, Gaia Research, Edinburgh ISBN 1-904-680-18-6

The summary of the study.

Halliday S.P, Chapman B, Jones P and Liddell H.L. (2005) Affordable Low Allergy Housing, Gaia Research, Edinburgh ISBN 1-904-680-17-8

Development of an affordable low allergy building specification that avoids, where possible, known and suspected allergens and minimises the conditions in which they can have an adverse impact. The project aimed to raise the profile of breathing related disability to a level where it is given the same importance in building design as is presently the case for access for the physically disadvantaged.

Halliday S.P and Stevenson F.B.A. (2004) Sustainable Construction and the Regulatory Framework, Gaia Research, Edinburgh ISBN 1-904680-19-4

Thinkpiece on the Scottish Regulatory framework in the light of the Building (Scotland) Act 2003, where sustainable development became a fundamental requirement.

Healthy Building Network. Target Materials: Overview.

Information on materials to avoid and products commonly made from them. Chlorine based, PBT and heavy metals are focus. Also suggests avoidance of Formaldehyde, other VOCs and Pthalates because they have an effect on the indoor air quality.

www.healthybuilding.net/target_materials.html

Jaakkola, J.J., Verkasalo, P.K. and Jaakkola, N., (2000) Plastic wall materials in the home and respiratory health in young children. American Journal of Public Health; Vol. 90 pp. 797-799

Lynge, E., Anttila, A. and Hemminki, K., (1997) Organic solvents and cancer. Cancer Causes Control, The Harvard-Teikyo Program Special Issue, Vol. 8, No. 3, pp. 406-419

National Office of Building Technology and Administration, Norway, Guidelines to

the Technical Regulations under the Planning and Building Act (1997) (English version available from: <http://www.be.no/beweb/english/englishtop.html>)

Pohlabein, H., Jöckel, K.H., Bröske-Hohlfeld, I., Möhner, M., Ahrens, W., Bolm-Audorff, U., Arhelger, R.; Römer, W., Kreienbrock, L., Kreuzer, M., Jahn, I., Wichmann, H.E., (2000). Lung cancer and exposure to man-made vitreous fibers: results from a pooled case-control study in Germany. American Journal of Industrial Medicine, Vol. 37 Issue 5 pp. 469 - 477

PVC in Buildings: Hazards and Alternatives. www.healthybuilding.net

Concise fact-sheet on risks posed by PVC and alternatives to common PVC products.

Royal Commission on Environmental Pollution (2003) Chemicals in Products TSO (The Stationery Office)

A very important source. It does not pull its punches and sets alarm bells running as to the enormity of the problem – the immense lack of testing and identification of what has not been put in place by government. It invokes, therefore, the precautionary principle as the only reasonable response.

Rumchev, K.B., Spickett, J.T., Bulsara, M.K., Phillips M.R., and Stick, S.M., (2001), Domestic exposure to formaldehyde significantly increases the risk of asthma in young children, European Respiratory Journal Vol. 20 pp. 403-408

Steingraber. S. (1997) Living Downstream Virago Press, London

Starts out where Rachel Carson left off and attacks the recidivist chemical industry, which has regained a foothold since 'Silent Spring' and which for many years was subject to non requirement for declaration of hazards due to ongoing wartime secrecy legislation not being lifted. Very readable, but mainly concentrates on carcinogens.

Wantke, F., Demmer, C.M., Tappler, P., Gotz, M., Jarisch, R., (1996) Exposure to gaseous formaldehyde induces IgE-mediated sensitization to formaldehyde in school-children, Clinical & Experimental Allergy, Vol. 26 Issue 3 pp. 276-280

William F.J., (2000), Health and Productivity Gains from Better Indoor Environments and Their Relationship with Building Efficiency, Annual Review of Energy and the Environment, Vol. 25 pp. 537-566

Appendix D Additional Background Reading

Anderson J., Shiers D (2002) The Green Guide to Specification, Blackwell, Oxford

British Medical Association (1991) Hazardous Waste & Human Health, Oxford University Press

Significantly this book by the BMA links exposure to toxic waste with ill health. It traces the growth of the problem and identifies the nature of the risks. It also addresses the issue of safe recycling. ("It is the ironic role of today's science and technology to mitigate the damage caused by the unthinking disposal of the toxic wastes created by yesterday's science and technology" Skinner & Bassin 1988.)

Chao CY et al Feasibility Study of an Indoor Air Quality Measurement Protocol on 12 parameters in Mechanically Ventilated and Air Conditioned Buildings, Indoor + Built Environment Jan Feb 2001

Costner, Pat, Beverley Thorpe and Alexandra McPherson. (2005) Sick of Dust. Chemicals in Common Products – A Needless Health Risk in Our Homes. NY: Clean Production Action.

This report uses the analysis of dust collected from 10 homes in each of 7 states in the USA to assess the types and levels of hazardous chemicals present in the homes. The tested for several specific chemicals in each of the following classes; Brominated diphenyl ethers (used as fire retardants), Phthalates (plasticizers in PVC), Organotin Compounds (stabiliser in PVC), Alkylphenols (cleaners and cosmetics), Perfluorinated Organics – PFOA/PFOS - (used in stain-resistant materials) and Pesticides (often used in and around homes and impregnated into products). The report suggests the phasing out of hazardous chemicals from use and also suggests actions that the general public can take to reduce the toxics in their homes.

Crump D., et al A protocol for the assessment of indoor air quality in homes and office buildings BRE 2002

Coward SKD et al Indoor Air Quality in Homes in England BRE 2000

Fanger O.L (1998) Hidden Olf in Sick Buildings ASHRAE Journal

Francis. B.M. (1994) Toxic Substances in the Environment, John Wiley & sons Chichester

A serious textbook on all aspects of toxicology – from Environmental Chemistry to Environmental Toxicology to Ecology. Very thorough and based on the fact that "without understanding the scientific underpinning of the headlines one cannot judge the magnitude of the risk."

Godish, T. Formaldehyde and Building Related Illness, Journal of Environmental Health. Vol. 44, no. 3, pp. 116-121. 1981

The apparent association between building-related illness and formaldehyde contamination of indoor environments is reviewed. In addition to results of field investigations, emphasis is placed on formaldehyde's toxicity, its possible carcinogenicity and apparent association with asthma. Specific problems associated with mobile homes, urea formaldehyde foam insulation, conventional wood-frame housing and non-residential buildings are also discussed. Definitive epidemiological studies are needed to determine whether a causal relationship between building-related illness and formaldehyde contamination of indoor environments exists. Information on which materials to avoid and what products are commonly made from them. Chlorine based, PBT and heavy metals are the focus. It also suggests the avoidance of Formaldehyde, other VOCs and Phthalates because they have an effect on the indoor air quality.

Halliday S.P (2003) Module 6: Ventilation and Cooling Strategies Sustainable Construction CPD Gaia Research, Edinburgh

Halliday S.P (2003) Module 14 Appraisal Tools and Techniques Sustainable Construction CPD Gaia Research, Edinburgh

Harte. J et al (1991) Toxics A to Z: A Guide to Everyday Pollution Hazards U.Cal Berkeley.

Has a useful alphabetical list of hazardous chemicals and their effects. This is introduced via principles of toxicology exposure and environmental risks and then categorised under 4 headings – metals, petrochemicals, radiation and pesticides.

Howieson S.G. (2005) Housing and Asthma, Taylor and Francis.

The UK has the highest prevalence of asthma symptoms in 13-14 year olds in the world. Over the past 25 years the incidence of asthma episodes has increased by a factor of three to four in adults and six in children. This book looks at what factors specific to the UK can be identified as key drivers, and more importantly, what can be done to either slow this increase or reverse the trend?

Hunting, E. Shelter: Documenting a personal quest for non-toxic housing. What Is Non-Toxic Housing?

<http://radio.weblogs.com/0119080/stories/2003/01/30/whatIsNontoxicHousing.html>

An explanation of 'non-toxic housing' as opposed to 'toxic housing'. The article describes the reasons for indoor pollution and their effects. Hunting discusses Baubiologie – the study of the relationship between architecture and nature – and lists Schneider's 25 Principles.

Lange, John H. Has the Indoor Environment and Built Environment Started Changing Modern Health? Indoor + Built Environment. 11 (2006) 119-122

Looks at the effects of the indoor environment on human health. The strive for energy conservation is, in part, blamed for the increase in 'sick building syndrome'. The report reminds us that it is the dose that makes the poison and that society wants the benefits of toxic chemicals without the toxic side effects. Combines factors of increased pollutants in the built environment and indoors with the life-style changes that have lead to some people spending as much as 80% of their time indoors. This combined approach is described as 'urban toxicology'.

London Hazards Centre (1988) Toxic Treatments London Hazards Centre Trust

How long does it take? One of the earliest books to flag up the problem of timber treatment. Starting from a specific case study and then outlining (already in 1988) 10 years of denial of the issues by the timber products industry, this book lays out the risks and how the chemicals persist in the body, then demonstrates why they are not necessary and finishes with a section on decontamination.

McIntyre, D.A. 1980 Indoor Climate Applied Science Publishers Barking.

Mainly a text book for the technically competent. A bit thin on the chemical contaminants side – but does already flag up formaldehyde – and particularly chipboard – as an issue, including success in obtaining the reduction in its use in Denmark.

National Asthma Campaign Info Sheets [www](http://www.nac.uk)

Oie L (1998) The role of indoor building characteristics as exposure indicators and risk factors for development of bronchial obstruction in early childhood NTNU Trondheim

Paajanen L. et al (1994) Effect of Insulation Materials on the Bio-deterioration of Buildings VTT

Simonson C. J. (2000) Moisture, Thermal and Ventilation Performance of Tapanila Ecological House VTT

Singh J. Allergy Problems in Buildings Quay Books 1996

Thornton, Joe. (2000) Pandora's Poison: Chlorine, Health and a New Environmental Strategy. Cambridge, Mass: MIT Press Ltd,

Deals with the global accumulation of toxic chemicals. Evidence that organochlorine exposure causes health problems, incl. cancer. Proposes environmental policy to blame. Suggests phase out chlorine-based products & replacing with safe alternatives.

Spengler.J et al (2001) Indoor Air Quality Handbook McGraw-Hill

Highly technical but comprehensive textbook.

Sterling, Peter and Nicole Paquette. Toxic Chemical Exposure in Schools: Our Children At Risk. Vermont: VPIRG, March 1998.

Findings of tests and surveys of several schools in Vermont area. It details the adverse health effects experienced by staff and pupils in schools where toxic chemical exposure was occurring. Common complaints were headaches and nausea. The report has useful tables showing the different sources of toxins within the school environment. The building materials category includes adhesive and caulking compounds, carpet, roofing materials, pressed wood products, drapery, floor and wall coverings, paints and stains and varnishes. Action suggested by the report includes a safe materials policy, enforced ventilation standards and co-ordinated purchasing of non-toxic alternatives.

Thornton, Joe. Environmental Impacts of Polyvinyl Chloride (PVC) Building Materials. www.healthybuilding.net/pvc/ThorntonPVCSummary.html

A briefing paper for the Healthy Building Network that details the hazards of PVC throughout its life. The bioaccumulation and toxicity of the additives of PVC, particularly phthalates, but also dioxins, vinyl chloride, metals and ethylene dichloride. By-products of PVC are persistent, bioaccumulative and toxic, causing cancer, neurotoxicity and immune system suppression. These by-products are found in worryingly high concentrations in human breast milk. Thornton suggests the phasing out of PVC building materials.

World Health organisation (1992) Our Planet Our Health WHO, Geneva

Notable for its omissions – especially for the absence of anything significant relating indoor climate to health problems although there is a good section on product manufacture and industrial related effects.

Yu C and Crump D (2002) Digest 464 Part 1: VOC emissions from Building Products - Sources, testing & emission data Part 2: VOC emissions from Building Products - Control, evaluation and labelling schemes BRE

Yu C and Crump D (2003) IP12/03: VOC emissions from flooring adhesives BRE

Appendix E Useful Additional Contacts

Accociation for Environment Conscious Building (AECB)
<http://www.aecb.net/>

American Lung Association Health House
<http://www.healthhouse.org/>

Building Air Quality
www.baq1.com/

BuildingGreen.com Indoor Environment Quality
www.buildinggreen.com/menus/subtopics.cfm?TopicID=5

Department for Environment, Food and Rural Affairs (DEFRA) – Air Quality, Pollution, Chemicals, Statistics and Pollution
www.defra.gov.uk/environment/airquality/
www.defra.gov.uk/environment/statistics/
www.defra.gov.uk/environment/airquality/eu-int/eu-directives/paints-directive/index.htm

Envirodesic
www.envirodesic.com/index.html

Environmental Health Perspectives
<http://ehp.niehs.nih.gov/members/1999/suppl-3/465-468rylander/rylander-full.html>

Environmental Protection Agency
<http://www.epa.gov/iaq/voc.html>

European eco-label
http://ec.europa.eu/environment/index_en.htm

EU Sustainable Development Strategy http://ec.europa.eu/sustainable/welcome/index_en.htm

Greenpeace
www.greenpeace.org/international/campaigns/toxics/polyvinyl-chloride/pvc-alternatives-database/

Health & Safety Executive
www.hse.gov.uk/

Health Protection Agency
<http://www.hpa.org.uk/>

Healthy Building Network
<http://www.healthybuilding.net/>

Healthy Home & Workplace
<http://www.healthyhouse.com/>

International Centre for Indoor Environment and Energy
<http://www.ie.dtu.dk/>

International Institute for Bau – Biologie
<http://www.bau-biologieusa.com/>

International Society of Indoor Air Quality and Climate
<http://www.ie.dtu.dk:80/isiaq/>

International Standards Organisation
www.iso.org
www.eota.be/

National Green Specification for helpful advice and examples of environmental specification
www.greenspec.co.uk –

REACH
http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

Royal Commission on Health and Pollution (RCEP) Study on Urban Environments, Well-being and Health
www.rcep.org.uk/urbanenvironment.htm

Scotland's Sustainable Development Strategy 2005 www.scotland.gov.uk/Publications/2005/12/1493902/39032

Scottish Building Standards Agency
www.sbsa.gov.uk

SEDA - the premier NGO in Scotland for Ecological Design
www.seda2.org –

Select Committee on Science and Technology
www.parliament.the-stationery-office.co.uk/pa/ld200506/ldselect/ldsctech/21/4111706.htm

SEPA
www.sepa.org.uk

Sustainable Development Directorate of the Scottish Executive www.scotland.gov.uk/Topics/SustainableDevelopment

UNISON
www.unison.org.uk/safety/doc_view.asp?did=181

U.S. EPA Toxics Release Inventory
www.epa.gov/tri/

World Health Organisation – Air Quality Guidelines
http://www.euro.who.int/air/activities/20050222_2

World Wildlife Fund
www.wwf.org.uk

Appendix F Specification Notes

(1) VOCs

Volatile organic compounds are soluble and hence capable of causing emissions. Wetter products can thus release more VOCs. They vary according to their boiling points

VVOC (very volatile organic compounds): 0-500C

VOC (volatile organic compounds): 50-2500C

SVOC (semi-volatile organic compounds): 250-3800C

TVOC (total volatile organic compounds)

The German Environment Agency makes a recommendation that the total VOC (TVOC) concentration in interiors does not exceed 1-2mg/m³ internal air movement in the first year. In building related products, typical VOCs will be:

Aliphates: found in paints, adhesives, thinners, carpets

Aromates: products containing solvents: synthetic resin paints, adhesives, carpets, paints

Styrene: insulating materials, coatings, carpets, paints

Heterocyclene: synthetic resin paints, solvents, carpets

Terpenes: wood products, natural and alkyd resin paints, stove enamel

Aldehydes: drying oils, alkyd resins, linoleum floor coverings

Formaldehyde: wood and panel products, paints, urea formaldehyde foams, insulating materials, fillers, furniture

Ketones: water and solvent based products, eg paints, adhesives, strippers

Alcohols and esters of monovalent alcohols: water and solvent based products, eg paints, adhesives, strippers; polyurethane foams, filler compounds

Glycols: water based products, eg acrylic paints, adhesives, joint sealers; stove enamel, wood stains, dispersion paints, wood stains

Pyrrolidone derivatives: strippers, paints, water based paints

Trimeric isobutylenes: foam backed carpets, rubber products

Phthalates: plasticizers in latex and other paints, adhesives, varnishes, carpets and synthetic materials.

Biocides: timber preservative, leather, carpets

Flame retardants: carpets, furnishings, intumescent paints

(list taken from Hegger, Auch-Schwelk, Fuchs, Rosenkranz 2006 Construction Materials Manual: "Hazardous Substances" section by Alexander Rudolphi)

(2) enviroblock see www.masterblock.co.uk

(3) Floor paint, for sealing dusty concrete surfaces, a low VOC silicate masonry paint such as Volvox would be suitable <http://www.earthbornpaints.co.uk/products/silicate/index.htm#primer>

(4) Most additives will emit VOCs during the curing process. If applying a sealer or other coating to the floor, check that the curing compound is compatible with the floor finish. Also ensure there is sufficient ventilation during the curing process.

(5) Formaldehyde in construction materials: medium density fibreboard (MDF), hardboard, oriented Strand Board (OSB), particleboard and chipboard are all processed woods which often contain formaldehyde based resins as a binder or adhesive. Formaldehyde is considered a probable carcinogen even at low exposure levels. Exterior grade particleboard is manufactured from phenol resin; interior grade particle board is manufactured using urea-formaldehyde which is 10 times more toxic than phenol resin. However pure phenol formaldehyde is poisonous. Formaldehyde free versions of all of these products are available and should be specified.

Relatively small doses of formaldehyde can lead to irritation of the eyes, a dry throat and sleeping problems. They can also trigger allergies. Board materials containing formaldehydes will offgas slowly over several years. According to the World Health Organisation, there is sufficient evidence in humans (and animals) for the carcinogenicity of formaldehyde < <http://monographs.iarc.fr/ENG/Monographs/vol88/volume88.pdf>>

Most countries have set recommended limits for formaldehyde in the indoor air. Germany, Canada and the Netherlands set the level at 0.1ppm, Other countries vary from targets of 0.05 to 0.4ppm. In the UK, the HSE seems to be mainly concerned with the effects of urea-formaldehyde in cavity walls. We could find no evidence in the UK of statutory controls on formaldehyde emissions for the indoor climate < <http://www.hse.gov.uk/lau/lacs/37-9.htm>>

For a full breakdown of the guidelines for different countries, see Aldehydes by Thad Godish Ph.D, C.I.H. in Chapter 32 of Indoor Air Quality handbook, John Spengler, Jonathan Samet, John McCarthy, 2000.

See also: Breyse, P.A. 1984. Formaldehyde levels and accompanying systems associated with individuals residing in over 1000 conventional and mobile homes in the state of Washington in Berglund, B., T.Lindvall and J.Sundell (Eds). Indoor Air: Sensory and Hyperreactivity Reactions in Sick Buildings, Vol. 3, pp.403-408. Stockholm: Swedish Council for Building Research.

(6) Medite Ecologique is made from zero added formaldehyde giving a finished product which complies with the German directive of less than 0.1ppm. See http://www.medite-europe.com/en/products_ecologique.php

(7) The manufacture of the chemical PVC produces many toxic byproducts, including dioxins, polychlorinated biphenyls (PCBs), and organochlorines. Dioxins are also released when PVC is burnt. Increasingly PVC is becoming restricted. Countries such as Germany, Austria, Japan, the Netherlands, Norway, Sweden, and Denmark have PVC restrictions in place. Low and Zero VOC adhesives are available and some styles can be loose laid, but the product is best avoided.

See Ross Spiegel and Dru Meadows. Green Building Materials. A Guide to Product Selection and Specification. 2006.

USA Environmental Protection Agency website item on PVC <http://www.epa.gov/ttn/atw/hlthef/vinylchl.html>

Also see a good summary of the main problems areas of PVC at the NGS website < <http://www.greenspec.co.uk/html/design/pvcproblem.html>>

(8) Hodgson, A.T. 1998. Draft Final Report. Sacramento, CA: California Air Resources Board

(9) website contacts for flooring products:

linoleum <<http://www.forbo-flooring.co.uk>>,

rubber <<http://www.nora.com>><<http://www.ryburnrubber.co.uk>><

<http://www.berleburger.de/en>>,

cork <<http://www.corkfactory.com>><<http://www.apcork.co.uk/default.htm>

><http://www.siestacorktile.com/>

(10) Visqueen make Zedex CPT which is a co-polymer thermoplastic which does not contain pitch, bitumen or PVC http://www.visqueenbuilding.co.uk/product_detail.asp?id=49&sid=142

(11) Most standard paints contain petroleum derivatives. Titanium dioxide is commonly used as a white pigment, according to NIOSH, titanium dioxide may cause lung fibrosis and is considered an occupational carcinogen. Paint products contain a variety of VOCs some of which do not dissipate for many months after application. 'Low odour' paints may have reduced VOCs but they can still give off harmful formaldehyde and acrolin. Even natural paints may emit natural VOCs.

As a guide, for general interior and exterior applications, specify water based latex based primers and paints with no aromatic hydrocarbons and a VOC content less than 10 grams a litre. For high impact locations such as door frames, use water based high performance acrylics instead of solvent based paints.

Some paints are designed to have very low VOC and reduced Titanium dioxide and are considered an improvement on standard acrylic emulsions. See Natural Building Technologies trade emulsion <http://www.natural-building.co.uk>

(12) There is now available a wide range of natural pigment paints which do not use titanium dioxide. These range from limewashes and lime paints, natural silicate paints, plant oil and tree resin emulsions and linseed oils. The majority are solvent free although some products may use naturally derived solvents such as alcohol and orange oil. The following list of manufacturers and suppliers should be considered:

BIOFA Villa Natura paints <http://www.mikewye.co.uk> and <http://www.biofa.co.uk>

Holkham Linseed paints <http://www.holkhamlinseedpaints.co.uk>

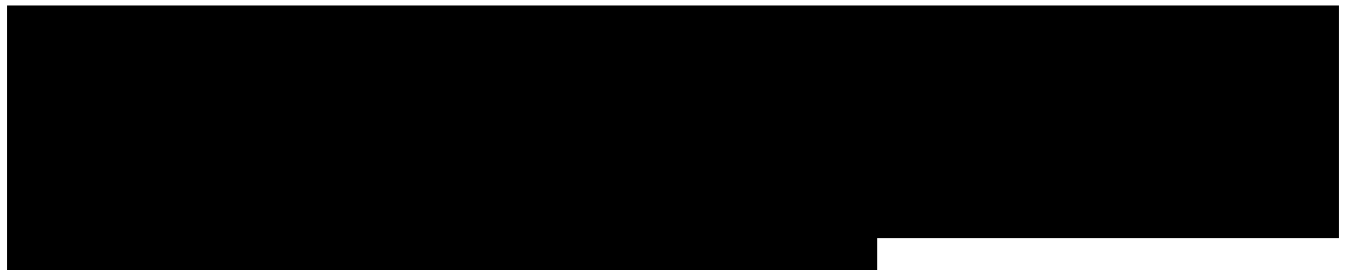
Auro <http://www.auro.co.uk>

The Danes use lime lye which bleaches and preserves the moisture regulating properties of wood. They also stock a variety of greener surface finishes such as varnishes, oils, and beeswax. <http://uk.faxelud.dk/>

Suppliers:

Womersleys Ltd stock Aglaia natural paints, Beeck mineral paints, Buxton limewash <http://www.womersleys.co.uk/acatalog/>

The Green Shop stock Earthborn clay paints, Stuart Furby's lime earth paints, Auro, Osmo and Holkham linseed paints <http://www.greenshop.co.uk>



(14) Flame Retardants: the World Wildlife Fund commissioned a study of 39 members of the European parliament. Blood samples were analysed for a total of 101 chemicals finding traces of DDT, PCBs; brominated flame retardants, phthalates and perfluorinated compounds (see < http://www.wwf.org.uk/news/n_0000001187.asp >)

The report, Chemical Check Up <<http://assets.panda.org/downloads/checkupmain.pdf>>

, released at a press conference in Strasbourg also revealed that:

- Every person tested is contaminated with a cocktail of bio-accumulative, toxic chemicals;
- 76 chemicals from the 101 looked for were found in the blood of those tested;
- the highest number of chemicals found in any one person was 54, while the median number of chemicals detected was 41;
- 13 chemicals were found in every single person tested. These include chemicals banned in Europe over twenty years ago, as well as chemicals in widespread use today such as phthalates and perfluorinated compounds;
- HBCD, another flame retardant used in expanded polystyrene foam, textiles and upholstery, was found in one person: the first time this chemical has ever been found in human blood as far as WWF is aware. The latest research from WWF can be obtained at < <http://www.wwf.org.uk/chemicals/science.asp> >

(15) Mastics: apart from linseed oil based putty and mastic, most tube extruded mastics are either plastic or bitumen based. The plastics usually contain polysulphide, silicone, polyurethane and various acrylic substances. Polyurethane mastics contain 10-60% phthalates. Plastics of polysulphide, polyurethane and polyacrylates contain chlorinated hydrocarbons or flame retardants. Sealants will continue to outgas throughout their life. When interior sealants are being specified avoid those containing butyl rubber, neoprene, styrene butadiene rubber and nitride. Also avoid sealants with aromatic solvents, formaldehyde, mercury, lead, chromium and their compounds. The following sealants are more acceptable for indoor use if they cannot be avoided: oleoresinous, acrylic emulsion latex, polysulfide (small amounts of toluene vapours) and silicone (small amounts of xylene and other solvents) (see also Ross Spiegel and Dru Meadows. Green Building Materials. A Guide to Product Selection and Specification. 2006)

(16) see NBT Thermoplan hollow clay blocks <http://www.natural-building.co.uk/thermoplan_ziegel_clay_blocks.htm>

(17) Wood Preservatives: organic wood preservatives contain pesticides and fungicides. Whilst substances like DDT, PCP, Dieldrin and Lindane are largely prohibited, waterborne preservatives which are commonly used in building construction, include chromated copper arsenate (CCA), ammoniacal copper quaternary (ACQ), ammoniacal copper zinc arsenate (ACZA), ammoniacal copper arsenate (ACA), copper azole, copper citrate, permethrin. Under EC legislation, CCA is now restricted in buildings other than housing. Our first choice should always be to avoid preservatives by good design and the selection of suitable timber species. CKB salts (copper, chromium, boron) are used as preservatives in this country but are not allowed in Scandinavia. A typical product contains 31% copper sulphate; 1% copper oxide; 25% boric acid with Sodium dichromate used as a fixing aid. It is described as hazardous with the warnings "Harmful when brought into contact with the skin; toxic if swallowed; very toxic if inhaled; causes burns; irritates respiratory organs"

Where preservative is required then consider Boron based compounds, although treatment can only be carried out on green timber with a moisture content with a moisture content of over 50%. Other treatments are available see Visor Wood, they use a product made from sugarcane <http://www.kebonyproducts.com/>
Wood Polymer Technologies describe in English the Visorwood process which carries the Nordic Swan ecolabel for "durable wood" <http://www2.wpt.no/index.cfm>

For alternative products see <http://www.greenspec.co.uk/html/product-pages/probor.php>
Also see pages 433 -440 of Bjorn Berge, Ecology of Building Materials, 2000

(18) See W. Gene Tucker, Ph.D. Volatile Organic Compounds in Chapter 31 of Indoor Air Quality handbook, John Spengler, Jonathan Samet, John McCarthy, 2000

(19) Egger UK make what is described as an OSB with a formaldehyde free binder (E1 less than 0.03ppm). It is called Eurostrand OSB 4 Top, however it does use a polyurethane binder. See http://www.egger.co.uk/co-uk-eng/egger-co-uk-products-flooring-boards_9734.htm
Kunz, the German firm, used to make 'Plysoc' which was marketed as a formaldehyde free particleboard. This is no longer stocked in the UK. In Germany it is marketed under the trade name of 'LivingBoard' and comes in two varieties 'face' and 'classic'. It is described as a wood based panel and looks more like OSB than particleboard, but it is formaldehyde free. Contact details as follows: Jürgen Iber, Gebietsverkaufsleiter
Tel. : +49 (0) 7972 69145 email : juergen.iber@pfleiderer.com
<http://www.pfleiderer.com>

(20) Clay boards can be sourced from NBT at < <http://www.natural-building.co.uk/> > or Construction Resources at < <http://constructionresources.com/default.asp> > Fermacell board material at < http://www.fermacell.co.uk/specifier_home.html >

(21) Polystyrene is manufactured by the polymerization of styrene, creating expanded polystyrene (EPS) and extruded polystyrene (XPS). The finished product can have some unstable residues of monomers of styrene which may outgas. XPS, can also release small amounts of chlorofluorocarbons. When burnt, toxic fumes are given off. Also see page 152 of Bjorn Berge, Ecology of Building Materials, 2000

(22) Exposure to styrene will occur from breathing indoor air contaminated with styrene vapours from building materials, tobacco smoke and consumer products, like prepackaged food containers. Breathing styrene can affect the nervous system, and breathing high levels of styrene can lead to depression, concentration problems, tiredness and nausea. For more information see < <http://www.atsdr.cdc.gov/tfacts53.html> >

(23) Hygroscopic insulants tend to be made from natural materials. Depending on the qualities of the material, further chemicals may be included in the finished product. Flame retardants are used in most of the products apart from wood fibre insulants. The following is a selection of some of these hygroscopic insulants:

Wood Fibre and cellulose based Insulants

Termotra make a wood fibre insulation that is blown into cavities, but requires to be dried. We understand that the flame retardant is ammonium sulphate <http://www.termotra.se/>

Thermocell make a wood fibre insulation that can be blown dry, uses Ammonium Sulphate rather than Boron as a flame retardant. <http://www.thermocell.dk/>

Vital Insulation batts (Vital 040) made from wood pulp and wood fibres, using a cellulose glue. Contains pH neutral boron as protection against rot and fire. <http://www.vitalfinland.fi>
<http://www.constructionresources.com/>

Homatherm produce a number of wood fibre products, HolzFlex Mais is a flexible wood fibre insulation batt which uses ammonium sulphate as a flame retardant.

Homatherm also make a cellulose batt insulation from recycled newspaper and recycled jute sacking called flexCL 040. Uses boric acid as a flame retardant and Ammonium Sulphate as a hydrating agent. < <http://www.homatherm.com/>>

<http://www.constructionresources.com/>

Gutex wood fibre insulation boards. These products are also marketed by Construction resources under the name of Thermosafe and Thermowall <http://www.gutex.de/en/index.html>
<http://www.constructionresources.com/>

Blown, sprayed or loose cellulose fibre is available and is treated with boron based fire retardants. Warmcell 100 is made in the UK and available from <http://www.naturalbuilding.co.uk/>
<http://www.naturalinsulations.co.uk/>

Termex cellulose insulation is a Finnish product <http://www.termex.fi/>

Hemp and recycled products

Steico make a flexible hemp insulation batt called Steico canaflex and uses ammonium phosphate as a retardant. They also make a wood fibre insulation called Steicoflex. <http://www.steico.de/index.php?start=02>

Isonat is a hemp insulant mixed with recycled cotton fibres, treated with fire retardant.

Thermohemp is an all hemp insulant with sodium bicarbonate acting as the flame retardant

Wool Insulants

Thermafleece is treated with borax and a 'natural fire proofing agent'. The wool is from UK sheep. Available from Second Nature <http://www.secondnatureuk.com/>

You can also use New Zealand wool (preferably if you live in New Zealand) otherwise their website gives the fact that wool also absorbs formaldehyde, see <http://www.woolbloc.co.nz/index.htm>

(24) Ilonka A, TM Meerts, JJ van Zanden, EAC Luijks, I van Leeuwen-Bol, G Marsh, E Jakobsson, Å Bergman and A Brouwer. 2000. Potent Competitive Interactions of Some Brominated Flame Retardants and Related Compounds with Human Transthyretin in Vitro. *Toxicological Sciences* 56: 95-104. To quote from the report:

"The results presented in this study clearly demonstrate for the first time that hydroxylated brominated flame retardants of several different classes are able to bind to human transthyretin in vitro, some with extremely high potency, e.g., TBBPA and PBP. This is an important finding, as brominated flame retardants are used extensively at present for a large variety of applications and can be detected in wildlife and humans. The results of this paper thus indicate the possible capability of a large group of particularly brominated industrial chemicals to interfere with and potentially disrupt the thyroid hormone transport and metabolism."

See <http://www.ourstolenfuture.org/NewScience/behavior/2000ilonkaetal.htm>

(25) TBS Elastomers make 'ecoseal EP' roofing membranes which use thermoplastic polypropylene, see <http://www.tbselastomers.com/>

Firestone make 'Ultraply TPO' which is a thermoplastic polyolefin, see http://www.firestonebpe.com/roofing/ultraply/_en/

(26) see section on acoustical ceilings, page 225 from Ross Spiegel and Dru Meadows. *Green Building Materials. A Guide to Product Selection and Specification*. 2006

(27) Foamed glass board insulation is made from crushed glass and carbon and has a high compressive strength < <http://www.foamglas.co.uk/>>

Wood fibre boards are made by a number of companies, see < <http://www.pavatex.de/>> and < <http://www.steico.com/>>

(28) LSHF electrical cable is insulated with polyolefine insulation, is halogen free and low smoke under fire conditions so does not produce toxic fumes like PVC. See < <http://www.cse-distributors.co.uk/cable/2491B-6701B.htm>>

(29) Traditionally, treatment of dry rot (over the last 30 years at least) has necessitated the cutting back of all infected timber by about 1 metre (although BRE suggests a margin of approximately 400mm is in fact satisfactory). The affected walling is normally irrigated at closely spaced intervals and chemicals injected. Some phenolic solutions can migrate to the internal wall surface resulting in crystals of pentachlorophenol. These can dry in the air and cause a health hazard. Sometimes a 'toxic box' is formed around the infected area. However it is difficult to ensure that the fungal spores are contained only within this box. From an ecological viewpoint, the unnecessary use of chemicals should be avoided.

The Danes have developed a heat treatment system to eradicate dry rot. It is not suitable for wet rot. The complete building is enclosed in a covered scaffolding and hot air blowers applied. This exposes any infested construction (masonry and timber) to a temperature of 50°C for a period of 16 hours. This will kill off any dormant dry rot spores hidden within the structure. The advantage of this process is that the whole building is treated and not simply those areas identified under survey. Also no chemicals are used and since the building is dried out, the risk of providing damp conditions for new timbers is avoided, reducing the need for further preservation. Heat treatment of dry rot is carried out in Denmark, Norway and Germany (see < <http://cordis.europa.eu/itt/itt-en/01-2/innov02.htm>>

In the UK, contact < http://www.thermolignum.com/Rot_Eradication.html>

Also Research paper by David Watt, Belinda Colston and Duncan Spalding: Assessing the impact of chemical treatments on the health of buildings and their occupants. December 2000 Vol 3 No13, Centre of Conservation Studies, School of Architecture, De Montfort University. < http://www.rics.org/NR/rdonlyres/35B81AFF-1030-4ACA-9DDF-12897DB0661E/0/assessing_the_impact_of_chemical_treatments_on_the_health_of_buildings_20001201.pdf>

(30) Rothounds from Hutton and Rostron Environmental Investigations Ltd < <http://www.handr.co.uk/rothounds.htm>>

(31) Boron and Boron rods and paste comes in many forms. See < http://www.dryrot.biz/treat_decay_diydoc.htm>

(32) Natural Building Technologies provide a wood fibre board for internal use. However not every external wall will be suitable. Any walls should already be dry and vapour permeable. The existing stone wall is initially made flat with a clay render, then the woodfibre board is directly fixed to the wall and then finished with a lime render. It is not suitable for basement conditions or in areas of high exposure. (NBT also supply a range of wood fibre boards for a variety of purposes) See < www.natural-building.co.uk>

(33) Hardwood flooring is available from Scottish forests. The Association of hardwood Sawmillers have an excellent website locating the main suppliers < http://www.ashs.co.uk/PageAccess_id_34.htm>

(34) Natural vegetable oils can be used to protect light coloured floors. The oil provides a liquid and dirt resistant surface, but the wood is still allowed to breath, see Faxel A/S at < <http://uk.faxelud.dk/Default.asp?Action=Details&Item=221>>

See also note (12) for a list of suppliers who also stock wax floor products.

(35) VOC emissions from taping compounds and the plasterboard can be minimised when they are encapsulated with paint. See page 223 from Ross Spiegel and Dru Meadows. Green Building Materials. A Guide to Product Selection and Specification. 2006

(36) Living Roofs is an independent organisation giving advice and information on green roofs <http://www.livingroofs.org/index.html>

Also see

<http://www.mclawroofing.co.uk/prod-green.html>

<http://www.greengridroofs.com/>

<http://www.bauder.co.uk/data/usercontentroot/systems/Green%20Roof%20Systems/default.asp>

(37) A study of 51 renovated German homes found, 2 years after renovation, that a number of “new” VOCs were being released, including longifolene, phenoxyethanol and butyldiglycolacetate. These compounds, instead of being released in large quantities shortly following application of the surface coating, were emitted in smaller quantities at first but continued to be released at a steady rate over much longer periods of time.

From Lance A. Wallace Ph.D. Assessing Human Exposure to Volatile Organic Compounds. Chapter 33 of Indoor Air Quality handbook, John Spengler, Jonathan Samet, John McCarthy, 2000. The German study is from Reitzig, M. et al: Voc emissions after building renovations: Traditional and less common indoor air contaminants, potential sources, and reported health complaints. 1998

(38) Alternative floor coverings to vinyl:

Rubber Flooring: <http://www.nora.com/>, <http://www.ryburnrubber.co.uk/>

<http://www.berleburger.de/en>

Linoleum: <http://www.forbo-flooring.co.uk>

Cork: <http://www.corkfactory.com/>, <http://www.apcork.co.uk/default.htm>

<http://www.siestacorktile.com/>

(39) At the time of writing, we have been unable to fully clarify the environmental and health risk of using Boron. Bjorn Berge has advised that “boric salt and borax are both looked at as a bad environmental choice by Norwegian authorities. This does not mean that they are illegal, but there is an effort to remove them from the industrial material-cycles. Also they are placed on the OBS-list (250 substances dangerous to environment and health to give special attention) (see Norwegian Pollution Control Authority at www.sft.no) The Swan-mark (the scandinavian alternative to Nature plus) are completely banning products with boron”

(40) See Ivor Davies, Bruce walker, James Pendlebury: Timber Cladding in Scotland; Arca 2002

(41) British Gypsum make “gyproc cove adhesive” for fixing plaster coves. See < http://www.british-gypsum.bpb.co.uk/products/plasterboard___accessories/gyproc_decorative_products/gyproc_cove_adhesive.aspx>

(42) Water based flame retardants are available from a number of manufacturers. We cannot vouch for their chemical contents. See < <http://www.bollomfireprotection.co.uk/index.html>>

< <http://www.albicoatings.co.uk/index.php>>

(43) Clay plasters can be obtained from a number of suppliers:

Tierrafino plasters tend to be smooth and come in a range of colours< <http://www.tierrafino.com/>>

Claytec base and finish clay plasters from NBT at < <http://www.natural-building.co.uk/>>

For Lime and clay products, contact the Scottish Lime Centre at < <http://www.scotlime.org/>>, also Masons Mortar at < <http://www.masonsmortar.co.uk/>>

(44) LECA (lightweight Expanded Clay Aggregate) is available from Claytec at < http://www.claytek.co.uk/leca_home.htm>

Also foamed cellular glass aggregate is available with the trade name “Hasopor” from < <http://www.hasopor.com/>>

(45) GGBS or Ground Granulated Blastfurnace Slag is available from most concrete suppliers, or directly from “Civil and Marine” (a Hanson Company) at <www.civilandmarine.co.uk> The Quarry Products Association has more information on slag and it’s uses, see < http://www.qpa.org/prod_slag01.htm>

(46) Self finished polished floors. See 'superfloor' as laid in the Kelvingrove museum by Clyde Valley Drilling < <http://www.cvd ltd.co.uk/surfaceprep/htcsuperfloor.htm>>
Also Contech UK at < <http://contechuk.co.uk/index.htm>>

(47) Gypsum based self levelling screed, made by Lafarge Gyvlon < <http://www.gyvlon-floors.co.uk/>>

(48) Mill finish aluminium gutters, available from Alumasc at < <http://www.alumasc-exterior.co.uk/rainwater/Systems.aspx?systemid=4§ion=finishes>>
And from Marley at <<http://www.marleyalutec.co.uk/>>

(49) Geotextile membrane such as "Lotrac" are available from Don and Low in Angus, see < <http://www.lotrak.com/>>

(50) Dense deafening or 'pugging' may be of the following types –
Traditional ash (usually 75 mm); 2-10 mm limestone chips (60 mm) also comes bagged with the trade name "quietex", available in 1 ton pallets from Shierglas Quarry, Blair Atholl PH16 5LL tel 01796 481325; 2-10 mm whin aggregate (60 mm); or dry sand (50 mm).

(51) Whilst sheet vinyl itself does offgas formaldehyde slightly (<8-30 μ g/h)/m² it emits less than particleboard (1-400), plywood (5-1,000), wood veneers (10-12,000). Information from: Volatile Organic Compounds by Gene Tucker Ph.D, in Chapter 31 of Indoor Air Quality handbook, John Spengler, Jonathan Samet, John McCarthy, 2000.

(52) HOMATHERM flexCL 040 is a batt insulation made from cellulose and recycled jute sacking. It can be used in cavity wall construction provided the cavity is ventilated. See Construction resources < <http://www.constructionresources.com/default.asp>>

(53) For the effect of brain development on mice, see: Viberg, H., et al., 2004, Environmental Toxicology and Pharmacology, Vol 17, Issue 2, pp61-65

(54) For flame retardants in sediment see: Kierkegaard, A. et al., 2004, Environmental Science & Technology, Vol 38, Issue 12, pp3247-3253

(55) For flame retardants in british birds see: ENDS report 349, Feb 2004, pp14-15.

(56) The author finds that simple nailing of skirtings and facings is often easier to dismantle than screwing, as screws can rust and screw heads become blocked with filler and paint making dismantling difficult. Floorboards if tongued and grooved will invariably be damaged unless they are screwed or secured by countersunk timber straps.

(57) Holzweg floor adhesive is a natural resin and latex adhesive for glueing cork tiles, linoleum and carpeting onto floor surfaces such as cement screed (but unsuitable for epoxy-resin screeds) see Construction Resources <http://www.constructionresources.com/>

(58) For more information on the appropriate conditions for asthma see: Howieson, Stirling., 2005 Housing and Asthma, Spon Press