Design for Deconstruction

SEDA Design Guides for Scotland : No. 1

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SCOTTISH EXECUTIVE

SEDA

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1 Introduction

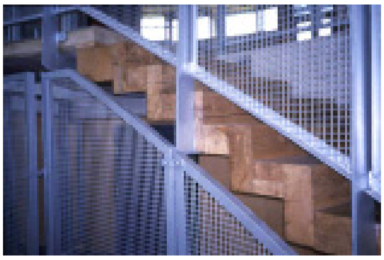
Each year it is estimated that 72.5 million tonnes of construction and demolition waste is created in the UK. This costs the UK's construction industry around £193 million each year in landfill tax, excluding disposal charges.

Construction and Demolition (C&D) waste has been estimated at 6.28 million tonnes for Scotland. That works out at well over one tonne of rubble per person. Of this, 2.31 million tonnes. (36.7%) was recovered or recycled, with an estimated 1.36 million tonnes (21.7%) sent for recovery at exempt sites and 2.62 million tonnes (41.6%) sent to landfill[1] .

Unnecessary construction waste can be prevented through re-use.
Source: F. Stevenson

Scotland is therefore still dumping well over a third of all its Construction and Demolition waste when most of its landfill sites are now full, and at a time when it is using nearly three times the amount of resources that the earth can sustain for a country this size[2] . Materials and waste are Scotland's "biggest hitter" when it come to Scotland's ecological footprint[3] , accounting for 38% of it, with food (29%) and energy (18%) following well behind.

Recycling only partially addresses the construction waste problem, because it can use up considerable resources in re-processing and transportation. Only a fraction of construction elements are actually reclaimed and reused for their original purpose, despite this often being the best environmental option at a local level. The Scottish Ecological Design Association (SEDA) has commissioned this Guide (the first of its kind in the UK), to help address the above problem and provide practical guidance on how to reduce construction waste at source.



Re-used railway sleepers forming new stairs.
Source: F. Stevenson

Designing details for deconstruction at the start of a project enables one building, at the end of its useful lifespan, to be the resource for the next and helps "close the loop" for resource use. It also designs out future risk and cost by ensuring that building elements and products can be quickly and easily maintained and replaced. This is particularly important if they become unacceptable under future environmental legislation, which is an increasingly common occurrence. Detailing for deconstruction makes any property more attractive as an investment opportunity.

The general guidance here is firmly focused on the idea of practical reuse, and should be read in conjunction with other guidance on sustainable design[4] , deconstruction[5] and recycling[6] where necessary to provide an overall design framework[7] . The details provided have been fully costed, tested and subjected to a Defects Liability insurance assessment. They are offered as viable alternatives to standard details, and illustrate the possibilities that exist for re-use. It simply remains for you, the reader, to apply them appropriately in the context of your next project…

Footnotes:

[1] Figures are for 2001 in Priority Waste Stream Report on Construction and Demolition Waste, The National Waste Plan, SEPA, 2003

[2] Scotland's Footprint, 2004, Best Foot Forward. http://www.scotlands-footprint.com/

[3] An ecological footprint is an estimate of the land and sea area needed to provide all the energy, water, transport, food and materials that we consume.

[4] See for example Communities Scotland's "Sustainable Housing Design Guide for Scotland", 2000 and www.greenspec.co.uk, for guidance on design and specification.

[5] See for example CIRIA's guide 607: "Principles for Designing for Deconstruction", 2004

[6] Again, both BRE (Building Research Establishment) and CIRIA (Construction Industry Research and Information Association) have produced well developed guidance on waste minimisation and recycling in a number of texts.

7 See Halliday, S: "Green Guide to the Architects Job Book", 2000, RIBA for a good overview of when to implement sustainable design principles during the procurement

2 The Context

Key Principles

1. Promote "upstream" solutions which treat causes of construction waste and avoid "end of pipe" solutions which only treat the symptoms.

2. Aim to design out construction waste in the first place, then re-use construction elements and only resort to recycling them if re-use cannot be achieved efficiently.

3. Follow the five key principles promoted by the EU: the proximity principle; regional self sufficiency; the precautionary principle; the polluter pays; and best practicable environmental option (BPEO).

4. Aim to demonstrate a cost saving through the use of reclaimed materials, where possible, taking all costs into account[1] including storage and double handling.

2.1 Aims of this Guide

- To highlight benefits of deconstruction which can minimise construction waste, cost, aid the local economy, reduce transport (if done on regional basis), reduce CO_2 emissions by avoiding new materials, retain cultural value of existing materials and reduce demand on natural and virgin resources, thus minimising pollution
- To promote "upstream" solutions which treat the causes of construction waste and avoid "end of pipe" solutions which only treat the symptoms
- To promote Design and Detailing for Deconstruction as everyday activity in the construction industry

Obtain re-used materials locally in order to reduce transportation impacts.
Source: F. Stevenson

2.2 Target audience

This Guide will help all those who wish to improve the resource efficiency of buildings through their construction, e.g:

- clients –building owners and users,
- principal and specialist contractors,
- interior designers
- architects
- technicians
- structural engineers
- building service engineers
- building surveyors
- quantity surveyors/ cost consultants
- maintenance and facilities managers
- project managers
- planning officers
- building control officers
- funding bodies and their professional advisors
- government agencies,
- Non-governmental organisations

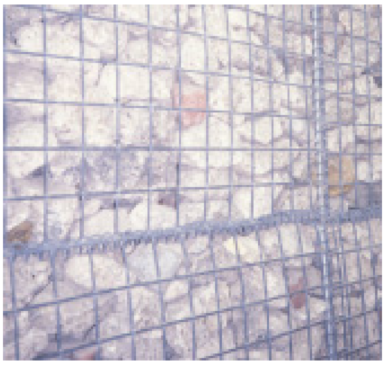
2.3 How to use this Guide

This Guide is divided into six sections. The first three sections provide an overview of resource efficiency. While sections Four and Five describe the approach and principles involved in designing for deconstruction.

Section Six provides a number of key details which have been optimised in terms of deconstruction. These are compared with standard details for a variety of construction types, and costed. This section will be primarily of interest to the design team. It should always be read in conjunction with sections Four and Five, as the details cannot be simply "lifted" from this Guide; they must be placed in a suitable context.

At the end of this Guide there is an annotated list for further reading, as well as a list of useful contacts and websites.

Architectural salvage yards provide a variety of reclamed building materials.
Source: F. Stevenson



Gabions enable low grade materials to be recycled, but check that wiring will last.
Source: F. Stevenson

Waste concrete aggregate can be recycled and re-used in numerous ways.
Source: F. Stevenson

2.4 Scope and definitions

This guide focuses on the design for deconstruction (DfD) of building projects which are based on Scottish building practice and climate for appropriate detailing.

Deconstruction: the dismantling of a building in such a manner that its component parts can be re-used.

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.

Upcycling: taking a low grade material and turning it into a high grade material, often using human energy.

Downcycling: taking a high grade material and turning into a low grade material, often using fuel energy.

2.5 The economics of deconstruction

From the clients' point of view the following are sound economic reasons for using DfD[8]:

- to increase the flexible use and adaptation of property at minimal future cost
- to reduce the whole-life environmental impact of a project
- to maximise the value of a building, or its elements, when it is only required for a short time
- to reduce the quantity of materials going to landfill

Footnotes:
[8]Costs for deconstruction should always be calculated on a whole life basis, including demolition and the necessary "future-proofing" for the potential upgrading of any building

- to reduce a future liability to pay higher landfill taxes
- to reduce the risk of financial penalties in the future, due to changing legislation, through easily replaceable building elements
- to minimise maintenance and upgrading costs incurred by replacement requirements

A key economic benefit of design for deconstruction is the ability for a client to "future proof" their building, both in terms of maintenance and any necessary upgrading, with minimum disruption and cost. The wider economic benefits to society include minimising waste costs at all levels.

Numerous projects have been costed, and while some have come in on budget[9], others have not. Much depends on the canniness of the design team and contractor, from the outset, with cost savings to be viewed as bonus rather than a given. Design for deconstruction should always be adopted for its wider economic, social and environmental benefits rather than any initial cost saving[10].

In terms of using reclaimed materials, it is important that the cost of using virgin products and materials, as well as their transportation and disposal costs are offset against the cost of the reclaimed materials and any additional labour cost for installing these. It *may* then be possible when all costs are taken into account, to make a cost saving[11] through the use of reclaimed materials, although this is not usually the cheapest option.

Current economic barriers to design for deconstruction and re-use of reclaimed materials and products include: the additional time involved for deconstruction and the difficulty of costing this against re-used materials which will be used on a different project, the damage caused by poorly designed assemblies and connectors as well as the limited flexibility of reclaimed elements. Reuse is not subsidised in the same way that manufacture is in terms of energy, infrastructure, transportation, and economies of scale, all of which have hidden environmental costs.

Although the reclamation of construction materials and products can represent up to 40% of some demolition companies' revenues[12], the problems of storage and double handling materials between sites can increase the cost of re-use considerably. The ideal use of reclaimed materials is either on the same site, or one very near by, to avoid excessive transport costs.

Poorly detailed connectors can prevent effective re-use of timber.
Source: F. Stevenson

There was no additional cost for recycling or re-use in the BRE Office of the Future.
Source: F. Stevenson

Using reclaimed timber at BedZed, made an overall cost saving.
Source: F Stevenson

Footnotes:

9 BRE's Office for the Future is an example of reuse and recycling with no additional cost overall on the contract, as detailed in Hobbs, G and Collins, R (1997) Information Paper 3/97: "Demonstration of reuse and recycling of materials: BRE energy efficient office of the future", BRE, Watford

10 The CIB Task Group 39 has spent several years considering this and produced a number of conference proceedings relating to Deconstruction and Material Use: http//www/cce.ufl.edu/affiliations/cib

11 A good case in point is the BedZed project in England where the use of reclaimed timber made an overall cost saving. See "Building For a Future", Vol 13, No.4, p.61.

12 See Sassi, P (2002)

2.6 Responsibilities, roles and principles

Under the Environment Act 1995, The Scottish Environment Protection Agency (SEPA) is responsible for national waste regulation and strategy in Scotland. Domestic waste collection and disposal remain the responsibility of the local authorities while commercial/industrial waste is the responsibility of the producer. Planning authorities are obliged to consult SEPA on development plans to forge a relationship between development plans and the waste strategy.

Waste hierarchy

The waste hierarchy adopted by SEPA [13] encourages the adoption of options for managing waste in the following order of priority:

1. Waste should be prevented or reduced at source as far as possible;
2. Where waste cannot be prevented, waste materials or products should be reused directly, or refurbished before reuse;
3. Waste materials should then be recycled or reprocessed into a form that allows them to be reclaimed as a secondary raw material;
4. Where useful secondary materials cannot be reclaimed, the energy content of waste should be recovered and used as a substitute for non-renewable energy resources;
5. Only if waste cannot be prevented, reclaimed or recovered, it should be disposed of into the environment by landfilling, and this should only be undertaken in a controlled manner.

Construction waste management should move increasingly towards the first of these options, using a framework governed by five key principles promoted by the EU:

- the proximity principle;
- regional self sufficiency;
- the precautionary principle;
- the polluter pays; and
- best practicable environmental option (BPEO).

Clearly, reuse of building elements should take priority over their recycling, wherever practicable, to help satisfy the first priority of waste prevention *at source*.

Reuse of building elements should take priority over their recycling where practical.Source: Edward Cullinan Architects

Proximity and self-sufficiency

The proximity and self-sufficiency principles require waste to be dealt with as close as possible to where it is produced.

Precautionary principle

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. In practice it has proved notoriously difficult to implement this principle.

Footnotes:

13 SEPA, The National Waste Plan, 2003

Polluter pays

The ‘polluter pays’ principle requires producers of construction waste to bear the costs imposed by those wastes. The current Landfill Tax reflects some of these costs, but there is still no direct relationship between manufacturing costs and disposal costs for construction products and materials.

Re-using materials and products cuts out pollution produced by manufacturing processes.
Source: F. Stevenson

Best practicable environmental option

For any given set of objectives, BPEO identifies the option that provides the most benefits or the least damage to the environment as a whole, at acceptable cost, in the long term and the short term. Thus construction waste must be evaluated in terms of environmental, social and economic consequences.

Scottish building regulations and standards

The consideration of recycling is now a part of the Scottish Building Regulations[14] although there are no actual requirements in place to date. As such these regulations do little to promote design for deconstruction in themselves, but neither do they particularly hinder matters. It is the British Standards and European Codes which largely dictate whether or not reclaimed materials can be specified easily. To date there is no code for reclaimed materials, although there is now a code for recycled building aggregates.

Footnotes:

[14] The Building Act 2003 (Scotland)

3 Building Resource Efficiency

Key Principles

1. Resource efficiency is an ecological issue – the rates of use of any material must be sustainable and aim to maintain diversity in design and supply.

2. Aim to minimise waste by designing elements for maximum diversity of options when re-used.

3. Know Your Place – nothing can replace intimate "local knowledge" in relation to designing for a particular place. Avoid monocultural deconstruction solutions for different sites – each site is unique in terms of climate and resources.

4. Aim to minimise waste by increasing the number of times a construction element can be re-used.

5. Minimise transportation by allowing building to be fully adaptable with the minimum use of new resources. Avoid excessive transportation of materials.

6. Prefabrication maybe cost effective, but don't forget the external pollution costs associated with transportation – aim for local prefabrication wherever possible close to the site.

3.1 Local knowledge

Reducing waste is the main aim of this guide. There is little point in advocating DfD to reduce waste, however, without full consideration of the sustainable design, wider waste reduction and ecological resource issues relating to place.

Ideally, the designer should be knowledgeable about the local region and ecology relating to the site, as well as understanding where the more remote construction materials are coming from, and what the ecological impacts of design decisions are on both a local and global scale.

Ideally the designer should be knowledgeable about the local region - each one is unique.
Source: F. Stevenson

3.2 Natural and recycled resources

All resources have an initial natural *source, a rate* of extraction, and a natural *sink*, where unusable waste finally rests. A key consideration is to ensure that our rate of extracting materials is not greater than the earth can naturally assimilate in any one place at any given time.

DfD should aim to reduce the rate of extraction of the construction materials by maximising the re-use of construction elements. This means "future-proofing" against waste and pollution as far as possible by considering future scenarios for building use. As DfD matures material cycles will be become more closed with waste products playing more and more of a role in the overall resourcing of construction materials.

Energy Requirements for manufacturing and / or Producing Selected Building Materials

Material	kWh/tonne	kWh/m^3
1. Fletton bricks	175	300
2. Non-fletton bricks	860	1,462
3. Engineering bricks	1,120	2,016
4. Clay tiles	800	1,520
5. Concrete tiles	300	630
6. Local stone tiles	200	450
7. Local slates	200	540
8. Single layer roof membrane	45,000	47,000
9. Concrete 1:3:6	275	600
10. Concrete 1:2:4	360	800
11. Lightweight blocks	500	600
12. Autoclaved blocks	1,300	800
13. Natural sand/aggregate	30	45
14. Crushed granite aggregate	100	150
15. Lightweight aggregate	500	300
16. Cement	2,200	2,860
17. Sand/cement render	277	400
18. Plaster/plasterboard	890	900
19. Steel	13,200	103,000
20. Copper	15,000	133,000
21. Aluminium	27,000	75,600
22. Timber (imported softwood)	1,450	754
23. Timber (local airdried)	200	110
24. Timber (local greenoak)	200	220
25. Glass	9,200	23,000
26. Plastics	45,000	47,000
27. Plastic insulation		1,125
28. Mineral wool		230
29. Cellulose insulation		133
30. Woodwool (loose)		900

Source: Pat Borer, Centre for Alternative Technology

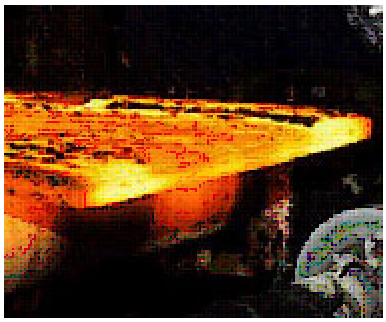
3.3 Energy

Embodied energy costs are a rough indicator of how much energy materials are using in DfD. Generally, the less energy used in the production of construction elements, the less impact there is on the environment.

It is often assumed that recycling construction products is just as energy efficient as re-using them, when this is in fact seldom the case. Recycling invariably involves re-processing, which in turn involves transport and manufacturing energy costs. A re-used element usually has virtually no embodied energy costs associated with re-processing, although transport needs careful consideration.

DfD can minimise energy costs by aiming to increase the number of times a construction element can be re-used without serious depreciation, loss of strength, rigidity and other factors associated with wear and tear. Durability has to be balanced against initial energy costs in manufacture and transport. Given that the re-use of building elements is highly unpredictable, it is still wise to always aim for low initial energy costs by using renewable materials where possible.

DfD can minimise waste by increasing the number of times an element can be re-used.
Source: N. Verow



Recycling is often not as energy efficient as re-using materials.
Source: F. Stevenson

3.4 Waste –closing the loop

An industrial ecosystem mimics a natural ecosystem through an interacting web of inputs, processes and wastes which “close the loop” by turning wastes back into resources. DfD can close the waste loop in two ways; firstly by re-using existing construction elements where practical and secondly by encouraging the designed elements to be re-used easily and locally. Ideally DfD should be contained as far as possible within a given regional area, to minimise transportation and maximise the local economy.

In Scotland, the landfill situation is now critical, with local authorities having to resort to transporting waste further and further afield or else burning it and releasing pollution into the air. There are a number of construction product reclamation sites in Scotland and the North of England[15] which should be scoured during the DfD process, if the design site is in Scotland.

3.5 Regionalism

Resources, energy, waste, transport and community are all interacting aspects of a regional approach to DfD. No aspect can be considered without thinking of the consequences for the other aspects on a local level. Bioregionalism takes this one step further by insisting on the inclusion of ecological aspects as well and recognising the differences between ecological systems in different regions.

Scotland can basically be divided into four broad regions, the North West, the North East, the South West and the South East, with the Central Belt region straddling between the North and South regions. Each region has its own unique “soft palette” of renewable, re-used, recycled and by-product construction materials which can be developed by working with other industries in the region. DfD can build on this by selecting from this palette. Visible re-use of certain locally made construction elements in appropriate locations within the building fabric can also preserve a deeper historic understanding of regional building construction practice.

DfD can help support communities in Scotland economically by keeping resource use and re-use as local as possible, thus retaining economic value within the region. For this purpose SEDA have helped to produce an information guide on local construction products and materials which are produced in Scotland[16].

Minimising transportation is key part of a successful DfD, given that we spend as much energy transporting our construction materials around the country as we do making them in the first place (see diagram over page).

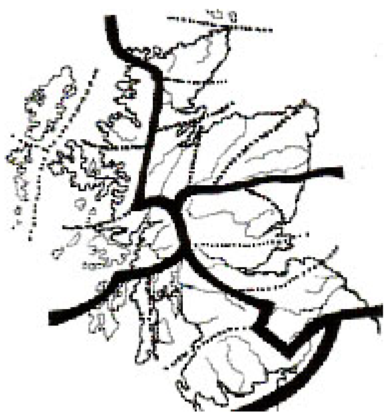
There are clear differences between reclamation and DfD practice in different parts of Scotland, which is a relatively unpopulated country. The majority of industry and population is concentrated in the Central Belt region from Glasgow through to Edinburgh. This region is well resourced for a locally derived DfD approach, with numerous salvage

Footnotes:
[15] See BRE’s excellent site on construction waste exchange: http://www.bremap.co.uk, for GIS information on reclamation sites in Scotland and http://salvomie.co.uk for information on availability of reclaimed products and materials.

Sheeps wool is highly renewable, re-usable, and has low energy costs.
Source: F. Stevenson

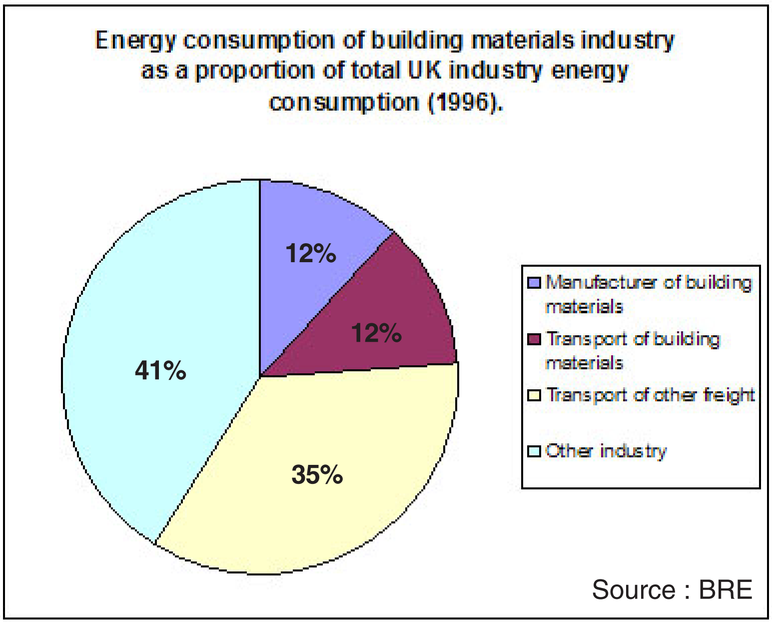
This natural wool product is biodegradable, healthy and as good as mineral wool for insulation.
Source: F. Stevenson

Dundee Contemporary Arts Centre. Visible re-use of existing local building fabric preserves historic understanding and maintaining a link with the past.
Source: N. Verow



Map showing 4 regions and sub bio-regions of Scotland based on rivers.
Source: Doug Aberlay

yards and manufacturers. It makes sense for design projects in the Central Belt to source and reclaim their construction products from within the region. Rurally, DfD may operate on a more hybrid basis with local renewable and reclaimed construction elements forming part of the "soft palette" complimented by elements obtained more remotely that can then be re-circulated within the region. For these more remote regions, transportation impacts will have to be carefully weighed against the advantages of importing re-used construction elements to the region.



Footnotes:

16 See www.sust.org and highlight the "Green Directory" or "Ecological Design Gateway" title to obtain an interactive database of indigenous Scottish construction materials and products.

4 Design Approach

Key Principles

1. Re-use and recycling are not interchangeable strategies; re-use is almost always environmentally preferable.

2. Design for maximum flexibility of spatial configuration within a structure, as this preserves the building as a whole.

3. Develop a comprehensive Deconstruction Plan early on - otherwise re-usable building elements may be destroyed unnecessarily.

4. Allow extra time from the beginning of the project to ensure that DfD is fully incorporated.

5. Aim to bring the whole project team and the client on board with the idea of DfD from the beginning of the project.

6. Audit contractors and ensure that initial briefing and training for DfD has taken place -this will pay dividends later on.

7. Carefully add all alterations to drawings and specifications so that there is an *integrated* set of "as built" drawings for maintenance and deconstruction purposes.

4.1 Strategy: re-use or recycle?

Re-use and recycling are not interchangeable strategies because design for re-use is almost always preferable to design for recycling only in terms of overall environmental impact, providing that transportation is not excessive, and that re-usable products are still recyclable at the end of their life.

Re-usable products should be recyclable at the end of their lifespan. Source: Zedcore.

When considering the brief for a new project as a designer, there is a natural hierarchy of waste minimisation to consider[17]:

1. adaptive re-use of existing building
2. design for adaptability and longevity of new buildings
3. re-use of building elements/assemblies
4. re-use of building components
5. recycling of materials
6. reclamation of energy from building elements, components or materials
7. landfill.

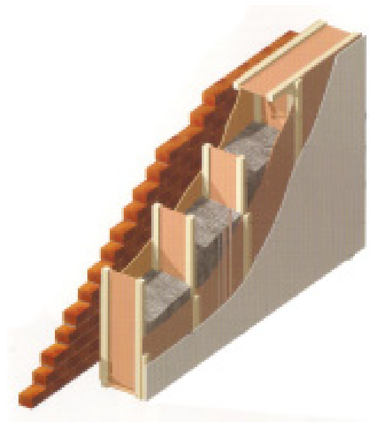
Design for deconstruction is most effective when it allows for maximum flexibility of spatial configuration within a given structure, as this preserves the building structure as a whole. Beyond this, designers need to think about "future-proofing" their details in such a way that maximises the possibilities for both building assemblies and their sub-components to be re-used in other buildings as far as practicable. Only if neither of these strategies is established as practical, following a cost-benefit analysis, should designers resort to a recycling-only strategy.

Design for deconstruction is most effective when it allows for maximum flexibility of spatial configuration. Source: F. Stevenson

Footnotes:
[17] This hierarchy is based on the EU waste hierarchy described in section 2

Building elements, such as a wall or floor, are often designed with highly interdependent components. This means that it is virtually impossible to take one part of the assembly apart without affecting everything else. There is a pressing need today to design assemblies with connections that allow each part to be replaced discretely, recognising the very different time spans that different components have.

Although CDM regulations and practice helpfully cover a number of issue relating to DfD, until it becomes a standard construction procedure ***extra time will have to be allowed from the beginning of the project to ensure that DfD is fully incorporated***.



Design assemblies with independent components whenever possible. Source: Tradis

4.2 Team Approach

If DfD is to succeed, it is vital that the whole project team and client are brought on board from the beginning of the project. Different stakeholders in the team will have different objectives and it is important to identify how far DfD can satisfy these and to establish priorities, procedures and lines of communication relating to DfD throughout the construction, maintenance and deconstruction phase of the building's lifespan. Table 1 over the page illustrates the tasks that various team members should undertake to maximise the potential of DfD.

Table 1: Strategic Action to Promote Deconstruction

RIBA Plan of Work Stages	Client	Design Team	Contractor
A to B - Planning and Feasibility	- appoint design team members who are sympathetic to DfD - ensure appropriate clauses inserted into appointment documentation - appoint contractor as early as possible to identify DfD opportunities, ideally through partnering agreements	- brief client on DfD - demonstrate best practice of DfD to client - ascertain the degree to which DfD can be applied in the project and develop initial DfD strategic plan - assess which building elements are most cost effective to DfD	- provide audit demonstrating waste minimisation strategies - obtain initial briefing and training on DfD
C to E- Proposals	- brief design team to ensure that DfD proposals fit in with requirements for upgrading, adaptability and flexibility in use	- organise pre-site meetings with contractor (where possible) to identify reused materials and construction processes which support DfD	- attend pre-site meetings with design team and client (where possible) - advise design team on deconstruction processes and potential salvage
F- Detail Design and Production Drawings	- check with design team that key elements and details still enable upgrading, adaptability and flexibility in use	- aim to cover as many of the DfD principles as possible - carry out a design check by producing a detailed plan for the deconstruction of the building and ensuring that the design proposals match this.	- advise design team on implications for deconstruction in relation to design and detailing (where possible)
G to L- Contract	- allow for additional time in contract period to promote DfD through careful construction practices - insist on *integrated* drawings and specifications "as built" as per CDM requirements	- make sure that contractors invited to tender are made fully aware of the commitment to DfD through the detailed DfD plan and briefed accordingly to allow for this in the tender - make DfD requirements explicit in tender documents	- identify good construction practice to promote DfD and advise design team accordingly - train sub-contractors as necessary
M - Maintenance	- ensure that ALL maintenance staff and future contractors are fully briefed on DfD strategy -instigate feedback strategy on building performance	- monitor performance of project over time (where possible) and build in the evaluation into future DfD	

Where the knowledge in DfD does not exist for the tasks outlined in this chapter, it may be appropriate to employ suitable expertise and training, which can be provided either through SEDA[18] or BRE[19].

Footnotes:

18 see www.seda2.org

19 see www.bre.co.uk

A major cultural shift is needed in all trades, which recognises the need for construction elements to be more separable. This means balancing the need for quick construction against the future requirements of DfD, such as avoiding excessive mechanical demolition techniques.

The contractor can add considerable insight into the construction process required to fulfil the requirements of the deconstruction plan, particularly if a partnering process is instigated to ensure their involvement with the design team at an early stage.

Establish benchmarks and targets for the number of potential re-uses for each existing element.
Source: F. Stevenson

4.3 Deconstruction in detail

The following more detailed tasks should be carried out at each stage of the RIBA Plan of Works to ensure that the DfD strategy is carried through at all levels:

Planning and Feasibility (RIBA work stage A-B):

- the lead person in the team should provide a full briefing on DfD to each team member and discusses their role both at collective team meetings and on an individual appointment basis
- Quantity Surveyors need careful briefing on the cost-benefit implications of DfD both in terms of initial construction costs and future maintenance costs
- Mechanical Engineers should be encouraged, in consultation with the rest of the design team, to design out as much as possible of the active servicing elements in a building and replace these with passive measures that have a longer life span
- Structural Engineers should ensure that their structural systems are easy to deconstruct and designed for maximum re-use possibilities
- other specialists should be briefed and consulted on DfD strategies as necessary
- establish DfD targets and benchmarks in terms of the percentage of the building that can be re-used as well as the number of potential re-uses for each existing element
- evaluate site constraints, project budget, the purpose of the building, its lifespan and the contract period as crucial determinants of DfD benchmarking
- it is vital that an accurate survey is carried out for existing buildings to identify existing DfD opportunities e.g. preserving the ability to remove existing joists easily
- ensure that the new design does not compromise the deconstructability of the existing building
- once all these tasks have been achieved the results should be fed into an overall DfD strategic plan for the project.

In-situ concrete can be an "immovable construction", which is hard to deconstruct.
Source: N.Verow

Structural engineers should ensure that their structural systems are easy to deconstruct and designed for maximum re-use possibilities.
Source: Trada

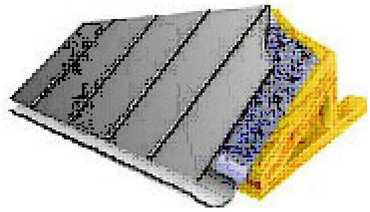
Outline Proposals and Scheme Design (RIBA work stage C-E)

- adopt the detailing principles for DfD outlined in Section 5 of this guide as well as other guidance on sustainable design as far as possible; aim to prioritise key principles
- QS to undertake a detailed cost-benefit analysis of low-cost DfD options, taking account of any identified sources of reclamation and offsetting them against the cost of virgin construction resources. For example, if a source of re-usable steel beams of a particular span and size is identified, then the QS and design team should take into account, at the earliest opportunity, how this resource can be "designed into" the building. Priorities should be identified at this stage.
- evaluate the structural and service options which can maximise DfD within the given constraints
- agree a list of reductions, which take DfD into account, should the project costs exceed the budget
- make sure the aesthetics for the project, which are clearly defined at this stage, take account of the agreed DfD strategic plan; sometimes an image can overrule the process!

This aesthetic prohibits DfD through use of continuous hard render.
Source: F. Stevenson

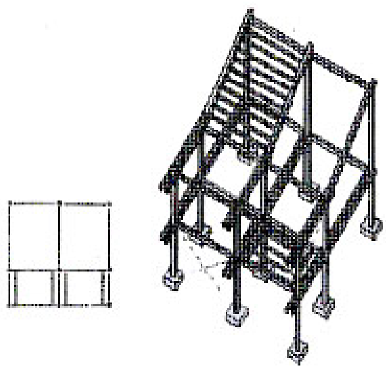
Detail Design and Production Drawings (RIBA work stage F)

- use the DfD strategic plan from stage A-B as a framework to develop the details and specifications in tandem with CDM requirements
- seek advice from manufacturers on whether, and how, product value can best be maintained through re-use and how products can be certified for re-use
- where it has been possible to identify re-usable elements from other buildings, incorporate these in the detailing, provided they do not violate the overall DfD strategy
- develop the strategic DfD plan to a more detailed level to take account of drawings, specifications and costs, as part of an iterative process of design
- carefully scrutinise standard specifications, such as the NBS, to ensure that the DfD is not compromised particularly by poor specification of materials, finishes, joints and connections
- use three dimensional drawing to aid the understanding of the process of DfD - it reveals hidden aspects of two dimensional drawing in terms of the construction/deconstruction process
- fully detail service drawings rather than specifying in outline to ensure full co-ordination for DfD



Seek advice from manufacturer on how to maintain and re-used products.

Source: F. Stevenson



A 3-D drawing is often more informative about the process of DfD than a 2-D one.
Source: N. Mills

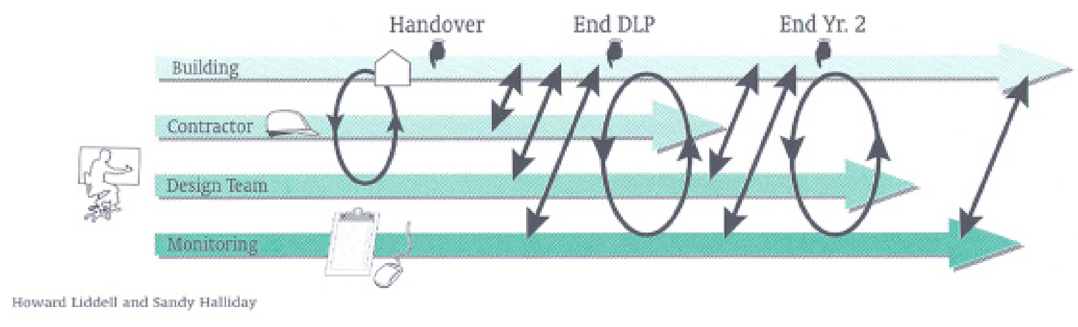
Going to Tender and Completing the Contract (RIBA work stage G-L)

- once the contract has been agreed, ensure that pre- site start meetings allow time for a thorough briefing and negotiation on the objectives of DfD as part of the project and the most effective means for achieving this
- encourage the design team and contractor to use BRE's SmartWaste website to source reclaimed materials locally.[4]
- ensure any alterations to the digital drawings and specification are *carefully integrated* into a revised set of drawings so that a genuine set of "as built" digital drawings is available for maintenance and deconstruction purposes - don't just add to the drawing pile, create a comprehensive digital archive!
- provide a comprehensive and digital operating and maintenance manual for the building, complete with logbook to record future maintenance ,carefully cross-indexed to aid rapid information retrieval
- ensure the manual contains a complete section on the DfD strategy as well as the revised "as built" deconstruction plan and drawings.

Maintenance/Upgrading (RIBA work stage M)

***The client and all parties should make a clear commitment to obtaining feedback* from the outset of the project**. The following tasks will assist with this:

- provide a contingency budget for changes which occur during commissioning and future maintenance, and the recording of these in the logbook, the deconstruction plan and on drawings
- provide for continuing dissemination and transfer of DfD related information during the lifespan of the building to all parties concerned which takes account of any transfer of ownership or upgrading of the building
- training for both the users and maintenance team on the DfD aspects of the building will help to prevent maintenance choices which disable the DfD function; this is vital if the DfD strategy is going to work effectively.



Source : Howard Liddell and Sandy Halliday

Footnotes:
4 http://www.bremap.co.uk

- undertaking post-occupancy evaluations and post-project appraisals to learn if aims of project have been met.

4.4 The Deconstruction Plan

Without a comprehensive Deconstruction Plan for the future, it is almost certain that designed re-usable building elements will be destroyed unnecessarily. The Plan should be issued to all parties at the outset of the contract to ensure a construction process that enables the deconstruction plan to operate.

For a successful Deconstruction Plan, which is a part of the overall DfD detailed plan, make sure the following tasks are undertaken:

1. Statement of strategy for DfD relating to the building

    - Demonstrate the strategy behind the designed re-usable elements and describe best practice to ensure they are handled in a way which preserves maximum re-usability

2. List building elements

    - Provide an inventory of all materials and components used in the project together with all full specifications and all war ranties, including details of manufacturers
    - Describe the design life and/or service life of materials and components
    - Identify best options for reuse, reclamation, recycling and waste to energy for all building element

3. Provide instructions on how to deconstruct elements

    - Provide up-to-date location plans for identifying information on how to deconstruct buildings.
    - Where necessary add additional information to the “as built” set of drawings to demonstrate the optimum technique for removal of specific elements.
    - Describe the equipment required to dismantle the building, the sequential processes involved and the implications for health and safety as part of the CDM requirements.
    - Ensure that the plan advises the future demolition contractor on the best means of categorising, recording and storing dismantled elements.

4. Distribution of DfD Plan

    - Revise the plan as necessary and re-issue to all parties at the handover stage, so that there is maximum awareness of the DfD requirements for the future, including building owner, architects and builder.
    - Place copies of the revised Deconstruction Plan with the legal deeds of the building, the Health and Safety file and the maintenance file.

4.5 Moving on –ownership and responsibilities

Underlying the diversity of building procurement strategies is one key imperative to ensure successful DfD – ***a sense of continuing "ownership" of the resources by the original designer and contractor.***

There are real and demonstrable economic benefits to Design for Deconstruction. However, until we re-orientate our attitudes towards buildings and view them as a repository of highly valuable resources, rather than just a container for the functions of ever changing clients, there will be no real incentive to ensure that the knowledge about the building, and the changes it undergoes, remains coherent over its complete lifespan and facilitates intelligent resource use.

We need to view buildings and their inherent resources as a "service provided". This provides an incentive for all parties to make sure maximum value is derived from the building both during maintenance and at the end of its life.

Think of this building as a providing a service rather than being just a product.
Source: F. Stevenson

5 Deconstruction Detailing Principles

Key Principles

1. Design Buildings to be adaptable to different occupancy patterns in plan, in section and in structural terms.

2. Ensure that buildings are conceived as layered according to their anticipated lifespans.

3. Ensure all components can be readily accessed and removed for repair or replacement.

4. Adopt a fixing regime which allows all components to be easily and safely removed, and replaced through the use of simple fixings. Design connectors to enable components to be both independent and exchangeable.

5. Use only durable components which can be reused. Try to use monomeric components and avoid the use of adhesives, resins and coatings which compromise the potential for reuse and recycling.

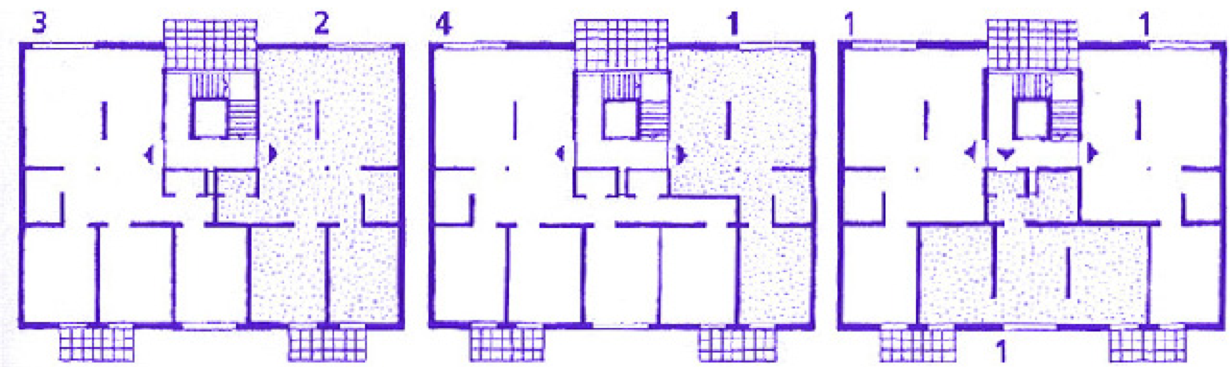
6. Pay particular attention to the differential weathering and wearing of surfaces and allow for those areas to be maintained or replaced separately from other areas.

7. Carefully plan services and service routes so that they can be easily identified, accessed and upgraded or maintained as necessary without disruption to surfaces and other parts of the building.

5.1 Adaptabilty

Aiming to design buildings to be adaptable will tend to lengthen their service lives, and so minimise the energy and resources required over that period. Current practice for most buildings is based on a 60 year lifecycle. This is very short when one thinks of previous generations of buildings that have stood easily for 200 years or more.

An important consideration is layout. The image below shows the same tenement block arranged in three different ways, allowing for three different occupancy patterns, with the minimum of alteration required. Occupancy patterns change and such layouts make it cost effective to react to changing markets, considerably extending their useful life.



Alternative 1
3-bedroom flat +
2-bedroom flat

Alternative 2
4-bedroom flat +
1-bedroom flat

Alternative 3
Three 1-bedroom flats

From Ecological Construction Practice – A-Z Manual for Cost-conscious Clients by H.R. Preisig, W. Dubach, U. Kasser & K. Viriden. Werd Verlag. CRB Zurich University of Applied Sciences, Winterthur.

For such layouts to work, the planning of the building has to be carefully considered. Zones of similar function should be grouped and the structure kept simple, impinging as little as possible on the internal arrangements. Serviced areas such as bathrooms and kitchens need to be strategically positioned, or allowed for, in order to anticipate change, as well as connection options between rooms.

The golden rule is to ***anticipate change***, and to design buildings that make such changes easy to achieve. The logic of this approach has been developed in the UK particularly by the emergence of "Lifetime Homes"[20] which address the changing needs of building occupants.

Even at individual room scale, design can anticipate and allow for future changes of use, as shown below through the size of room, and the location of doors and windows.

From Ecological Construction Practice – A-Z Manual for Cost-conscious Clients by H.R. Preisig, W. Dubach, U. Kasser & K. Viriden. Werd Verlag. CRB Zurich University of Applied Sciences, Winterthur.

Buildings such as this tend to be built to standardised grids and fairly simple geometries. Adaptability is also a function of other aspects such as structural layout and layering of the construction, as discussed below.

5.2 Layering

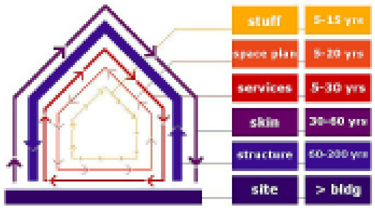
Different parts of a building perform different functions and have different lifespans. Much of the waste arising from construction comes not from demolition of complete buildings, but from incremental processes: refurbishment, upgrading, fit-out changes to reflect organisational changes, wear and tear or weathering and components reaching the end of their service life.

These processes generate considerable and unnecessary waste either because the components were not really worn, or unwanted, or because the buildings are designed so that not only the component itself, but several adjacent and connected elements have to be removed.

Footnotes:

[20] www.jrf.org.uk/housingandcare/lifetimehomes/

Stewart Brand, in his book “How Buildings Learn” offers a helpful conceptual framework for dividing the parts of a building into these different lifespan elements. Each layer performs a different function, and can be expected to last a certain time before replacement. Those with faster replacement cycles are closer to the surface, more easily accessed, and able to be removed from more permanent components beneath without undue disruption or damage.



Left, each “layer” of a building has a different life span (after Steward Brand, 1994)

For the sake of faster site construction, pre-fabricated elements are sometimes used where main structure, insulation, and finished skins are bonded together in a single piece. Unless they are demountable, such assemblies are subject to the weakest link in the chain – the least durable element – failing, whereupon the entire piece may need replacement, often at a higher cost than the simpler repair or maintenance of just the outer cladding, for example.

Make sure prefabricated panels can be re-used and recycled at the end of their lifespan.
Source: Trada

5.3 Access

Lack of adequate access is one of the single biggest inhibitors of successful deconstruction. Access to elements for repair and removal may be considered in three ways.

1. Sequential access:
Sequential access this is discussed in the section above on layers. Access is strategically poorly devised if a more permanent element is in front of the one requiring attention or removal.

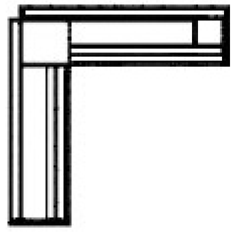
2. Physical access:
This means being able to reach a component and remove it safely and completely. Generally, the larger the construction element, the more room there is required for deconstruction and removal. Large elements which are too heavy to be lifted by workers, but to which access by a crane is impossible, are an example of physical access problems to avoid.

3. Access to fixings:
If the fixing to a component is behind it and not accessible, then much more work will be needed to remove it. Often, there is simply not enough room left for construction workers to be able to manoeuvre with appropriate tools in order to remove elements by unfixing them. Some components require a special tool to be dismantled, which needs to be nearby and marked, and a spare kept just in case. Some components have many fixings visible, where only one is needed to remove it, but is that particular fixing marked?

Elements should be kept small enough for easy manual replacement where possible.
Source: F. Stevenson

Planning and detailing for deconstruction should be checked in terms of access and ensuring that whole construction elements can be successfully removed from the building through identified access routes, especially where anticipated lifespans are shorter. This should be linked to the Health and Safety Plan.

5.4 Connections

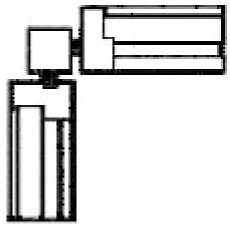


Plan section of an direct connector for wooden panels.

The design of connections is arguably the single most important aspect of designing for deconstruction. The type of connection used between construction elements will determine whether or not it can be successfully deconstructed (see table 2).

Connections come in three categories in terms of how they interface with components:

- direct connectors
- indirect connectors
- infilled connectors



Plan section of an indirect connector for wooden panels.

Direct connectors usually interlock or overlap with components, which can make deconstruction difficult due to the assembly process. Indirect connectors are usually easier to deconstruct because they are interchangeable and independent from the components. Infilled connectors such as glued or welded connectors can be virtually impossible to deconstruct unless the filler is very soft, such as lime mortar.

Connectors should always be designed to enable components to be both *independent* and *exchangeable*. Equally, the geometry of the components' edges in relation to the connection design will dictate whether or not components can be disassembled.

Table 2: Evaluation of Connection Alternatives for Deconstruction

Type of Connection	Advantages	Disadvantages
Screw fixing	- easily removable	- limited re-use of both hole and screws - cost
Bolt fixing	- strong - can be re-used a number of times	- can seize up making removal difficult - cost
Nail fixing Friction	- speed of construction - cost - keeps construction element whole during removal	- difficult to remove - removal usually destroys a key area of element - relatively undeveloped area - poor choice of fixings - structurally weaker
Mortar	- can be made to variety of strengths	- mostly cannot be re-used, unless clay - strength of mix often overspecified making it difficult to separate bonded layers
Resin bonding	- strong and efficient - deal with awkward joints	- virtually impossible to separate bonded layers - resin cannot be easily re-cycled or re-used
adhesives	- variety of strengths available to suit task	- adhesive cannot be easily re-cycled or re-used, many are also impossible to separate
Riveted fixing	- speed of construction	- difficult to remove without destroying a key area of element

The best fixings are those which are themselves durable, and help to preserve the structural integrity and finish of the construction elements to be joined, during the process of deconstruction.

The use of notching, cutting and holing should be avoided where possible and the designation of “fixing free zones” can help maximise opportunities for re-use of lengths of material. Friction jointing is the least disruptive form of fixing and highly desirable for structural elements which may be re-used. Examples of friction joints include timber-on-timber sleeve joints, clamps and pre-formed sockets for receiving elements.

Two key criteria for designing connections which can be disassembled while maintaining the integrity of all elements are:

1. Avoid interpenetration of connectors with components
2. Adopt dry-jointing techniques in preference to chemical jointing

Try to minimise interpenetration of connectors with components.
Source: F. Stevenson

5.5 Durable Components

For the potential of deconstruction strategies to be realised, and for waste arising from construction to be reduced, it is important that the components that can be readily recovered without damage are durable enough to be repaired or reused with the minimum of work and cost.

Friction jointing is the least disruptive form of fixing.
Source: F. Stevenson

Component lifecycles for buildings, such as windows, doors, panelling and roofing are calculated on the basis of 10-25 years. This is a relatively energy-intensive and short cycle when one realises that many Victorian buildings still have their existing components. “Patchable” construction detailing allows elements such as doors, windows, finishes to be easily maintained through partial rather than wholescale replacement.

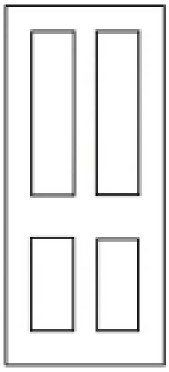


Diagram of a patchable door element showing panels that can be replaced.

Components should be designed to maximise the number of times they can be re-used. This requires careful consideration of the durability of the edges between the connector and component. The more robust the edges, the more likely the component and connector can be re-used again and again. Dry-joint techniques that avoid excessive pressure on either component or connector are likely to be the most successful, particularly if the fitting is simple.

Where a component or finish is not particularly durable and unlikely to be re-used, it is important that it can be easily recycled. This is easiest if the component is of a single material or can quickly be broken down into individual materials.

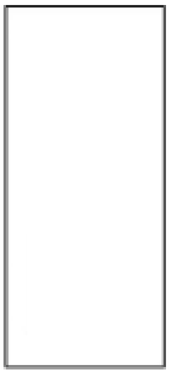


Diagram of a non patchable door element with single panel.

5.6 Structure

The structure of a building is designed to carry the primary live and dead loads, as well as resisting lateral forces such as wind. It is the most permanent feature of any building and should be designed to allow for the greatest number of possible occupancy scenarios so as to enable the structure of the building, at the very least, to be useful (and therefore kept out of the waste steam) for many generations to come. There a number of ways this can be achieved.

In the first instance there should be a sufficient floor to ceiling height to enable the widest possible range of anticipated uses. Suspended floor and ceiling structures can make up the difference as required.

The number of internal columns or walls, which could compromise the potential of the building to be used for different functions in the future, should be minimised. For this reason, frame structures with sufficient resistance to lateral force within the frame are to be preferred to panel or solid masonry buildings where bracing tends to be achieved by cross walls, which can reduce long term options for occupants. There are however many masonry and panel buildings which are well used where they are generous enough.

Masonry structure
Source: F. Stevenson

There are generally three primary types of building structure: Masonry, Frame and Panel. The relative advantages of each with regard to deconstruction issues is given in table 3.

Table 3: Evaluation of Structural Alternatives for Deconstruction

Type of Structure	Advantages	Disadvantages
Masonry	- individual components- break down into small, easily reusable units - solid mass can be recycled if monolithic -re-use does not dictate design	-blocks need soft binder to be reused which reduces strength - may include reinforcement which is harder to deconstruct - requires heavy machinery to break down solid mass - may have cross walls which compromise long term occupancy pattern options
Frame	- structurally efficient, allows for multiple occupancy patterns - easy to deconstruct into re-usable elements if detailed appropriately (not concrete in-situ) - can be layered separately from cladding and insulation - can be factory made (not concrete in-situ)	- difficult to deconstruct unless framework is detailed with appropriate joints - notching, holes and binding with resins can reduce possibilities for re-use - depending on size and type can be manually or mechanically deconstructed
Panel system	- structurally efficient - factory made –gives precision - all components can be built in to minimise waste	- requires mechanical deconstruction - materials are bound together and hard to separate - need for cross wall bracing reduces internal options

Large scale structural sections need complex dismantling equipment on site but offer the advantage of maximising possibilities for re-use especially when standardised. On domestic buildings it may be preferable to have a number of smaller standardised structural elements to perform the same task and allow for easy disassembly.

Frame structure
Source: F. Stevenson

5.7 Insulation and Airtightness

Insulation and airtightness features of buildings often require upgrading, but the reasons and timeframes for this are quite different from either the structural basis of a building, or the external or internal skins, and so we suggest that insulation is considered separately, and treated as a separate 'layer' in the construction wherever possible. It is important to ensure that insulation levels can be upgraded without damage or disruption to the structural forms of the building, and furthermore that the skins of the envelope can be repaired or replaced without disruption to the insulation and airtightness layer.

Pre-fabricated composite panelling structure.
Source: F. Stevenson

Sprayed insulation, such as cellulose fibre or urea formaldehyde, is difficult to salvage during deconstruction, whereas blown insulation can be extracted although this involves the use of a suction machine and certain details t have been fulfilled such as the avoidance of bonding resin. Both rigid and flexible slab or batt insulations can in theory be reused, but rigid slabs tend to be easily damaged while flexible batts offer greater potential for simple reuse, as long as it has not collected too much dust and detritus. Natural materials such as cellulose insulation and sheepswool offer the greatest potential for waste reduction since they are ultimately biodegradable and so represent a zero waste option in the long run. Appropriate storage of recovered insulation is vital to prevent degradation.

Flexible insulation bat on the left offer greater pontential for re-use.
Source: F. Stevenson

5.8 Skins

The external skin of any building has a number of functions to fulfil, most of which involve protection from the elements, although aesthetics plays an important part.

Bonded external insulation systems are difficult to recycle or re-use.
Source: F. Stevenson

Strategically, it is worth assessing the differential weathering likely to be experienced across the outer surfaces of the building. For example, corners are often particularly vulnerable, as well as the lowest sections of cladding, where splashback can lead to discoloration and decay in organic cladding materials. If possible, these areas should be made separately removable for more frequent maintenance, repair or replacement.

Un-treated timber rainscreens are easy to re-use if bolted.
Source: F. Stevenson

The weathering skin should be removable without damage and disruption to the insulation layer and the structure, though this is not always possible, depending on the overall construction type chosen. This ‘replaceability’ also has advantages when wishing to upgrade external appearances for aesthetic reasons only.

It is tempting to specify bonded elements for a building skin, which combine insulation with cladding, for speed of construction, but this usually defeats attempts at deconstruction, as the elements cannot be recycled or re-used easily[21] [22] and wastage rates are increased when failure of one component leads to the unnecessary wastage of the other.

The weathering skin should be removable without damageand disruption to the insulation layer.
Source F. Stevenson

The size of cladding elements should be kept small enough for easy manual replacement as well as deconstruction. Wear and tear on large elements can create excessive wastage, as the whole element has to be replaced rather than patched.

Internal building finishes may be considered in a similar fashion. Differential wear and tear can be anticipated with good design, and careful detailing will enable worn or unwanted surfaces to be removed without disruption elsewhere. The rapidly changing aesthetics of finishes means that assemblies with removable finishes are particularily effective because they can be easily updated during a refit, without having to remove the entire assembly.

Footnotes:

[21] Combined bonded elements could be detailed for reuse as a single element, but this is unusual

[22] External insulation systems often bond mineral finishes to the insulation behind, making both re-use and recycling very difficult. Paint finishes also inhibit recycling of aluminium, steel, and wood; mill finishes are preferable for metals where possible and internal woodwork should ideally be finished with wax or natural stains rather than paint.

5.9 Services

Keep services separated from other elements and “reversible”.
Source: F. Stevenson

Services must be carefully pre-planned to optimise opportunities for deconstruction,as they will inevitably be replaced several times during the lifetime of an average building. Typical services installations include:

- heating –heat emitters, supply pipes, flues and plant
- water –hot and cold supply and waste pipes
- lighting –electrical circuits and fittings
- power –electrical circuits, IT cabling and fittings
- cooling –air conditioning and mechanical ventilation
- fire detection and prevention systems
- security and control systems
- transportation systems – lifts, escalators
- sanitary systems

Bearing in mind the ‘Layering” diagram shown earlier, it follows that services will last longer than some internal finishes, but should be separately accessible in a way that does not compromise the finishes, the insulated and airtight envelope or the structural integrity of the building.

Strategic routing of the services should enable easy access and alteration and have minimum of interpenetration between other layers. Sometimes the simplest technique is to surface mount the services, though this should not compromise the potential to upgrade and maintain the internal finishes. A more common strategy is to provide a service void in certain areas, with simple access at critical points. In this way services are generally concealed and decoration and cleaning are easier on a day to day basis.

The routing of services should be pre-planned in relation to all sectional and plan detailing. It is important to obtain accurate service route plans at the contract design stage and as built drawings from service engineers and contractors whenever possible as part of the contractors requirements. The use of nominated contractors can help in this regard on larger projects.

All servicing fixings should be designed to be *fully reversible*, given the relatively short life span of servicing products and equipment. The use of suspended service trays for cabling and appropriately sized service ducts can ensure the separation of pipework and cabling to enable easy deconstruction.

The use of passive environmental strategies such as thermal mass for cooling and passive solar gain for heating, as well as “breathing” walls for ventilation can significantly reduce the amount of mechanical servicing needed in a building, which in turn can ease deconstruction.

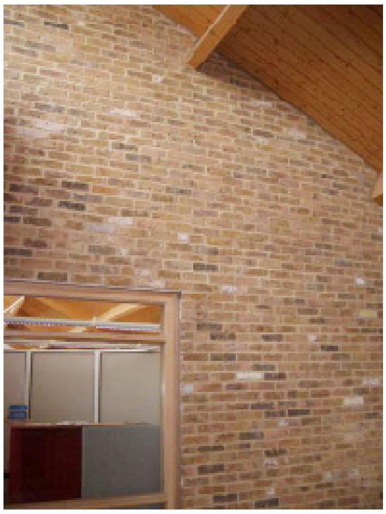
5.10 Key construction materials : re-use potential

Steel, masonry, concrete and timber comprise the vast bulk of construction materials and all offer possibilities for reuse where fixings have been designed to facilitate this. Timber tends to be susceptible to poor practice and is not re-used as often as steel and masonry. Glass and plastics tend to have limited reuse potential, and are generally more suited to recycling.

Steel:
Although there is extensive recycling of steel, re-use is still relatively uncommon[23], with most steel frames dismantled using thermal lances or shears, rendering them unusable in their original form. There are no design or structural testing standards relating to the re-use of steel to date but equally, there are no building control restrictions. Providing the steel component has not been highly stressed and shows no visible sign of plastic deformation it should be fit for re-use. The Steel Construction Institute offers guidelines on the appraisal of existing iron and steel structures for structural adequacy.


Steel is extensively recycled but rarely re-used, despite its potential for DfD.
Source: F. Stevenson

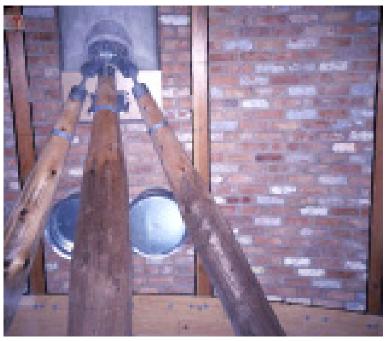
Masonry:
There is a strong tradition of re-using stone, slates, tiles, paviors and bricks in construction, prompted by the heritage industry, but surprisingly there are still no official standards relating to re-use. Dismantling is usually carried out by hand, to maximise the potentially high resale value of the component. The re-use of stone cladding panels can be problematic unless the joints and connectors are carefully designed for disassembly. The use of ordinary portland cement for binding rather than a softer lime mortar is a great limitation on the re-use of masonry, because it is often stronger than the brick or stone itself, and should be avoided where possible. Testing for fitness can be carried out in the same manner as for new materials but is currently not required.


Re-using bricks depends on using soft mortar joints where possible.
Source: F. Stevenson

Concrete:
Although concrete constitutes a large proportion of construction waste, there has been little re-use to date with the majority being downcycled for low-grade applications such as sub-bases or infill for landscaping. Most commercial concrete buildings are cast in-situ frames which have to be destructively demolished. In theory pre-cast floor slabs, beams and columns could be reclaimed but these are often cement bound or involve complex tensioning which creates a hazard during deconstruction. A further problem relates to the natural deterioration of concrete due to carbonation, as well as the hidden deterioration of metal reinforcement. Concrete block paviors are one component that can be re-used easily. There are no design or structural testing standards for the re-use of concrete and cost-savings over new products are minimal at present.

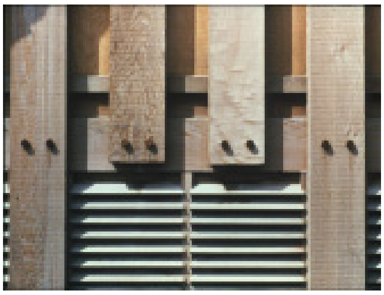

Concrete paviors can be re-used with sand bedding and allow access to services below.
Source: F. Stevenson

Timber:
High-value joinery items have enjoyed a long tradition of re-use in the construction industry, primarily in the domestic market, whereas structural re-use of timber is still rare. Many reclaimed timber components contain fixings that are both labour intensive to remove and also destroy the component. One way around this, is to specify “fixing-free” zones in structural timber which allows a significant proportion of defect-free timber to be re-used. Timber re-used for structural purposes must be strength-graded to BS4978 (softwood) or BS5756 (hardwood) or have an adequate paper trail to verify its integrity. Non-structural re-use of timber can be simply assessed according to durability of species and appearance.


Example of re-used timber telegraph poles as structural members.
Source: F. Stevenson

5.11 Risk and Safety Issues

There is a perceived risk among designers in the *specification* of re-used or recycled components and materials. In fact, the re-use of construction elements is not innovative; it has being going on for centuries, relying on the experience of the builder, designer and inspector rather than any set standards. Providing clear audit trails combined with expertise in inspection can help to clarify the provenance of materials and components as well as meet required standards. This process can often satisfy indemnity demands, as “due diligence” has been demonstrated.



Timber can be easily assessed for re-use according to durability of species and appearance.
Source: Trada

Additional visual inspection, or testing for certain materials or components known to be prone to decay, can be added to this to further minimise risk. Where there is no audit trail available for a material or component, it is important to engage the services of an expert inspector (as provided by Bioregional Reclaimed, for example). There is an urgent need for more training in this area.

In terms of *site practice,* design for deconstruction aims to minimise the risk involved in dismantling buildings. Demolition contractors prefer to dismantle buildings mechanically using automated equipment that operates remotely as this minimises the risk to the operative. Dry-joint systems rather than infill jointing and applied finishes can ease risk, providing the operative is fully briefed on the process involved. Pre-planning is essential and involves the designer considering exactly how their design can be safely taken apart and ensuring that this is written into the contract prior to construction.

The use of building logbooks which detail what has taken place in a building in terms of maintenance, replacement and alterations, is potentially an invaluable tool for deconstruction purposes. It has also been suggested by BRE that Material Recovery Notes (MRNs) (Hurley, 2003) should also be developed which can communicate information on key demolition/deconstruction products, and which can follow the product or assembly throughout its lifecycle. MRNs and logbooks can also minimise health risks by demonstrating the exact nature of any given assembly or product at any given time.

If a “clean” approach to design for deconstruction is adopted, which favours mechanical fixing and finishes over the use of chemical joints and applied finishes, this will also help to reduce any potential cross-contamination of products and materials, which is one of the major perceived risks in reclamation.

Design for deconstruction aims to minimise the risk involved in dismantling buildings.
Source: F. Stevenson

5.12 Existing building stock

There is far more potential opportunity to detail for deconstruction that will take place during the maintenance and alteration of existing stock, given that the rate of replacement of the building stock through new build relatively small[24]. This does, however, place particular demands on the designer.

Footnotes:

[23] Bioregional Reclaimed is a unique company that specialises not only in re-using steel but also in structurally assessing steel for re-use.

[24] For example, Scottish social housing is only replaced at 1% per year (Stevenson and Williams, 2000)

When designing for existing buildings, the first action should be to carry out a detailed audit and evaluation of the buildings' existing potential for deconstruction and re-use. Older buildings are often more "re-usable" than we think, with a significant amount of high-quality and durable components that can be identified in a reclamation audit for either reuse, reclamation or recycling. It is important to consider the amount of embodied energy tied up in each disposal option, and decide which option preserves the greatest amount of resource and embodied energy for the least energy cost. The historic value of any component should also be considered when evaluating the options.

Construction waste can be further minimised by good site practice to ensure that the demolition process carefully segregates reclaimable materials and products.

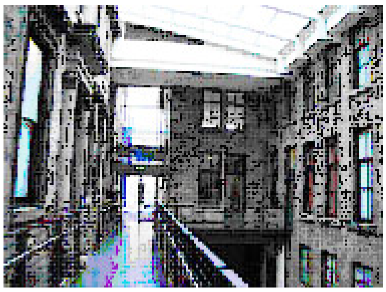
Good conservation practice which demands "reversibility" of detailing can help facilitate deconstruction of design interventions in older buildings. "Reversible" design can also help to preserve the inherent flexibility and adaptability that many older buildings exhibit, prior to the second world war. 19th century buildings often used relatively soft mortars for masonry as well as details facilitating the removal of key elements. Buildings constructed in the late 20th century and beyond, however, tend to use stronger mortars and other fixing and finishing techniques that make deconstruction more difficult.

When detailing for alterations to existing buildings, the designer should strive to preserve any inherent deconstructability by ensuring that additions are "layered" on for easy removal. Fixing directly into masonry should be avoided, and the mortar joint used instead, to preserve the existing elements. Servicing should also be carefully designed to be "reversible". There is not excellent guidance on this (Warm, P. and Oxley, R. 2002).

There are certain additional risks involved when altering existing buildings in relation to design for deconstruction, that must be considered. While it may well be possible to design in a careful audit trail for products and assemblies in new buildings, it is not always possible to easily verify the provenance or integrity of existing structures, assemblies and components. "Reversible" design can mitigate against these problems by ensuring that any new intervention operates independently of the existing building where possible.

"Reversibility" of detailing can facilitate deconstruction of design interventions in older buildings.
Source: F. Stevenson

The first action with existing buildings is to carry out a detailed audit for potential re-use.
Source: N.Verow



It is important to "layer" on new additions to existing buildings for reversibility.
Source: F. Stevenson

6. The Details

Caveat

It is important to emphasise the scope and purpose of the following drawings and specifications.

They are included solely to show practitioners the sort of alterations that can be made in order to enable buildings to be repaired, altered and disassembled without undue damage to adjacent elements or the elements themselves, to afford as much re-use as possible and to increase the ease and cost effectiveness of re-use and recycling in construction generally.

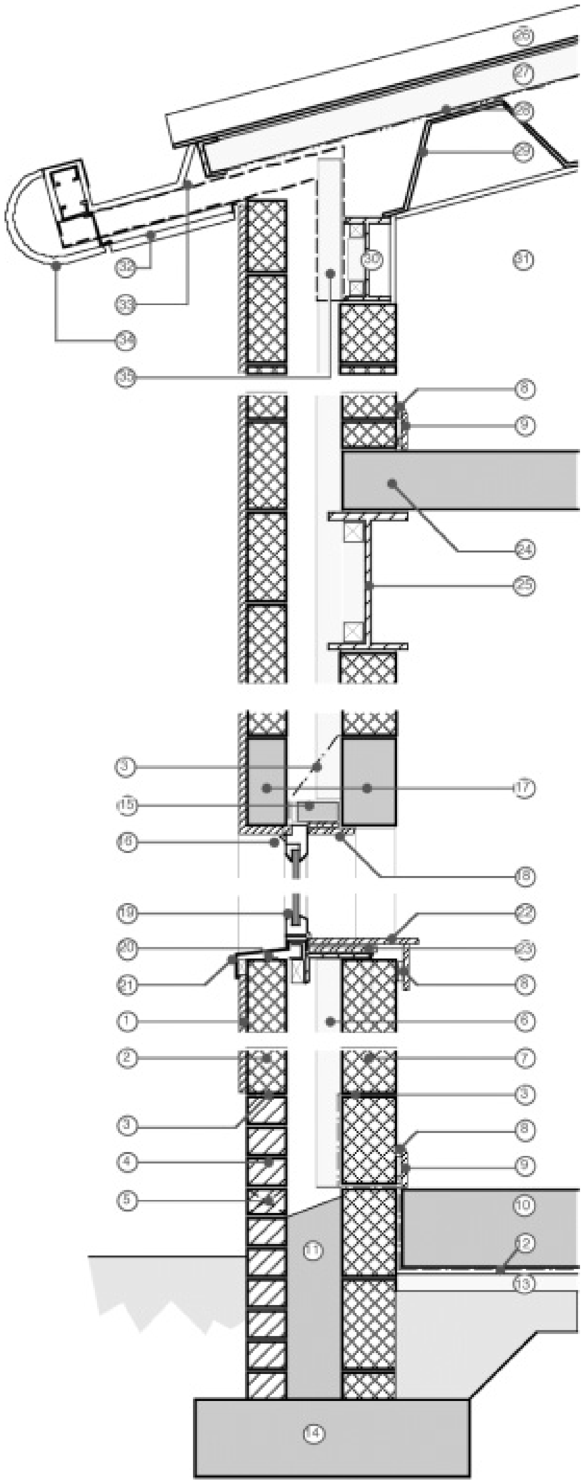
Their purpose is not to offer approved details in any sense, but to illustrate the difference between details and specifications which do not address deconstruction issues, and those that do. It is the differences between the originals and alternatives which is intended to be illustrative, not necessarily the alternatives themselves.

The original details have been taken from conventional details and specifications we believe to be broadly representative of their construction types. We hope the principles shown, and the specific references made will assist designers in making similar changes in their own work, but it goes without saying that SEDA cannot take responsibility for any work undertaken as a result of the use of these details.

Specifically, these details are not intended to show best practice in any sense, nor are they even intended to be up to date. We have striven in the preparation of these details and specifications to keep as close to the original as possible. We have done this in order to show that some quite fundamental alterations – in terms of deconstruction - may be made with the minimum of visual or functional impact on the original. Where these original details and specifications do not meet current standards or aspirations, the alternatives given are likely to be similarly wanting. To re-iterate, the purpose is not to produce approved details, but to illustrate the process of improvement – in terms of deconstruction only – that may be made.

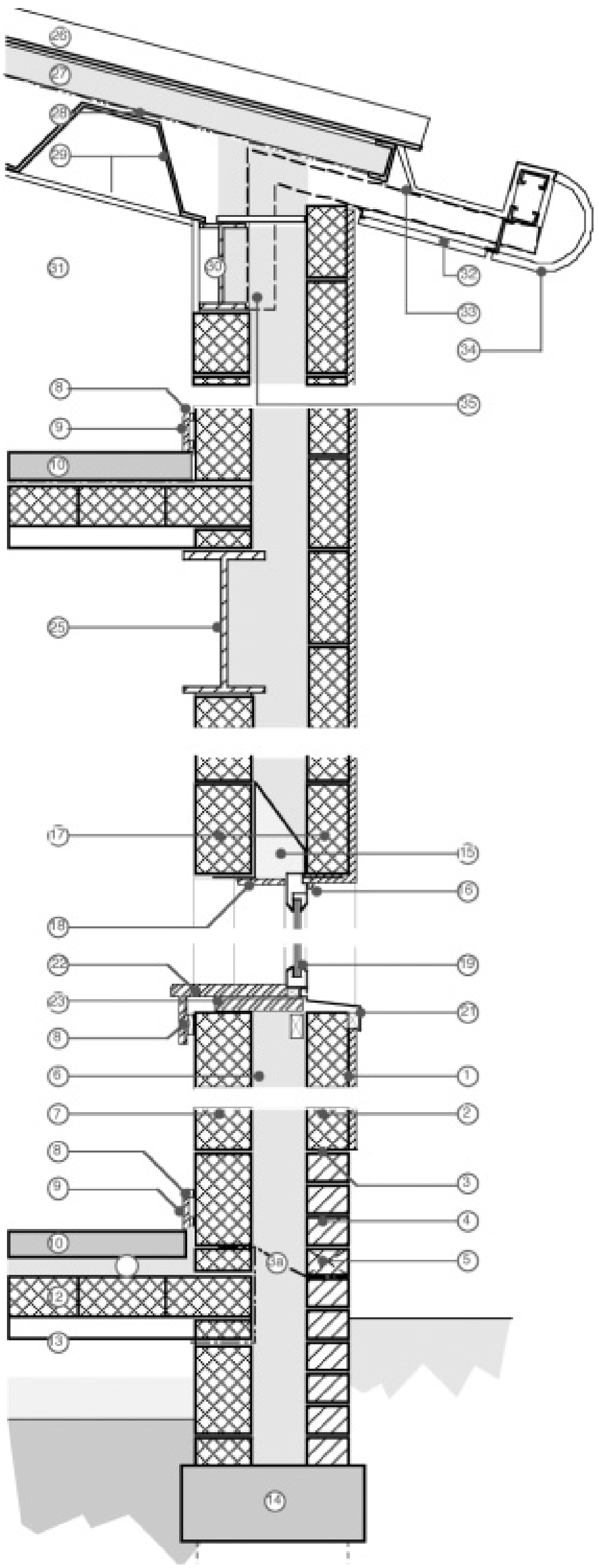
6.1 Steel Frame + Concrete Block Cavity Wall

Standard, durable and economic heavyweight construction applicable to most project types.



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
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, 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 compressed into void
16. Polysulphide sealant
17. Reinforced Concrete lintols to Str. Eng. 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, 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 loose 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



30. Eaves beam to structural engineers specification (k)
31. Raking rafter to structural engineers specification(k)
32. Mill finish metal soffit bolted to outrigger (j)
33. Pre-formed gutter and single ply lining mechanically fixed
34. Mill finish bullnose gutter mechanically fixed to roof structure (j)
35. Cranked mild steel outriggers bolted to eaves beam
36 External grade plywood board shot-fired to eaves beam to close cavity. 5mm gap to block.
37Eps insulation stuffed into gap to complete insulated envelope and reduce air infiltration

Alternative Specification

1. Lime: sand (a) render in two coats
2. 100mm dense concrete (n*) blockwork in lime (a) mortar
3. PVC (o*) damp proof course
3a. Horizontal supported or rigid cavity tray c/w stopends (b)
4. 100mm facing brickwork (p*) in lime (a) mortar
5. Perpend weep slot @ 900mm centres
6. Full fill blown cavity insulation, above and below cavity tray (c) Note: care under window.
7. 140mm concrete (n*) blockwork in lime (a) mortar with 2 coats matt emulsion (q*) paint finish
8. Soft wood timber packer nailed to wall
9. 19mm softwood skirting board with 2 coats biodegradable satin emulsion finish screwed to packer (d)
10. Min. 65mm screed with float finish, insulation/ expansion edge strip (e)
11. 50mm rigid polystyrene eps butt jointed insulation
12. 150 depth beam and block floor with standard block infill, lime grouted, min. 75mm ventilated and drained cavity beneath. Slip block infill. (f)
13. PVC (o*) damp proof course under beams, dressed up and into blockwork, lapped with cavity tray
14. Pre-cast, post tensioned ground beam over piles (g)
15. Insulated steel lintol supporting both block leaves (h)
16. Rubber gasket sealant (i)
17. (Standard concrete blocks only on steel lintol)
18. 15mm untreated sw timber surround with 2 coats biodegradable satin emulsion finish screwed to packer (d)
19. Proprietary aluminium double glazed window unit screwed to masonry or support steelwork [mastic tape deleted]
21. Mill finish pressed metal cill screwed to packer (j) allow for differential movement.
22. 15mm untreated sw timber cill and apron with 2 coats biodegradable satin emulsion finish screwed to packer (d)
23. c. 25 x 150mm untreated sw timber packer screwed to timber packer below, supporting window and cill, closing cavity and supporting cill board
25. Steel beam to structural engineers specification (k)
26. Standing seam roof mechanically fixed to support structure (l)
27. 100mm butt jointed eps (m) slab insulation mechanically fixed
28. Reinforced polyethelene vapour barrier laid loose with lap joints
29. 200mm structural metal deck (j)

Explanation

The greatest volume of waste likely to end up in landfill in this detail is the concrete blocks and mortar. Though downcycling of concrete rubble as hardcore is cost effective and common, even in-situ, the relative value of re-used blocks and the potential to reduce the largest volume of waste from going to landfill makes this the priority.

It is also possible that a major refurbishment might involve the removal of the walls while the frame, floors and roof might remain, this reinforces the prioritisation of the walls.

Linked to this is the cavity insulation. The original detail leaves little realistic opportunity for re-use of the batts, damage is almost inevitable given the difficulty in removing the blocks without considerable force, whilst sucking out injected beads before demolition of the cavity walls enables a very high percentage of the material to be re-used.

Generally windows now installed are likely to be entirely recycled at the end of their service life. However, if they are made easy to remove (from the wall and glass from frame) and repair (dry fixing, timber frame) then re-use may become cost effective which is the aim.

The mechanical bonding of individual roof elements is already good practice. Although most steel structure may be expected to last the lifetime of the building, the reduction in energy associated with reuse as opposed to recycling makes this item a high priority.

By volume, timber skirting is insignificant, but if a natural paint finish is used, it can be safely composted.

HIGH PRIORITY

Lime Mortar and Render (a)

Lime mortar and render is softer than the blocks and enables easy demolition and cleaning of the blocks, so they can be re-used.

No need for movement / expansion joints with lime mortar, better protection of walls from moisture / freezing.

Full Fill Cavity Insulation (c)

EPS Beads are injected and can be extracted again and re-used.
(Fibres and Foam cannot be easily extracted and re-used)

Three important criteria must be met for this to work: the beads must be unbonded, the design must ensure no leakage of beads, and the cavity must be reasonably clean at installation.

Built-Up Roofing (l)

Built-up roofing components, mechanically fixed will enable easier, and therefore more cost effective re-use and recycling.

Bonded or 'sandwich' panels can be recycled but as yet this is technically demanding, with few facilities available and high cost.

Bolted Steel Structure (k)

Most solid steel is recycled already, but bolted elements, of standard, repeated lengths will encourage component re-use, thus big energy savings.

Structural component re-use is rarely cost effective, though one supplier provided components and associated structural engineering advice, see index.

MEDIUM PRIORITY

Cavity Tray / No Trench Fill (b)

Trench fill makes any re-use of adjacent blocks impossible. The Cavity Tray performs the same task and is easy to remove.

Separate inserts for insulation fill required below tray. No concrete used and better perimeter insulation levels attained.

MEDIUM PRIORITY

Screed/Beam and Block Floor (e, f)

Allows for greater re-use (rather than recycling) of materials, if grouted with lime and separated from screed etc.

Also dispense with need for dpm, and reduces oversight material. However ventilation is required to solum, and less thermal mass available within insulated envelope.

Screw fixed skirting (d)

Screw fixing allows the skirting to be used for easy access / re-fixing, also reduced damage if dismantling

Principal benefits are within lifetime use for access to services, as re-use of skirting is unlikely in practice.

Window Detail (i)

Both glass and frame of metal and plastic windows will be recycled if easily removed and separated.

Ensure easy mechanical removal of all components (by screw or 'click' fix or rubber gasket) Avoid all glues, mastics, putties etc.

LOW PRIORITY

Steel Lintol (h)

Simplifies construction / dismantling, allows for use of continuous blockwork, avoids problems of cavity tray and insulation.

EPS or XPS Insulation (m)

Mineral Fibre insulation may soon become notifiable waste, adding cost to demolition efforts, so eps or xps is to be preferred.

Timber with biodegradable finish (d)

The resin bond of MDF is not biodegradable whereas untreated timber with biodegradable finish can be composted.

Pre-cast Ground Beam (g)

Large volume re-use possible if un-tensioning is straightforward and sizes compatible.

Mill finished Metal (j)

Mill finished metals increase the efficiency of recycling through reduced costs and pollution.

Costs

Lime render is comparable in cost to a high quality cement render, but adds around 60% to the cost of the economical dry dash originally specified.

Lime mortar sourced from a bulk silo adds around 33% to the cost of the walls overall. However, depending on the areas involved, using the alternative opening detail (which is cheaper than the original) and by substituting block walls only for the facing brick, this figure can be reduced to around 15%.

The cavity tray detail is more expensive than the trench fill, but the full fill insulation is cheaper than the batts, and overall the alternative is comparable in cost to the original detail and offers better insulation levels, in addition to allowing complete re-use of components.

At ground level, the beam and block floor is more expensive (by around 100%) than the slab, but the beam and block floor is cheaper than the reinforced slab at first floor by a similar margin. Taken together, the alternative is less than 10% more expensive, but with a second floor added, the alternative detail is around 10% cheaper.

EPS insulation in the roof adds around 50% to the cost, but this should be balanced against potential disposal costs in future.

The use of ground beams is not cost effective generally, unless specific requirements of a site dictate otherwise.

Defects Liability / Insurance Issues

No additional issues have been raised regarding the alternative details.

6.1 Index

(a) **Lime Mortar and Render** (Specification Items 1, 2, 4, 7)
There is no need for a movement or expansion joint with lime mortars and renders, and because the lime is vapour transmissive, there is better protection for the blocks against moisture freezing within the construction. Lime render may be coated with lime washes, which in addition to being traditional have a subtler and arguably more attractive finish than conventional masonry painted finishes.
Contact: eg: Limetec: 0845 603 1143 / www.limetechnology.co.uk

(b) **Cavity Tray / No Trench Fill** (Specification Item 3a)
Separate inserts for insulation fill required below tray. No concrete used and better perimeter insulation levels attained.
Contact: eg. Timloc System 2000 (01405 765 567)

(c) **Full Fill Cavity Insulation** (Specification Item 6)
Three important criteria must be met for this to work: the beads must be unbonded, the design must ensure no leakage of beads, and the cavity must be reasonably clean at installation. The defects liability assessment raised the issue of the importance of third party accreditation and approved installers as well as the need for correct and thorough installation of the material under windows and other awkward areas such as the proposed damp proof tray.
Contact: eg. Tebbway / Polypearl : 01724 847 844

(d) **Screw fixed Timber Skirting with Biodegradable Paint** (Specification Item 9, 18, 22)
This could help reduce ultimate demolition and disposal costs. Timber is also likely to sustain repeated removal and replacement better than MDF and so remain in use for longer. Principal benefits of the screw fixing are within lifetime use for access to services, as re-use of skirting is unlikely in practice. Nailing the timber packers to the concrete blocks is likely to lead to less damage than plugging and screw fixing, so this has been left unchanged. However, it is worth noting that nailing the packers to the mortared perpends will protect the blocks further from damage in the event of the removal of the packer. The depth of the skirting has been increased to 19mm to reduce the risk of warp.
Alternatively there are a variety of pre-finished metal skirtings which are potentially more durable than timber and suitable for reuse, these are more costly but can be integrated with service runs and even heating pipes so saving costs elsewhere. Contact: eg: Heat Profile: 01483 537 000 / www.heatprofile.co.uk

(e) **Unbonded Screed** (Specification Item 10)
Cementitious mix more compatible with other likely waste for crushing, but depth may be reduced to 35mm or less if polymer added to mix (eg. Ronacrete: 01279 638 700). To cater for movement of the screed and to offer a degree of insulation around the edges and so reduce ‘cold bridging’ it is important to position an edge strip of a material like eps, woodfibre board, dense mineral fibre or similar. This edge strip also helps in the ultimate dismantling of the screed.
Contact: eg. RMC Readymix (0117 977 9534)

(f) **Beam and Block Floor** (Specification Item 12)
Also dispense with need for dpm, and reduces oversight material. However ventilation is required to solum, and less thermal mass available within insulated envelope.
Contact: Precast Flooring Federation (PFF), 0116 253 6161

(g) **Pre-cast Ground Beam** (Specification Item 14)
Installation is fast and less weather dependant, site removal much simpler and probably cheaper.
Contact: eg. Roger Bullivant, www.roger-bullivant.co.uk

(h) **Steel Lintol** (Specification Item 15)
Use of continuous blockwork simplifies construction and means fewer ‘one-off’ units for potential re-use. Steel lintols are easier to re-use.
Contact: eg. Catnic (029 2033 7900)

(i) **Window Detail** (Specification Item 16)
In practice this means frames should be screw fixed to sub-frames or packers, and glass should be dry fixed within the frame. Timber windows only represent a better environmental option if they are untreated and dry glazed (i.e not putty or silicone fixed / bonded to frame etc.) This is because a treated timber frame is now likely to represent toxic waste, and the low value of the frame material (as opposed to metal or plastic) will preclude the economic sense of dismantling the window unless it is easy so to do. This is best achieved by specifying an untreated timber frame with full or partial aluminium external facings, biodegradable internal coatings, such as by Osmo (01296 481 220 / www.osmouk.com) and gasket dry fixed glazing units (e.g by Exitex 00 353 4293 71244 / www.exitex.ie). Anglian Windows (operate a 100% reclamation of post consumer materials) on 01603 787 000.
Compressible fillers may be able to be used in place of silicone between the window frame and building fabric, such as Compriband (01914190505 / www.compriband.co.uk), this product is likely to leave less of a residue between connecting surfaces when removed.

(j) **Mill finish Metal** (Specification Item 21, 29, 32, 34)
Most sheet metals used in construction are coated in one way or another. These coatings tend to be either metallic, for example zinc plating (galvanising), anodising or similar, or plastic based, for example, polyester powder coated, pvc, enamel and so on. All coated sheet metal CAN be recycled (it is very rarely re-usable) but the various coatings do complicate and therefore increase the cost of reclaiming the metal. The most cost effective recycling of metal is clearly when there is no contamination by coatings, glues etc. This being the case, the best practice when using sheet metal – from the point of view of recycling – is to use unbonded (mechanically fixed) uncoated sheet. Steel cannot easily be used without some form of protective coating (which is exposed and must be carefully re-touched if there is any site cutting required), whereas aluminium, copper and some others can be used with a mill finish which requires no additional coating and is nonetheless extremely durable.

(k) **Bolted Steel Structure** (Specification Item 25, 30, 31)
Structural component re-use is rarely cost effective, though one supplier provided components and associated structural engineering advice, see below.
Contact: Bioregional Reclaimed (Surrey) 0208 404 0647

(l) **Built Up Roofing** (Specification Item 26)
Bonded or ‘sandwhich’ panels can be recycled but as yet this is technically demanding, with fewer facilities able to do the work and therefore less cost effective.
Contact: any built –up roofing supplier

(m) **EPS or XPS Insulation** (Specification Item 27)
Demolition Contractors contacted agreed that H&S concerns about mineral wool would mean it may soon be classed with asbestos. Expanded or extruded polystyrene has been used to reduce potential future costs.
Contact: any e/xps supplier.

(n*) **Recycled Content Concrete Blocks** (Specification Item 2)
Using recycled aggregates in blocks reduces resource use and removes materials from the waste stream.
Masterblock 01285 646 800 / www.masterblock.co.uk] manufacture lightweight and dense concrete blocks made of 100% recycled aggregates with a cement binder. At present they are the only company we know of doing so, though Thermalite in Birmingham [01675 468 451 / www.thermalite.co.uk] make aerated blocks which contain up to 85% recycled pfa (pulverised fuel ash) in their manufacture, though note there are concerns about the health implications of what may be radioactive slag waste.

(o*) **Using Recycled Material DPCs** (Specification Item 3, 13)
Using recycled material reduces both resource use and waste. In addition, PVC is widely held to be a particularly hazardous material both in manufacture and in use.
We know of three manufacturers who avoid PVC and utilise recycled content in their damp proof membranes and courses. Visqueen in Oxfordshire [01993 776346 / www.visqueenbuilding.co.uk] provide both dpms and dpcs with between 60% and 97% recycled LDPE. Frank Mercer in Lancashire [01942 841 111 / www.toughsheet.co.uk] manufacture dpms and dpcs with 98% post

consumer recycled LDPE and claim a cost saving and improved performance over conventional materials. Capital Valley Plastics Ltd. in Gwent [01495 772 255 / www.capitalvalleyplastics.com]] supply dpms with 100% recycled, mostly post consumer LDPE. All three are potentially recyclable at end of life but no apparent measures are in place to ensure this happens.

(p*) **Reused Brickwork** (Specification Item 4, 7)
Bricks are one of the few construction elements which remain relatively easy to source for re-use.
One source, UK wide, is Salvo (www.salvo.co.uk), other sources will include local scrap merchants and salvaged building material suppliers.

(q*) **Mineral Paint finishes to Blockwork** (Specification Item 7)
Conventional paint finishes tend to form a 'skin' which can become damaged when blocks are re-used, and which cannot be easily overpainted.
Mineral paints, on the other hand, form no such 'skin' and instead bond with the block forming more of an integral surface finish. Blocks using mineral paint finishes are likely in practice to be more readily overpainted and thus more cost effective when re-used.
Contacts include Keim Paints (01746 714 543 / www.keimpaints.co.uk) and Beecks Paints, available for Natural Building Technologies (01844 338 338 / www.natural-building.co.uk)

Caveat

It is important to emphasise the scope and purpose of the following drawings and specifications.

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Their purpose is not to offer approved details in any sense, but to illustrate the difference between details and specifications which do not address deconstruction issues, and those that do. It is the differences between the originals and alternatives which is intended to be illustrative, not necessarily the alternatives themselves.

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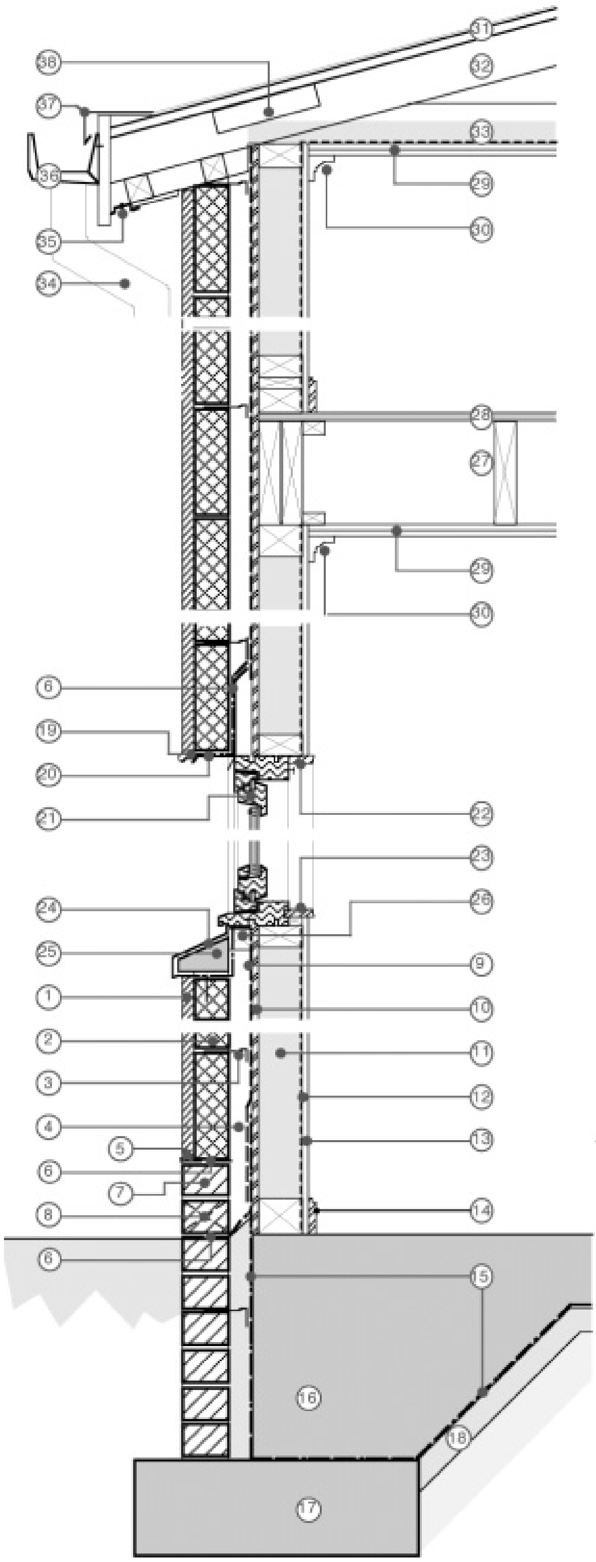
6.2 Timber Frame with Concrete Block Outer Leaf

Standard, fast and economic construction applicable to most project types.

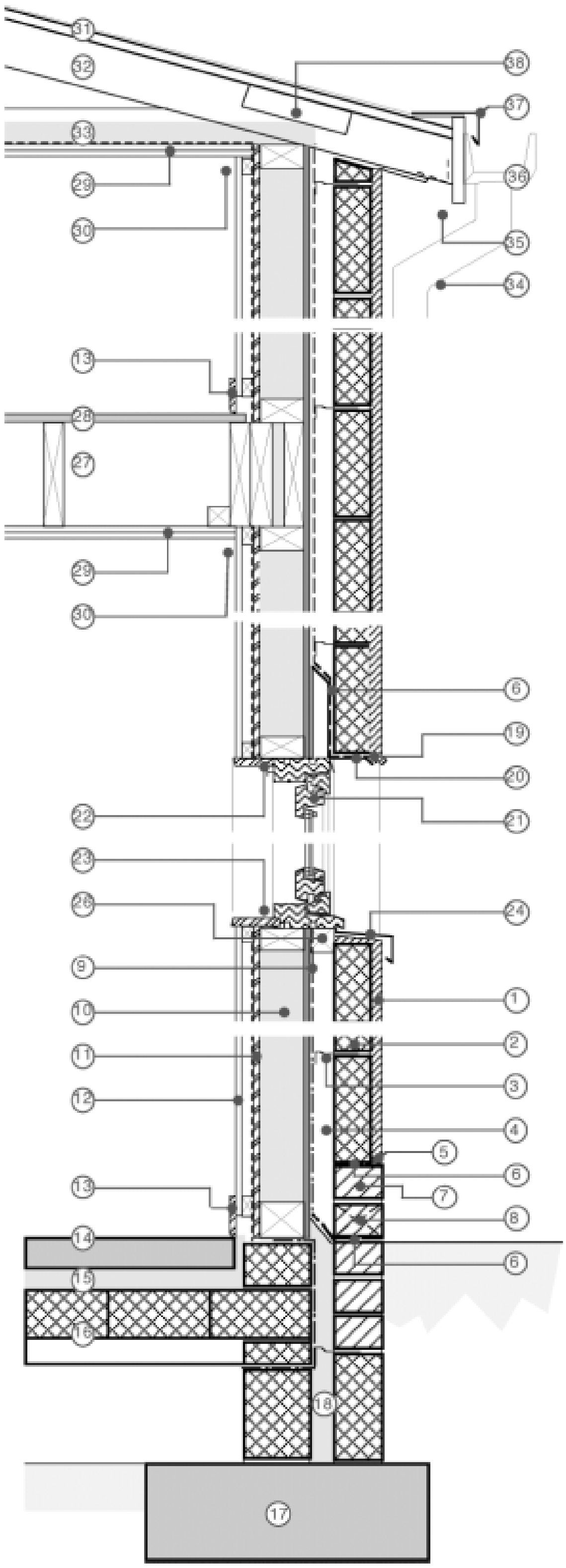
Typical Specification

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. 95mm soft wood studs @ 600mm centres - nail fixed to form frame with 100mm mineral fibre quilt insulation held in cavity by frame construction
12. Vapour barrier stapled to interior side of studs
13. 12.5mm plasterboard
14. 75 x 15mm MDF skirting board nail fixed to frame
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
28. 18mm tongue and groove chipboard screwed to joists
29. 2 layers 12.5mm plasterboard nailed to u/side of joists
30. Extruded polystyrene cornice glue fixed - 1 coat satin emulsion finish
31. Proprietary single ply membrane roofing with profiles @ 600mm centres - membrane mechanically fixed to ply sheathing deck fixed to truss
32. Proprietary timber roof truss with bolted joints



33. 100mm rigid polystyrene eps butt jointed insulation
34. UPVC down pipe
35. Vents within soffit
36. Aluminium ppc gutter mechanically fixed to edge board by brackets
37. Mechanically fixed angle flashing
38. Insulation stop

Alternative Specification



1. Lime: sand (a) render in two coats, or dry cladding materials (p*) eg. timber,/ mineral board
2. 100mm dense (q*) blockwork in lime (a) mortar
3. Cavity wall ties mechanically fixed @ 900mm centres horizontally and 450mm vertically - all staggered
4. 50mm ventilated cavity
5. Render stop bead fixed @ 600mm centres
6. PVC (r*) damp proof course and rigid tray
7. 100mm facing brickwork (s*) in lime (a) mortar
8. Perpend weep slots @ 900mm centres
9. Taped and sealed breather paper fixed to 10mm 'Panelvent' board (b) screwed (c) to studs.
10. 95mm untreated (b) soft wood studs @ 600mm centres with 100mm cellulose fibre (b) insulation
11. Vapour Check (b) stapled to OSB board (b), screwed (c) to studs. Vapour check taped and sealed.
12. 12.5mm t+f p'board (t*) over 25mm service void (d)
13. 19mm softwood skirting board with 2 coats biodegradable (e) paint finish screwed (c) through board to raised (f) packer, min. 50mm space behind for services (f)
14. Min. 65mm screed with float finish, insulation / expansion edge strip (g)
15. 50mm rigid polystyrene eps butt jointed insulation
16. 150 depth beam and block floor with standard block infill, lime grouted, min. 75mm ventilated and drained cavity beneath. Slip block infill. (h)
17. Pre-cast, post tensioned ground beam over piles (i)
18. 50mm rigid polystyrene eps butt jointed edge insulation in cavity to cavity tray
19. Render stop nailed to blockwork at 600mmcentres
20. Galv. steel lintol / cavity closer to Struct. Eng.'s spec
21. Proprietary pine tilt and turn double glazed window unit (u*) screwed to masonry or support framework
22. 19mm timber internal surround with 2 coats biodegradable (e) paint finish, screw fixed, (c)
23. 19mm timber cill with 2 coats biodegradable (e), screw fixed, (c)
24. Mill finish (j) aluminium external cill flashing mechanically fixed to frame, supported by block / mortar build-up beneath (no cill piece) (k)
26. SW packer cavity closer
27. Timber joists @ 450mm centres fixed at perimeter support by mechanically fixed steel joist hangers
28. 22mm t+g timber boards screw (l) fixed to joists
29. 2 layers 12.5mm t+f plasterboard (t*) screwed (c) to underside of joists
30. No cornice (v*)
31. Proprietary single ply membrane roofing with profiles @ 600mm centres - membrane mechanically fixed (m) to ply sheathing deck screwed (c) to truss
32. Proprietary timber roof truss with bolted joints
33. 100mm flexible batt (n) insulation with fine mesh overlay to prevent disruption and keep clean
34. UPVC (w*) down pipe
35. Galv. steel mesh strip stapled to back of eaves board and back of timber soffit board before screw fixing to trusses, leaving requisite gap. Timber soffit boards to be painted with natural finish (o)
36. Mill finish (j) aluminium gutter mechanically fixed to edge board by brackets. Timber edge board, finished with natural coating. (e)
37. Mechanically fixed angle flashing
38. Insulation stop

Explanation

While the replacement of cement mortar and render with lime allows for a significant volume of potential landfill to be recovered, the other two high priorities for this detail focus on the potential to reduce the disruption and waste which arises from frequent service and internal finish alterations.

The service void offers construction process advantages and subsequent ease of medium and long term service alterations, while the small gap provided behind the screw fixed skirting allows for rapid and easy access to services without disruption to the wall finish.

The breathing wall reduces the waste at the end of the life of the building, but far greater volumes of waste are likely to be saved by the two measures above which address waste arisings from the building in use, hence their respective prioritisation.

Whilst the use of polystyrene at low levels within the cavity is unavoidable, it makes less sense in the loft, where rigid boards cannot realistically be cut to precisely fit between joists, and re-use is unlikely.

The use of timber boards instead of chipboard for the upper floor is preferred from the point of view of resource use, waste reduction, and health of occupants, but to do so carries cost penalties, largely from inconveniences on site, which can only be partly offset against the cost of additional floor finishes, and so remains a low priority.

Despite making little reduction in the waste overall, some of the low priority measures cost little or no more than the conventional specification and as such may be recommended for those with minimal leeway on cost.

HIGH PRIORITY

Service Void (d)

This allows for flexibility of services arrangements in the long term without disruption or risk of damage to the insulated wall fabric

This measure is likely to reduce major fabric disruption and waste arisings from service re-routing / upgrading - one of the most common reasons for demolition and waste.

Screw fixed skirting (c)

Screw fixing allows the skirting to be used for easy access to services without further disruption to the wall surface.

Principal benefits are within lifetime use for access to services, as re-use of skirting is unlikely in practice. Advantageous with or without service void (or indeed with other inner leaf constructions)

Lime Mortar and Render (a)

Lime mortar and render is softer than the blocks and enables easy demolition and cleaning of the blocks, so they can be re-used.

No need for movement / expansion joints with lime mortar, better protection of walls from moisture / freezing.

MEDIUM PRIORITY

‘Breathing’ Wall (b)

The ‘breathing’ wall uses only non-toxic materials, and with intrinsic protection against decay, allows all timber used to be untreated, so all materials may be safely re-used, recycled or composted - a zero waste option.

Hygroscopic insulation materials must be used.

Natural, Flexible Loft Insulation (n)

Rigid insulation between joists is unlikely to be re-used so a flexible alternative is to be preferred. Natural, biodegradable insulants offer a safe and zero waste alternative to man-made alternatives.

Flexible batts are also more likely to fit snugly and realise the anticipated energy savings.

MEDIUM PRIORITY

Screed / Beam and Block Floor (g, h)

Allows for greater re-use (rather than recycling) of materials, if grouted with lime and if unbonded.

Also dispense with need for dpm, and reduces oversight material. However ventilation is required to solum, and less thermal mass available within insulated envelope.

Screw Fixing (f)

Causes less damage and allows for greater re-use of materials than nailing.

Where components may be moved during their service life, screw fixing makes such removal and replacement easy and less disruptive.

LOW PRIORITY

Screwed Timber Floor Boards (l)

Allows for complete re-use of materials with no waste and safe composting of materials at the end of their life.

Timber with 'Natural' Paint (e)

Neither MDF or conventional paints are biodegradable whereas untreated timber with 'natural' paints can be safely composted.

Mechanically fixed Roofing (m)

Mechanically fixed components are easier to dismantle and re-use.

Pre-cast Ground Beam (i)

Large volume re-use possible if un-tensioning is straightforward and sizes compatible. Costly.

Eaves Detail (o)

Significantly improved detail but small volumes.

Mill finished Metal (j)

Mill finished metals increase the efficiency of recycling through reduced costs and pollution.

Simplified Cill (k)

Simplified detail, cost benefit but small volumes.

Costs

Lime render adds around 60% to the cost of the economical dry dash originally specified and lime mortar sourced from a bulk silo adds around 33% to the cost of the walls overall. However, by using the alternative opening detail substituting block walls only for the facing brick, this figure can be reduced to around 15%.

With careful design, cost neutrality could be achieved by substituting, for example, the first floor outer leaf with lightweight cladding such as timber.

The most advantageous measure is the breathing wall, service void and screw fixed skirting, though this costs around 75% more, due largely to the additional layer of OSB and the creation of the service void. However, the increased benefits in terms of ease of making alterations and upgrades, the improved recovery of components, the likely reduced cost of disposal, the increased insulation levels (linked to energy and cost savings) and reduced health risks to occupants make this measure arguably the most cost effective in the long run.

Replacing the chipboard floor with timber nearly doubles the cost, while substituting polystyrene for mineral wool, and natural flexible insulation for the polystyrene in the ceiling both add about 65% cost. Substituting the mdf for timber with natural coatings adds marginally to the cost, whereas removing the cornice and the revised eaves detail both reduce costs.

The beam and block floor is more expensive (by around 100%) than the slab. The use of ground beams is not cost effective, unless specific requirements of a site dictate otherwise.

Defects Liability / Insurance Issues

No additional issues have been raised regarding the alternative details, although the relative locations of the damp proof tray and sole plate were queried.

6.2 Index

(a) **Lime Mortar and Render** (Specification Item 1, 2, 7)
There is no need for a movement or expansion joint with lime mortars and renders, and because the lime is vapour transmissive, there is better protection for the blocks against moisture freezing within the construction. Lime render may be coated with lime washes, which in addition to being traditional have a subtler and arguably more attractive finish than conventional masonry painted finishes.
Contact: eg: Limetec: 0845 603 1143 / www.limetechnology.co.uk

(b) **'Breathing' Wall** (Specification Item 9, 10, 11)
The 'breathing' wall works by using an external sheathing with a high vapour permeability. This means that any moisture getting into the wall can easily escape (as long as the cavity is ventilated) so there is no risk of moisture build-up. The timber is protected therefore and need not be treated, the use of the hygroscopic cellulose insulation normally marketed as an integral part of the system is recommended.
Contact: Excel Industries: 01685 845 200

(c) **Screw Fixing** (Specification Item 9, 11, 13, 22, 23, 29, 31)
Screws enable components to be more readily removed without damage either to the component being removed, or the component to which it was fixed, a double benefit which enhances the possibility of components being able to be re-used, rather than recycled or even dumped. Several screw systems are now available where pre-drilling is not required, which reduced the cost and time differential between this and conventional nailed fixings.
Contact: n/a

(d) **Service Void** (Specification Item 12).
Services, Fittings and Fixtures are the elements of a building that are most likely to be altered or upgraded most often. Making it easy for Clients to alter these elements makes long term running of the building cheaper and reduces waste because removed elements often cause damage to other parts of a building, simply because of the layering of the construction.
Contact: n/a

(e) **Timber, with Biodegradable Paint Finish** (Specification Item 13, 22, 23, 36)
This could help reduce ultimate demolition and disposal costs. At the end of the life of the component, the component cannot be disposed of without a degree of pollution to the ground and groundwater and so should be treated as a separate waste. A 'natural' paint finish which is non-toxic and biodegradable on untreated timber will allow an otherwise 'natural' to be safely composted at the end of its life and so represent a zero waste option in the long term. Timber is also likely to sustain repeated removal and replacement better than MDF and so remain in use for longer.
Contact: eg. Natural Building and Decorating: 01546 886341, NBT Paints: 01844 338338, Construction Resources: 0207 450 2211, OS Colour: 01296 481220

(f) **Screw fixed skirting and Gap behind** (Specification Item 13)
Even though in this alternative detail there is a service void, the value of this detail is that everyday alterations to services may be made without access / damage to the general wall surface
Contact: n/a

(g) **Unbonded Screed** (Specification Item 14)
Cementitious mix more compatible with other likely waste for crushing, but depth may be reduced to 35mm or less if polymer added to mix (eg. Ronacrete: 01279 638 700). To cater for movement of the screed and to offer a degree of insulation around the edges and so reduce 'cold bridging' it is important to position an edge strip of a material like eps, woodfibre board, dense mineral fibre or similar. This edge strip also helps in the ultimate dismantling of the screed.
Contact: eg. RMC Readymix (0117 977 9534)

(h) **Beam and Block Floor** (Specification Item 16)
Also dispense with need for dpm, and reduces oversight material. However ventilation is required to solum, and less thermal mass available within insulated envelope.
Contact: Precast Flooring Federation (PFF), 0116 253 6161

(i) **Pre-cast Ground Beam** (Specification Item 17)
Installation is fast and less weather dependant, site removal much simpler and probably cheaper.
Contact: eg. Roger Bullivant, www.roger-bullivant.co.uk

(j) **Mill finish aluminium** (Specification Item 24, 36)
One advantage of aluminium over steel is that it needs no coatings to be durable. Plastic coatings add toxicity to the material and complicate the recycling process, adding to the pollution associated with extraction of the metal.
Contact: eg. ARWS (029) 2039 0576, Alumasc (01744 648 400)

(k) **Simplified Cill** (Specification Item 24)
Alternatively remove the aluminium and retain the masonry cill, but it is of less value to recyclers and inflexible in terms of window sizes for which it is useful and so is less likely to be re-used or recycled at the end of its service life.
Contact: n/a

(l) **Screw fixed Timber Floor Boards** (Specification Item 28)
To optimise this detail, the timber should be of reasonable quality (worth re-using), 4-side tongue and grooved, and screwed down with a minimum of (visible) fixings to make removal as easy as possible. In addition, a natural oil or wax finish should be applied which does not need to be sanded off before subsequent application of finishes.
However, there are a number of difficulties. If the timber is fixed as soon as the frame is up, the timber laid will probably shrink and move once the building is weathertight and heated, necessitating a ‘second fix’ to avoid large gaps between boards. In addition, the floor will inevitably get dirty (and require some remedial treatment) unless conscientiously protected throughout the build. If the timber is installed after the building has been made weathertight and with the heating on, a temporary floor surface (and possibly bracing element) will be needed for a large part of the build and then removed.

(m) **Mechanically fixed Roofing** (Specification Item 31)
Bonded or ‘sandwich’ panels can be recycled but as yet this is technically demanding, with fewer facilities able to do the work and therefore less cost effective. Mechanically fixed roofing components can be separated allowing for simpler recycling potential.
Contact: any built –up roofing supplier

(n) **Natural, flexible loft Insulation** (Specification Item 33)
Flexible batts (or loose fill options) are also likely to fit snugly and realise the anticipated insulation levels. Natural, biodegradable insulants offer a safe and zero waste alternative to man-made alternatives which, in some cases, may become notifiable waste and so represent a potential hidden cost (and waste) at the time of eventual disposal.
Contact: eg. Second nature Thermafleece (01768 486 285 / www.secondnatureuk.com), Construction Resources: (0207 450 2211 / www.constructionresources.com/), Excel Industries: (01685 845 200 / www.excelfibre.com/building), NBT: (01844 338338 / naturalbuildingproductscouk.ntitemp.com/)

(o) **Timber and Mesh Eaves Detail** (Specification Item 35)
This is a zero-waste alternative to the painted mdf/ply and pvc ventilator detail.
Contact: n/a

(p*) **Alternative cladding materials**
Dry fixed materials such as timber or other rigid boards are easier and cheaper to dismantle, offering greater potential for reuse.
The use of timber is ideal as it offers in addition a compostable, zero waste option, while some mineral, timber fibre based and other synthetic products are recyclable.

(q*) **Recycled Content Concrete Blocks** (Specification Item 2)
Recycled content blocks reduce waste going to landfill and the embodied energy and pollution of the block used.
Masterblock 01285 646 800 / www.masterblock.co.uk] manufacture lightweight and dense concrete blocks made of 100% recycled aggregates with a cement binder. At present they are the only company we know of doing so, though Thermalite in Birmingham [01675 468 451 /

www.thermalite.co.uk] make aerated blocks which contain up to 85% recycled pfa (pulverised fuel ash) in their manufacture. Note however concerns about health implication of potentially radioactive slag waste.

(r*) **Non-PVC Damp Proof Courses and Membranes** (Specification Item 6)
PVC is generally acknowledged as a particularly environmentally deleterious material and many environmental organisations advise against its use. LDPE options are easily and cheaply available, some are made of recycled material.
We know of three manufacturers who utilise recycled content in their damp proof membranes and courses. Visqueen in Oxfordshire [01993 776346 / www.visqueenbuilding.co.uk] provide both dpms and dpcs with between 60% and 97% recycled LDPE. Frank Mercer in Lancashire [01942 841 111 / www.toughsheet.co.uk] manufacture dpms and dpcs with 98% post consumer recycled LDPE and claim a cost saving and improved performance over conventional materials. Capital Valley Plastics Ltd. in Gwent [01495 772 255 / www.capitalvalleyplastics.com]] supply dpms with 100% recycled, mostly post consumer LDPE. All three are potentially recyclable at end of life but no apparent measures are in place to ensure this happens.

(s*) **Re-used Bricks** (Specification Item 7)
Bricks are one of the few construction elements which remain relatively easy to source for re-use.
One source, UK wide, is Salvo (www.salvo.co.uk), other sources will include local scrap merchants and salvaged building material suppliers.

(t*) **Alternatives to Plasterboard** (Specification Item 12, 29)
Plasterboard is ubiquitous and immensely useful, but it is difficult to fix in such a way as to enable complete re-use, and it is not necessarily safe to go to landfill.
Most uses of plasterboard involve either a complete skim coat, or a partial skim, both of which prevent any realistic re-use of the board once removed, as the screws attaching them are covered. This could be overcome by the use of a lining paper which can be removed, instead of skimming the boards. Since plasterboard (technically, ‘gypsum based board’) is normally painted, or coated in some other way, this coating can render the waste partially toxic. Alternative finishes such as timber boards or boards with secret fixings could be used to simplify dismantling.

(u*) **Window Detail** (Specification Item 21)
Timber windows should be untreated and dry glazed.
Timber windows only represent a better environmental option if they are untreated and dry glazed (i.e not putty or silicone fixed / bonded to frame etc.) This is because a treated timber frame is now likely to represent toxic waste, and the low value of the frame material (as opposed to metal or plastic) will preclude the economic sense of dismantling the window unless it is easy so to do. This is best achieved by specifying an untreated timber frame with full or partial aluminium external facings, and biodegradable internal coatings, such as by Osmo (01296 481 220 / www.osmouk.com) and gasket dry fixed glazing units (e.g by Exitex 00 353 4293 71244 / www.exitex.ie).

(v*) **No Cornice** (Specification Item 30)
Applied cornices are not likely to be re-used or recycled and hamper attempts to re-se of recycle surfaces to which they are fixed.
From the point of view of re-use, Cornices represent yet another component with little likelihood of re-use, get in the way of re-use of other materials and components, and unless fixed very lightly with a non-toxic adhesive, are best avoided.

(w*) **Non- PVC Rainwater Goods** (Specification Item 34)
PVC is generally acknowledged as a particularly environmentally deleterious material and many environmental organisations advise against its use. Metal based alternatives to pvc are common and more durable, if more expensive.
Mill finished aluminium systems are likely to be the alternative with the greatest potential for re-use, though copper systems are also available. Galvanised steel and painted cast iron options are also commonly used.

Caveat

It is important to emphasise the scope and purpose of the following drawings and specifications.

They are included solely to show practitioners the sort of alterations that can be made in order to enable buildings to be repaired, altered and disassembled without undue damage to adjacent elements or the elements themselves, to afford as much re-use as possible and to increase the ease and cost effectiveness of re-use and recycling in construction generally.

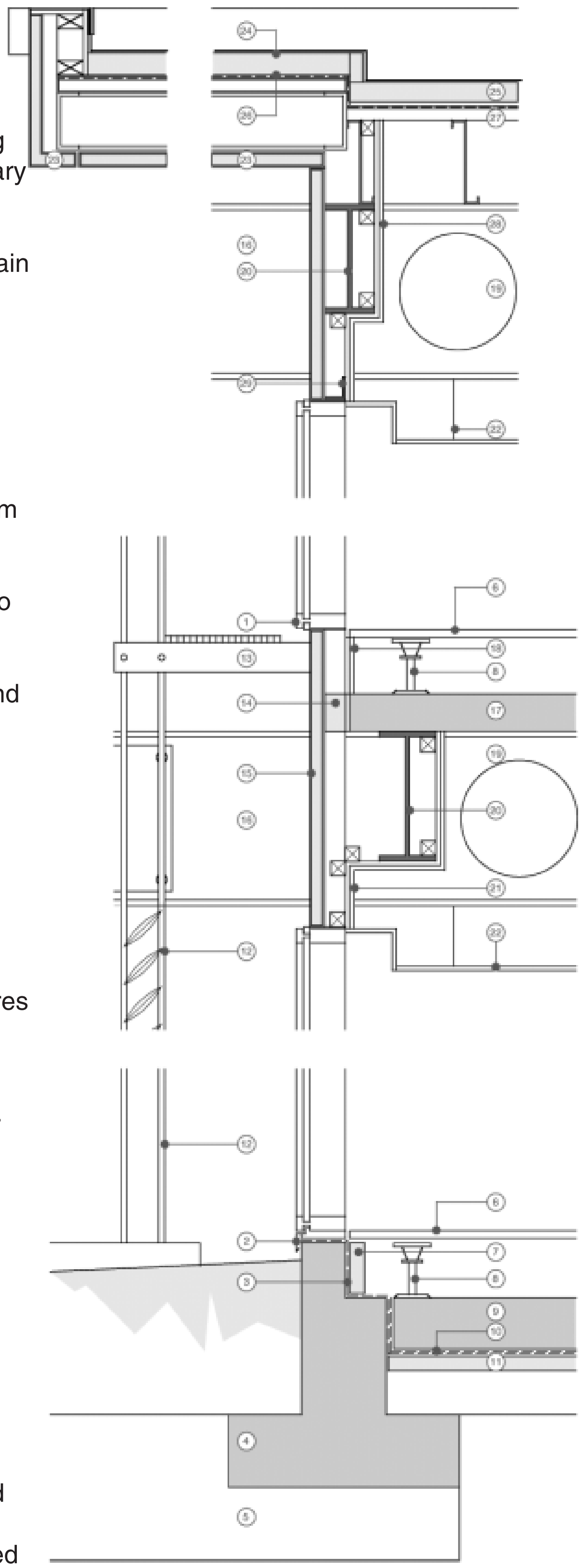
Their purpose is not to offer approved details in any sense, but to illustrate the difference between details and specifications which do not address deconstruction issues, and those that do. It is the differences between the originals and alternatives which is intended to be illustrative, not necessarily the alternatives themselves.

The original details have been taken from conventional details and specifications we believe to be broadly representative of their construction types. We hope the principles shown, and the specific references made will assist designers in making similar changes in their own work, but it goes without saying that SEDA cannot take responsibility for any work undertaken as a result of the use of these details.

Specifically, these details are not intended to show best practice in any sense, nor are they even intended to be up to date. We have striven in the preparation of these details and specifications to keep as close to the original as possible. We have done this in order to show that some quite fundamental alterations – in terms of deconstruction - may be made with the minimum of visual or functional impact on the original. Where these original details and specifications do not meet current standards or aspirations, the alternatives given are likely to be similarly wanting. To re-iterate, the purpose is not to produce approved details, but to illustrate the process of improvement – in terms of deconstruction only – that may be made.

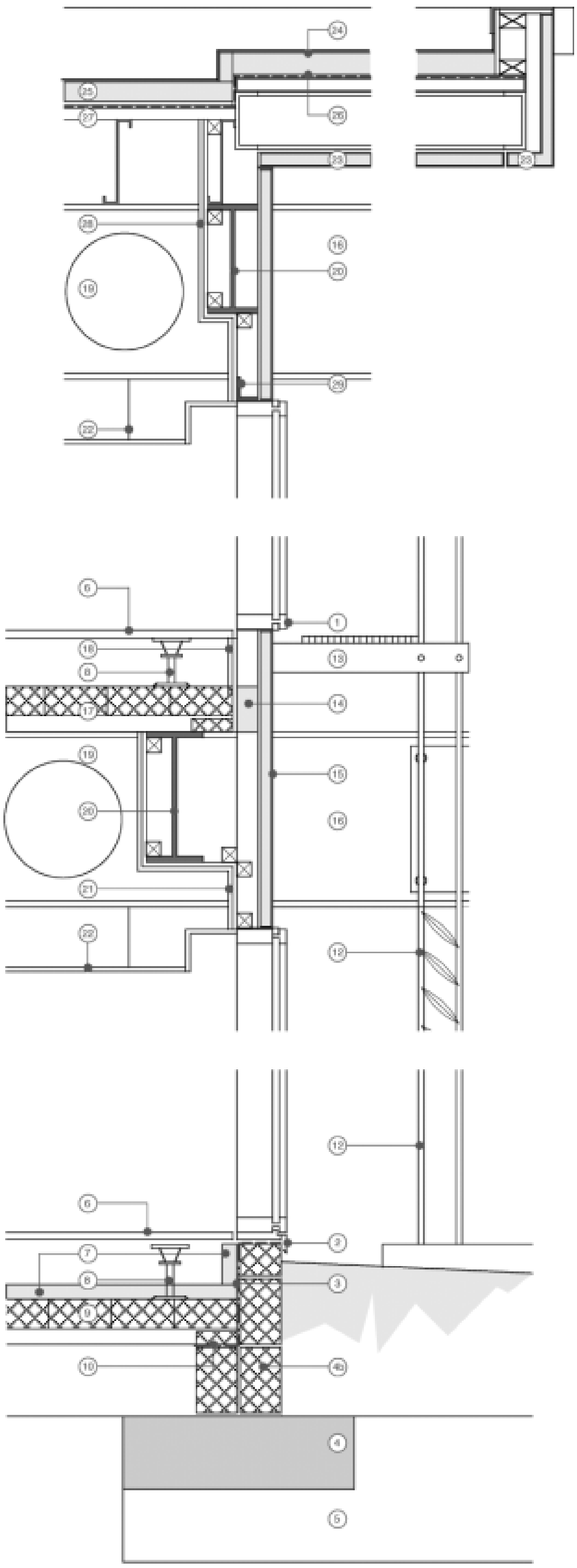
6.3 Steel Frame + Glazed Facade

Common lightweight construction associated with Offices and similar commercial applications.



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 rc 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 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 [not shown]
17. 125mm insitu concrete floor slab with float finish
18. 2 x 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 ppc 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 with vapour resistant tape
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. Secondary steel support angle



Alternative Specification

1. 175mm deep overall mill finish (a) aluminium curtain walling system with dry fixed components (b) spanning from ground floor slab to secondary steel at roof level, tied back to steel structure at intermediate floor levels
2. Mechanically fixed mill finish (a) aluminium flashing and infill between curtain walling and upstand
3. PVC (o*) Damp proof course
4. Precast, post tensioned ground beam (c) spanning between pad foundations

4b.140mm concrete block work in lime mortar. (d)

5. Pad foundation to external column
6. Standardised 225mm deep overall proprietary access floor system, using tackifier adhesive (waterbased adhesive) for carpet tiles (e) (p*)
7. 50mm flexible batt insulation (f)
8. Raised access floor pedestals mechanically fixed to floor @ 600mm centres
9. 150 deep beam and block floor with standard block infill, grouted with lime mortar, min.75mm ventilated and drained cavity beneath. Slip block infill. (g)
10. PVC (o*) Damp proof course linked to 3.
12. Mill finished (a) Aluminium louvre blade sun shading on tensioned steel rods spanning from roof steel to accessible (h) fixing point at ground level, using demountable fixings where possible (i)
13. Steel maintenance walkway, with mansafe anchor points, on cantilever steel arm, fixed to secondary steel and tension steel rod using demountable fixings where possible (i)
14. 1 hour stopping at floor slab edge
15. Insulated mill finished (a) aluminium panel glazed into curtain walling horizontally and vertically @ 1500mm centres with dry fixed components (b)
16. Projecting beam with bolted fin plate connection to external chs column [not shown]
17. 125mm deep beam and block floor with standard block infill, grouted with lime mortar. (g)
18. 2 x 15mm wallboard infill below raised access floor
19. Cellular beam (j)
20. Steel I section beam (j)
21. 2 layers 15mm wallboard (k) infill between curtain walling and floor slab screwed to batons (i)
22. Mill finished aluminium framed proprietary suspended ceiling system fixed as per manufacturers recommendations using metal infills with colour coding (l) (q*)
23. Insulated mill finished (a) aluminium soffit panels with dry fixed components (b) with accessible (h) screw (i) fixing to secondary steel framing
24. Single ply roof membrane mechanically fixed (m)
25. 80mm butt jointed eps (n) slab insulation mechanically fixed
26. Reinforced polyethelene vapour barrier lapped and sealed with vapour resistant tape
27. Profiled metal deck with Z purlins (j) mechanically fixed @ 600mm centres
28. 2 layers 15mm wall board (k) infill between curtain walling and roof deck screwed to batons (i)
29. Secondary steel support angle

Explanation

The cladding / glazing system is the highest priority due to the likelihood of replacement / upgrading over time, the energy involved in initial production and replacement, and the large volume of waste generated if not properly detailed.

Though not detailed as using intumescents in the original detail the use of board fire protection has been prioritised because of the relative simplicity of the alteration, and the significant resultant improvements in reclamation potential and toxicity reduction.

Even though the steel frame structure is the least likely element to be replaced in this detail, the large volume and high energy input in manufacture make demountable, bolted detailing of the steelwork overall a high priority.

The mechanical bonding of individual roof elements is already good practice from the perspective of re-use and recycling.

The beam and block alternative proposed is not compromised by the need for a screed in this application so makes good sense, enabling large quantities of inert material to be re-used.

Alterations to the applied insulation, in the roof and under the raised floor, allow for complete re-use of materials and are simple changes to make with no implications on the rest of the construction.

Both raised access floors and suspended ceilings offer benefits for flexibility and accessibility of services and other often-altered elements such as worn carpet areas. In the alternative details we have sought to optimise these benefits through greater durability of ceiling tiles and easier replacement of floor finishes which are significant sources of waste from wear and tear.

HIGH PRIORITY

Dry Fixed Cladding Components (b)

Dry fixing enables easy and complete separation of components for re-use or recycling.

Dry fixing here may mean the use of screws, clips, gaskets and compriband in preference to rivets, mastics, adhesives and tapes etc.

Board Fire Proofing (k)

Intumescent coatings are toxic and complicate re-use/recycling of steelwork.

Boards, such as gypsum are non-toxic and easily removed.

Bolted Steel Structure (j)

Most solid steel is recycled already, but bolted elements, of standard, repeated lengths will encourage component reuse.

Structural component re-use is rarely cost effective, though one supplier provided components and associated structural engineering advice, see index.

Mechanically fixed Roofing (m)

Mechanically fixed roofing components, will enable easier, and therefore more cost effective re-use and recycling.

Bonded or 'sandwich' panels can be recycled but as yet this is technically demanding, with few facilities available and high cost.

Accesible and demountable fixings (h, i)

Friction, clip, screw or bolted fixings are easy, quick and cheap to undo for both maintenance and eventual replacement of components.

Easy dismantling also means less damage to components so allowing greater reuse potential.

MEDIUM PRIORITY

EPS Roof Insulation (n)

Mineral Fibre insulation may soon become notifiable waste, adding to eventual disposal costs and waste.

Simple butt jointed eps batts may be easily re-used.

MEDIUM PRIORITY

Beam and Block Floor (g)

Allows for greater re-use of materials, if grouted with lime and separated from screed etc.

Also dispense with need for dpm, and reduces oversight material. However ventilation is required to solum, and less thermal mass available within insulated envelope.

Mill finished Metal (a)

Mill finished metals increase the efficiency of recycling through reduced costs and pollution.

Though there may be aesthetic implications.

Flexible Insulation (f)

Flexible insulation between floor access pedestals allows for re-use of the insulation

It also gives a better level of insulation in reality as rigid batts are unlikely to fit perfectly together.

Carpet Tile Adhesive (e)

A relatively weak adhesive will allow tiles to be removed easily and without damage to other components.

An improvement on this is to use leased, recycled tiles.

Durable ceiling Tiles (l)

Durable tiles, for example mineral or metal, will withstand repeated disruption and reduce waste.

First costs will be higher than eps alternatives.

LOW PRIORITY

Blocks with Lime Mortar (d)

Significant improvement on insitu rc upstand, but relatively small volumes.

Pre-cast Ground Beam (c)

Large volume re-use possible if un-tensioning is straightforward and sizes compatible.

Costs

Cost comparisons are difficult in this instance. Altering the finish of the curtain walling components to a mill finish is likely to have no effect on cost, although in some cases this is not standard so may attract a small surcharge, however the differences are lost when comparing the various systems on the market which vary widely in quality and cost. What can be said with confidence is that dry systems are the exception and as such are likely to be more expensive than traditional silicon sealed systems.

The use of ground beams is not cost effective generally, unless specific requirements of a site dictate otherwise, but while the beam and block ground floor is more expensive (by around 100%) than the slab, it is cheaper than the reinforced slab at first floor by a similar margin. Taken together, it may be possible to achieve cost neutrality with careful design, and depending on internal support arrangements.

EPS insulation in the roof adds around 50% to the cost, but this should be balanced against potential disposal costs in future. Substituting metal tiles for mineral ones appears to add about 30% cost, although this increase may be reduced by some ‘shopping around’ for alternative suppliers.

Defects Liability / Insurance Issues

No additional issues have been raised regarding the alternative details.

However, both original and alternative details are related to Design and Build situations where final curtain walling details, for example, are likely to be developed with the Main Contractor and a Proprietary System Provider. Some further clarification would be required on the suitability of a dry fixed system with regard to water shedding and drainage, ventilation capacity and airtightness of the backing wall.

6.3 Index

(a) **Mill finish Metal** (Specification Item 1, 2, 12, 15, 23)
Most sheet metals used in construction are coated in one way or another. These coatings tend to be either metallic, for example zinc plating (galvanising), anodising or similar, or plastic based, for example, polyester powder coated, pvc, enamel and so on. All coated sheet metal CAN be recycled (it is very rarely re-usable) but the various coatings do complicate and therefore increase the cost of reclaiming the metal. The most cost effective recycling of metal is clearly when there is no contamination by coatings, glues etc. This being the case, the best practice when using sheet metal – from the point of view of recycling – is to use unbonded (mechanically fixed) uncoated sheet. Steel cannot easily be used without some form of protective coating, whereas aluminium, copper and some others can be used with a mill finish which requires no additional coating and is nonetheless extremely durable.

(b) **Dry Fixed Components** (Specification Item 1, 15, 23)
In this context glazing and metal framing may be connected, held in place and made airtight by gaskets (such as rubber), clip fixings and screws in preference to silicon or other 'soft' and applied sealants, adhesive or resin bonds, adhesive tapes, welding and other such joins which render the separation of glass from metal, and of metal components from each other difficult and therefore costly. Compressible fillers, can also be used in place of silicone between the window frame and building fabric, such as Compriband (01914190505 / www.compriband.co.uk), this product leaves less of a residue between connecting surfaces when removed.

(c) **Pre-cast Ground Beam** (Specification Item 4)
Installation is fast and less weather dependant, site removal much simpler and probably cheaper. Contact: eg. Roger Bullivant, www.roger-bullivant.co.uk

(d) **Blocks with Lime Mortar** (Specification Item 4b)
There is no need for a movement or expansion joint with lime mortars and renders, and because the lime is vapour transmissive, there is better protection for the blocks against moisture freezing within the construction.
Contact: Blocks: any concrete block manufaturer, Lime mortar: Limetec: 0845 603 1143 / www.limetechnology.co.uk

(e) **Carpet Tile Adhesive** (Specification Item 6)
There are a number of water based and natural latex adhesives available, which can leave a limited amount of residue when separated. Rigid floor finish tiles may be mechanically clipped or even magnetically held down to much the same effect.
Contact: Construction Resources supply both natural latex adhesives and water based acrylic adhesives (02074502211 / www.constructionresources.com).
Dalsouple supply magnetic rubber tiles, where the issue is avoided altogether (01278 727777 / www.dalsouple.com)

(f) **Natural, Flexible Batt Insulation** (Specification Item 7)
Flexible batts (or loose fill options) are also likely to meet properly and realise the anticipated insulation levels. Natural, biodegradable insulants offer a safe and zero waste alternative to man-made alternatives which, in some cases, may become notifiable waste and so represent a potential hidden cost (and waste) at the time of eventual disposal.

(g) **Beam and Block Floor** (Specification Item 9, 17)
Also dispense with need for dpm, and reduces oversight material. However ventilation is required to solum, and less thermal mass available within insulated envelope.
Contact: Precast Flooring Federation (PFF), 0116 253 6161

(h) **Accessible Fixings** (Specification Item 12, 23)
Where, for example, there may be concerns about vandalism, it is preferable to use vandal-proof fixings than to make the fixings relatively inaccessible. There may also be aesthetic implications as this detail becomes more important the more frequently components are maintained and altered – which tends to be nearest the surface of a building. Accessible in this context means: a) easy to reach (not too high from floor, no scaffolding required /accessible from inside not outside etc.), b) easy to work (room for hand, arm, tool and movement, not too fiddly etc.), c) not requiring

such unusual tools that a standard tradesman would not be able to work / ensuring that special tools are on hand and clearly labelled, and d) fixings are clearly labelled, and information pertaining to the fixings and components is available. Contact: n/a

(i) **Easily Demountable Fixings** (Specification Item 12, 13, 21, 23, 28)
Such fixings enable components to be more readily removed without damage either to the component being removed, or the component to which it was fixed, a double benefit which enhances the possibility of components being able to be re-used, rather than recycled or even dumped. Several screw systems are now available where pre-drilling is not required, which reduced the cost and time differential between this and conventional nailed fixings.
Contact: n/a

(j) **Bolted Steel Structure** (Specification Item 19, 20, 27)
Structural component re-use is rarely cost effective, though one supplier provided components and associated structural engineering advice, see below.
Contact: Bioregional Reclaimed (Surrey) 0208 404 0647

(k) **Board Fire Proofing** (Specification Item 21, 28)
There may be situations where intumescent coating of steelwork is unavoidable for aesthetic or other reasons, but consider making connections where such steelwork can be board protected to minimise the need for intumescents and maximise the re-use and recycling efficiencies of the steelwork.
Contact: Several Gypsum or other board protection Suppliers.

(l) **Metal Ceiling Tiles** (Specification Item 22)
Suspended ceilings are advantageous from the point of view of Design for Deconstruction as they enable considerable amounts of services to be hidden, yet easily accessible for maintenance and alteration. This advantage is somewhat reduced if ceiling tiles are easily damaged and need frequent replacement.
Contact: Several Manufacturers and Suppliers.

(m) **Mechanically fixed Roofing** (Specification Item 24)
Bonded or ‘sandwich’ panels can be recycled but as yet this is technically demanding, with fewer facilities able to do the work and therefore less cost effective.
Contact: any roofing supplier

(n) **EPS or XPS Insulation** (Specification Item 25)
Demolition Contractors contacted confirmed that the reclassification of commonly used materials can have a dramatic impact on the costs at end of use. These issues have been discussed more fully in SEDA’s “Design and Detailing for Toxic Chemical Reduction in Building”. Expanded or extruded polystyrene has been used to reduce potential future costs.
Contact: any e/xps supplier.

(o*) **Using Recycled Material DPCs** (Specification Item 3, 10)
Using recycled material reduces both resource use and waste. In addition, PVC is widely held to be a particularly hazardous material both in manufacture and in use.
We know of three manufacturers who avoid PVC and utilise recycled content in their damp proof membranes and courses. Visqueen in Oxfordshire [01993 776346 / www.visqueenbuilding.co.uk] provide both dpms and dpcs with between 60% and 97% recycled LDPE. Frank Mercer in Lancashire [01942 841 111 / www.toughsheet.co.uk] manufacture dpms and dpcs with 98% post consumer recycled LDPE and claim a cost saving and improved performance over conventional materials. Capital Valley Plastics Ltd. in Gwent [01495 772 255 / www.capitalvalleyplastics.com]] supply dpms with 100% recycled, mostly post consumer LDPE. All three are potentially recyclable at end of life but no apparent measures are in place to ensure this happens.

(p*) **Recycled or Leased Carpet Tiles** (Specification Item 6)
Recycled material tiles reduce the waste stream, reduce resource use and often reduce energy and pollution associated with manufacture of components. Leased components return to the Manufacturer for recycling.
Contact: eg. Interface Carpets (01274 690 690 / www.interfaceeurope.com), Best Image (0870 3502 602 / www.best-image.com)

(q*) **Recycled Ceiling Tiles** (Specification Item 22)
Recycled material tiles reduce the waste stream, reduce resource use and often reduce energy and pollution associated with manufacture of components.
Contact: eg. Armstrong Ceilings (0800 371 849 / http://ceilings-eu.armstrong.com/CeilingsHome.asp)

Caveat

It is important to emphasise the scope and purpose of the following drawings and specifications.

They are included solely to show practitioners the sort of alterations that can be made in order to enable buildings to be repaired, altered and disassembled without undue damage to adjacent elements or the elements themselves, to afford as much re-use as possible and to increase the ease and cost effectiveness of re-use and recycling in construction generally.

Their purpose is not to offer approved details in any sense, but to illustrate the difference between details and specifications which do not address deconstruction issues, and those that do. It is the differences between the originals and alternatives which is intended to be illustrative, not necessarily the alternatives themselves.

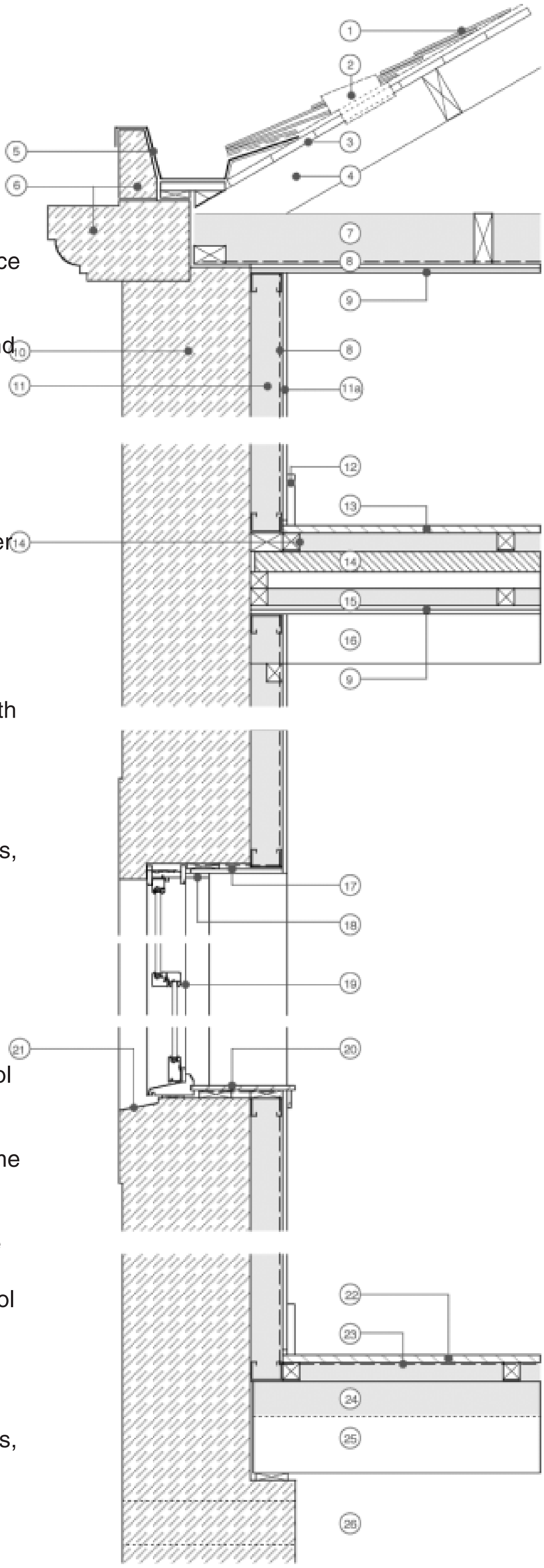
The original details have been taken from conventional details and specifications we believe to be broadly representative of their construction types. We hope the principles shown, and the specific references made will assist designers in making similar changes in their own work, but it goes without saying that SEDA cannot take responsibility for any work undertaken as a result of the use of these details.

Specifically, these details are not intended to show best practice in any sense, nor are they even intended to be up to date. We have striven in the preparation of these details and specifications to keep as close to the original as possible. We have done this in order to show that some quite fundamental alterations – in terms of deconstruction - may be made with the minimum of visual or functional impact on the original. Where these original details and specifications do not meet current standards or aspirations, the alternatives given are likely to be similarly wanting. To re-iterate, the purpose is not to produce approved details, but to illustrate the process of improvement – in terms of deconstruction only – that may be made.

6.4 Refurbishment of Masonry Building

Common form of construction

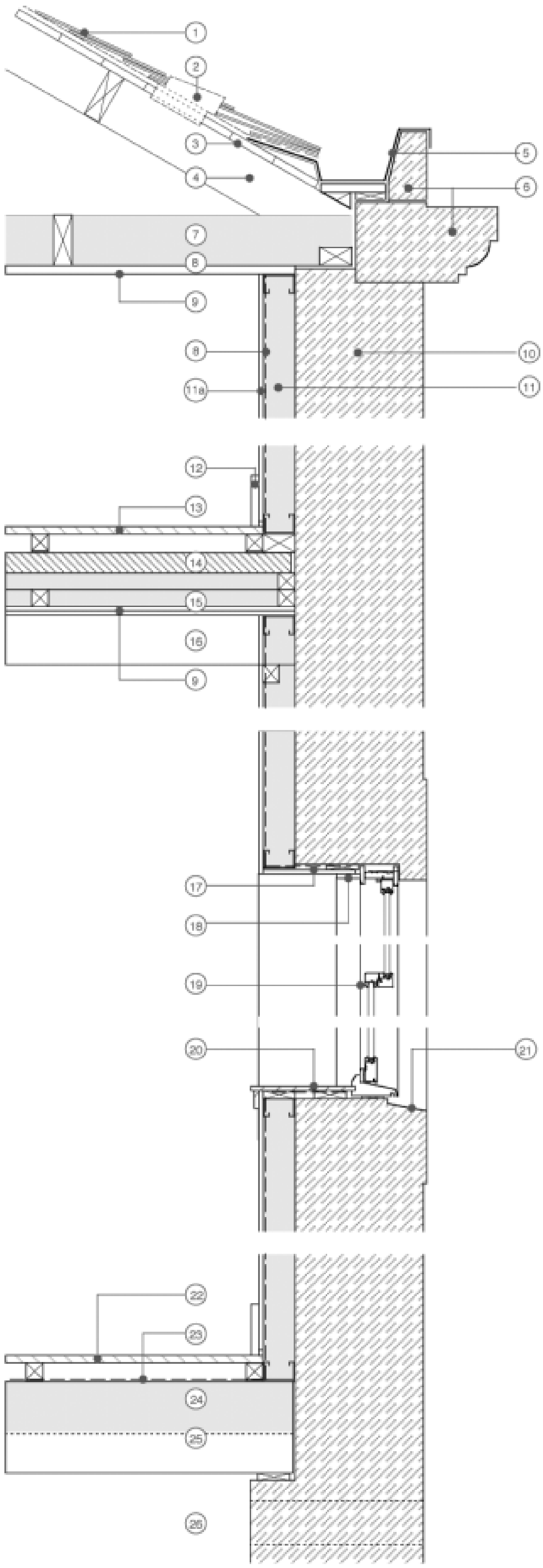
Typical Specification



1. Existing slates taken up and replaced, nailed through breather membrane 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 mineral wool insulation within existing 150mm ceiling joists.
8. Vapour Control layer
9. 2 layers of 12.5mm t&f plasterboard nailed to underside of existing ceiling joists (lath and plaster removed) 2 coat satin emulsion finish
10. Existing Stone External Wall.
11. 100mm mineral wool between 95mm proprietary metal studs fixed to existing external wall

11a1 layer of 12.5mm t+f plasterboard screwed to metal studs thru' vapour control layer (existing lath and plaster removed)

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 60mm thick floor boards.
15. 50mm mineral wool insulation within 50x50 softwood battens nailed to joists, with dwangs, to form ceiling between joists
16. Existing softwood joists, lower section exposed, 2 coat varnish.
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. Raised 22mm type III chipboard floor screwed to cushioned timber battens 50x50mm at 400 centres, 50mm mineral wool infill, resting on existing floor joists. (existing floor boards removed)
23. Vapour barrier
24. 100mm mineral wool insulation within existing joists, supported by netting.
25. Existing softwood joists, resting on packers.
26. Existing ventilated solum.



Alternative Specification

1. Existing slates taken up and replaced, nailed through breather membrane 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 natural, hygroscopic batt (a) insulation within existing 150mm ceiling joists.
8. No vapour Control layer to ceiling (b) [calculation required] Vapour control layer still required in wall
9. Existing Lath and Plaster ceiling finish (b) against existing ceiling joists, 2 coat biodegradable (a) paint finish
10. Existing Stone External Wall.
11. 100mm mineral wool between 95mm proprietary metal studs fixed to existing external wall

11a1 layer of 12.5mm t+f plasterboard (j*) screwed to metal studs thru' vapour control layer (existing lath and plaster removed)

12. 19mm softwood (c) skirting board with 2 coats biodegradable (c) paint finish screwed (d) through board to studs
13. Raised 22mm easy access timber (e) floor screwed to cushioned timber battens 50x50mm at 400 centres, 50mm service void beneath. (f)
14. Existing 60mm thick floor boards.
15. 100mm Natural, biodegradable (a) insulation above and within 50x50 softwood battens nailed to joists, with dwangs, to form ceiling between joists
16. Existing softwood joists, lower section exposed, 2 coat biodegradable (g) oil/wax finish
17. Plasterboard (j*) returned to form soffit, vapour control layer continuous over treated softwood or ply packers
18. Timber (c) Soffit lining tacked not glued (h) to window frame and plasterboard, gasket (i) sealed with 2 coats biodegradable (c) paint finish
19. Double glazed replacement timber sash and case window. Dry Gasket sealed (i) all around externally.
20. Timber (c) Cill into frame groove and over vapour control layer and packers, gasket (i) sealed with 2 coats biodegradable (c) paint finish
21. Existing shaped stone cill.
22. Raised 22mm easy access timber (e) floor screwed to cushioned timber battens 50x50mm at 400 centres, 50mm service void beneath. (f) over existing floor joists. (existing floor boards removed)
23. Vapour barrier
24. 150mm Natural, biodegradable (a) insulation within existing joists, supported by netting.
25. Existing softwood joists, resting on packers.
26. Existing ventilated solum.

Explanation

Ultimately, the complete re-use of a building, as described in the above details, is almost always the most effective form of waste reduction, though sometimes it is not practical or cost effective.

Nonetheless, such refurbishment projects can sometimes still produce vast quantities of waste as internal finishes and defunct services are stripped out. The aim of the alternative detail is to show how further refurbishments may be made with minimal waste arisings, and in some parts to indicate ways of reducing waste from the initial refurbishment process itself.

The most important priority, because it addresses the long term use and workings of the building, is the combined use of the easy access timber floor and the service void beneath. This detail allows for simple and therefore cheap alterations in the most likely areas (services provision) and has the potential to reduce by a considerable sum the waste arisings to emanate from the building over the next few generations. The disadvantages of using timber in new build situations are removed and it is also worth noting that at the end of their service life, the boards may be safely composted if they have not been coated in toxic, non-biodegradable coatings.

The use of natural insulation is shown as a high priority because of the relatively high volumes involved. Similarly the retention of the existing lath and plaster, if acceptable, again reduces the likely landfill associated with the initial refurbishment.

The other medium and low priority measures are as such because of the relatively low volumes involved.

HIGH PRIORITY

Easy Access Timber Flooring (e)

This particular detail, in conjunction with the service void beneath, enables very easy access to services during the building's life.

Chipboard is unlikely ever to be re-used and the resin bond is not readily biodegradable. Easy access screw fixed timber flooring is re-usable and is completely biodegradable at the end of its life.

Service Void (f)

This allows for flexibility of services arrangements in the long term without disruption or risk of damage to other components

This measure is likely to reduce major fabric disruption and waste arisings from service re-routing / upgrading - one of the most common reasons for demolition and waste.

Natural Insulation (a)

Some mineral fibres may soon become notifiable waste and so may represent additional cost at the time of disposal.

Natural Insulants are biodegradable and hygroscopic so they can be safely composted – zero waste – and help manage moisture in the building which can be useful in certain cases.

MEDIUM PRIORITY

Keep Existing Lath and Plaster (b)

Keeping the Existing Lath and Plaster reduces the volume of waste destined for landfill.

Hygroscopic insulation materials must be used in the loft if no vapour control layer is to be applied.

Timber with 'Natural' Paint (c)

Neither MDF or conventional paints are biodegradable whereas untreated timber with 'natural' paints can be safely composted.

Timber is also likely to sustain repeated removal and replacement better than MDF.

MEDIUM PRIORITY

Gasket Fixings (i)

Dry gasket fixings allow for complete and easy separation and removal of components.

Silicone and other mastic-type sealants can make meaningful re-use and even recycling of components difficult, costly and sometimes even impossible.

No Glue (h)

Glued connections make subsequent removal, for maintenance or replacement much more difficult, costly and potentially damaging to the component itself and those to which it is glued.

The alternative is simply to ensure that the fixing is made adequately without the need for glue.

Screw Fixing (d)

Causes less damage and allows for greater re-use of materials than nailing or gluing.

Where components may be moved during their service life, screw fixing makes such removal and replacement easy and less disruptive.

LOW PRIORITY

Biodegradable Oil/Wax Finish (g)

Timber components may be safely composted if no re-use can be found, but this may be compromised by chemical treatment or subsequent coatings that render the finished element at least partly toxic and non-biodegradable.

Costs

Replacing the chipboard floor with the easy access timber flooring and service void beneath adds around 25% to the cost of the flooring (although some of that cost is offset to the additional insulation needed in the ceiling beneath) This relatively minor cost increase, together with the major benefits in use make it the most important measure to take.

Substituting natural insulation for the mineral wool in the ceiling adds vastly to the cost, but if the plaster can be retained and touched up as described then the savings from not removing, adding a vapour check, two layers of plasterboard and decoration actually match the cost increases of the natural insulation thus achieving a zero cost increase overall.

With no change in detail to offset the costs of the natural insulation in the ground floor, the increase in cost of the alternative detail is around 300%.

Altering the mdf skirtings, and other linings, along with natural decorations adds approximately 25% to the costs. Sealing the windows with dry gaskets rather than silicon adds only nominally to the costs of installation.

Defects Liability / Insurance Issues

No additional issues have been raised regarding the alternative details.

However, on both details confirmation would be required regarding the risk of summer condensation on the vapour control layer and the need for a ventilated cavity, also the risks associated with cold bridging at the openings where the reveals are left uninsulated.

6.4 Index

(a) **Natural, Biodegradable and Hygroscopic Insulation** (Specification Item 7, 9, 15, 24)
In the case of the first instance of this use of natural insulants, in the loft, it is the hygroscopic nature of the natural insulations which is paramount, since it is this quality which is likely to enable the designer to avoid the vapour control layer.
Natural, biodegradable insulants offer a safe and zero waste alternative to man-made alternatives which, in some cases, may become notifiable waste and so represent a potential hidden cost - and waste - at the time of eventual disposal. Note that we have not suggested the use of a biodegradable insulant within the wall linings as there is no ventilation and some risk of decay.
Contact: eg. Second nature Thermafleece (01768 486 285 / www.secondnatureuk.com), Construction Resources: (0207 450 2211 / www.constructionresources.com/), Excel Industries: (01685 845 200 / www.excelfibre.com/building), NBT: (01844 338338 / naturalbuildingproductscouk.ntitemp.com/)

(b) **Keep Existing Lath and Plaster** (Specification Item 8, 9)
Though this option is not practicable where additional insulation must be installed and there is no other way to do so except by removing the lath and plaster, this is not the case in the loft space. Although no vapour control layer can be easily installed if the existing lath and plaster is kept, it is likely that a natural, hygroscopic insulant, combined with the loft ventilation could overcome concerns about interstitial condensation.
Contact: n/a

(c) **Timber with 'Natural' Paint Finish** (Specification Item 12, 18, 20)
This could help reduce ultimate demolition and disposal costs. At the end of the life of the component, the component cannot be disposed of without a degree of pollution to the ground and groundwater and so should be treated as a separate waste. A 'natural' paint finish which is non-toxic and biodegradable on untreated timber can be safely composted at the end of its life and so represent a zero waste option in the long term. Timber is also likely to sustain repeated removal and replacement better than MDF and so remain in use for longer.
Contact: eg. Natural Building and Decorating: 01546 886341, NBT Paints: 01844 338338, Construction Resources: 0207 450 2211, OS Colour: 01296 481220

(d) **Screw Fixing** (Specification Item 12)
Screws enable components to be more readily removed without damage either to the component being removed, or the component to which it was fixed, a double benefit which enhances the possibility of components being able to be re-used, rather than recycled or even dumped. Several screw systems are now available where pre-drilling is not required, which reduces the cost and time differential between this and conventional nailed or glued fixings.
Contact: n/a

(e) **Easy Access Screw fixed Timber Floor Boards** (Specification Item 13, 22)
The "Easy Access" part of this section refers to a particular type of floor detail pioneered in Scotland by Gaia Architects at the Glencoe Visitor Centre. The floor boards themselves are short, (for example 1200 mm lengths) tongue and grooved along their length but rebated at their ends. They are held down with timber strips which cover the rebated end of one line, and the rebated ends of the next, and it is only these strips which are screwed down to the battens beneath. The floor boards themselves are held merely by their tongue and grooved sides, and the strips along each end. When access is required to the service void beneath, a few screws only need be removed along the strips and the boards themselves can be removed without any damage to any component. All components can be independently repaired, tightened or replaced, and the whole can be readily re-used.
To optimise this detail, the timber should be of reasonable quality (worth re-using), and a natural oil or wax finish should be applied which does not need to be sanded off before subsequent application of finishes.
In addition, the difficulties sometimes associated with using timber floors in new build (refer 6.2) do not present themselves in this situation.
Contact: n/a

(f) **Service Void** (Specification Item 13, 22)
Services, Fittings and Fixtures are the elements of a building that are most likely to be altered or upgraded. Making it easy for Clients to alter these elements makes long term running of the building cheaper and reduces waste because removed elements often cause damage to other parts of a building, simply because of the layering of the construction. A service void in this case, with the use of the easy access timber flooring makes even better sense because of the ease with which it may be used.
Contact: n/a

(g) **Biodegradable Oil / Wax Finish** (Specification Item 16)
A biodegradable oil or wax finish on the other hand renders the timber component completely safe to compost at the end of its working life.
Contact: Contact: eg. Natural Building and Decorating: 01546 886341, NBT Paints: 01844 338338, Construction Resources: 0207 450 2211, OS Colour: 01296 481220

(h) **No glue** (Specification Item 18)
The alternative is simply to ensure that the tacked fixing is adequate on its own, and if not, to use screws, or a larger trim, to make fixing easier.
Contact: n/a

(i) **Dry Gaskets to avoid Silicone type Sealants** (Specification Item 18, 19, 20)
Where there is a need to seal components against air infiltration, and to maintain a tidy edge or corner detail, it is possible to use, for example, rubber gaskets to achieve this. They have the advantage of being easily removed as part of any replacement or maintenance works without damage to adjacent components and can be re-used.
Contact: eg. Exitex Ltd. (00 353 42 93 71 221 / www.exitex.net)

(j*) **Alternatives to Plasterboard** (Specification Item 11a, 17)
Plasterboard is ubiquitous and immensely useful, but it is difficult to fix in such a way as to enable complete re-use, and it is not necessarily safe to go to landfill.
Most uses of plasterboard involved either a complete skim coat, or a partial skim, both of which prevent any realistic re-use of the board once removed.
Since plasterboard (technically, ‘gypsum based board’) is normally painted, or coated in some other way, such as with wall paper, it may represent partially toxic waste.

Caveat

It is important to emphasise the scope and purpose of the following drawings and specifications.

They are included solely to show practitioners the sort of alterations that can be made in order to enable buildings to be repaired, altered and disassembled without undue damage to adjacent elements or the elements themselves, to afford as much re-use as possible and to increase the ease and cost effectiveness of re-use and recycling in construction generally.

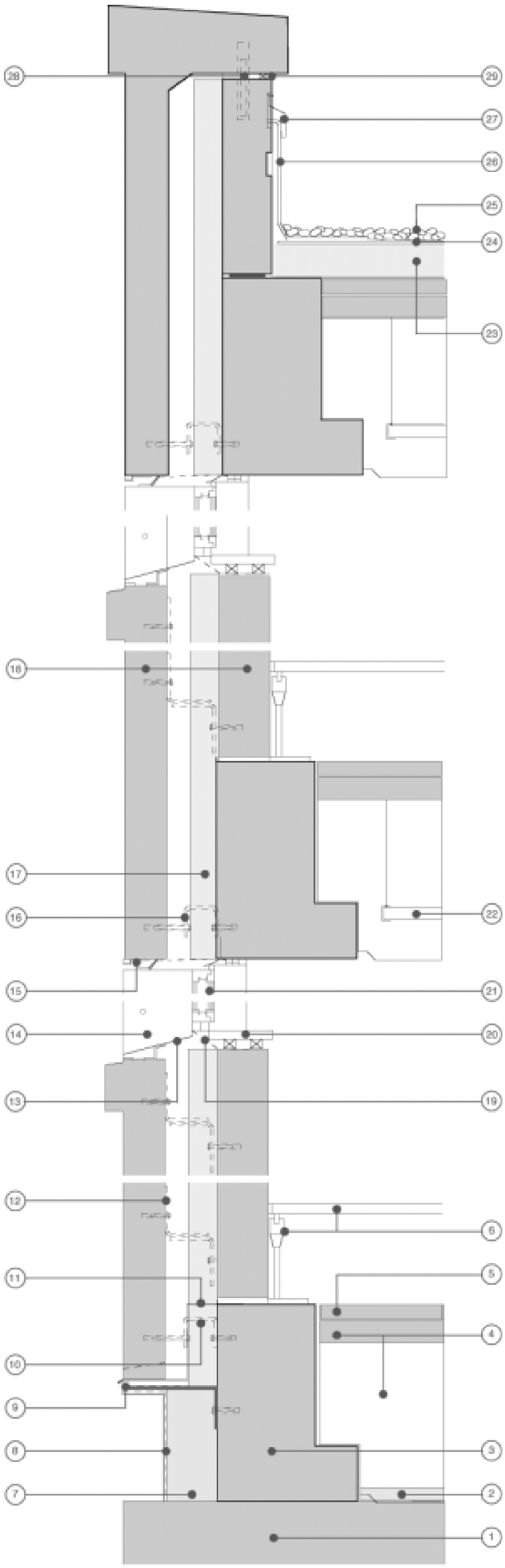
Their purpose is not to offer approved details in any sense, but to illustrate the difference between details and specifications which do not address deconstruction issues, and those that do. It is the differences between the originals and alternatives which is intended to be illustrative, not necessarily the alternatives themselves.

The original details have been taken from conventional details and specifications we believe to be broadly representative of their construction types. We hope the principles shown, and the specific references made will assist designers in making similar changes in their own work, but it goes without saying that SEDA cannot take responsibility for any work undertaken as a result of the use of these details.

Specifically, these details are not intended to show best practice in any sense, nor are they even intended to be up to date. We have striven in the preparation of these details and specifications to keep as close to the original as possible. We have done this in order to show that some quite fundamental alterations – in terms of deconstruction - may be made with the minimum of visual or functional impact on the original. Where these original details and specifications do not meet current standards or aspirations, the alternatives given are likely to be similarly wanting. To re-iterate, the purpose is not to produce approved details, but to illustrate the process of improvement – in terms of deconstruction only – that may be made.

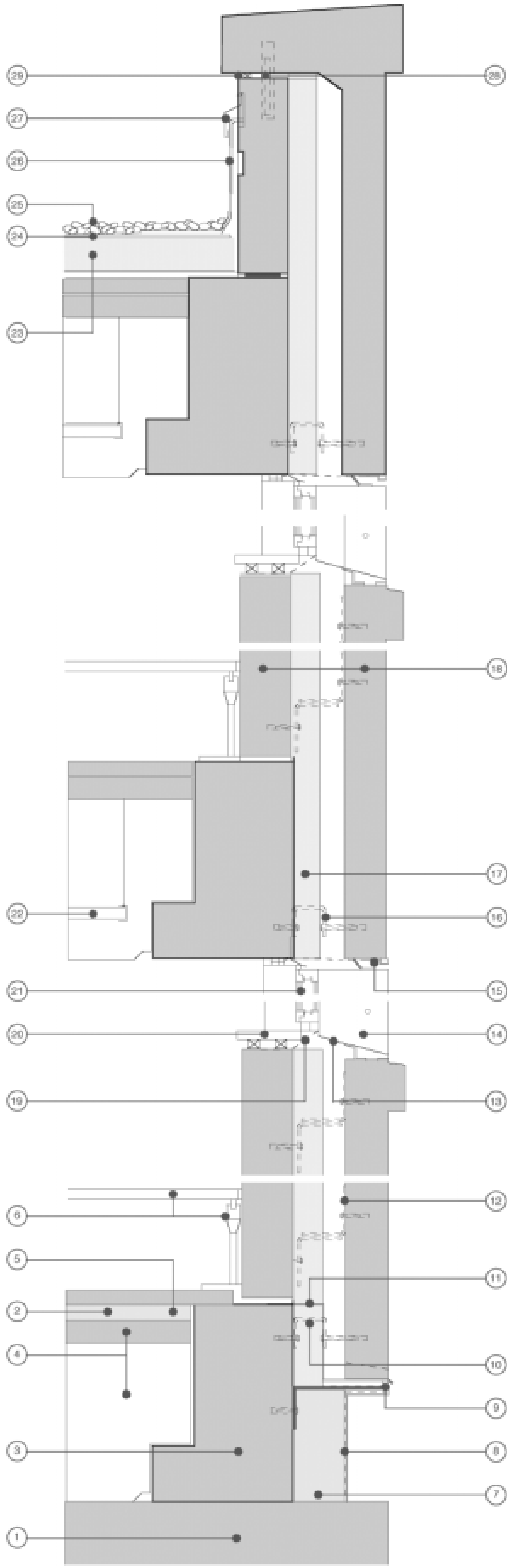
6.5 Concrete Frame and Panel

Relatively rare (in Scotland) heavyweight construction usually associated with commercial applications.



Typical Specification

1. Pad foundation
2. 50mm rigid polystyrene eps 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. Mineral tile as suspended ceiling system
23. Non-compressible extruded polystyrene insulation
24. Built-up Mineral Felt Roofing
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



Alternative Specification

1. Pad foundation
2. 50mm rigid polystyrene eps butt jointed insulation between T-units and screed as separating layer (a)
3. 690 x 350mm pre-cast concrete (i*) beam
4. Pre-cast concrete (i*) double T-unit spanning between beams
5. 50mm floating (a) structural screed (Other screeds to be separated, not bonded) (a)
6. 300mm deep access floor system, using tackifier adhesive (waterbased adhesive) for carpet tiles (b) (j*)
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, bolted at agreed centres to avoid compromise of concrete structure and re-use potential (c)
11. Continuous mill finish (d) aluminium flashing
12. 140 x 180 x 10mm stainless steel angle
13. Mill finish (d) aluminium sill with silicone sealant
14. Mill finish (d) 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 unreinforced (e) sandstone coloured pre-cast panel
19. LDPE (k*) membrane locked into window
20. Untreated (f) timber window sill
21. Thermally broken triple-glazed window
22. Metal (g) (l*) tile as suspended ceiling system
23. Non-compressible extruded polystyrene insulation
24. Mechanically fixed, recyclable (h) roofing system
25. Stone chippings as ballast
26. Mechanically fixed, recyclable (h) up-stand to suit
27. Mill finish (d) aluminium flashing mechanically fixed into rebate in panel
28. Dowel fixing
29. Silicone seal

Explanation

From the point of view of deconstruction and re-use of components, this form of construction is very poor. Whilst it is theoretically possible to re-use components, it is unlikely ever to be practical or cost effective so to do.

Because component dimensions are fixed, almost all of the components would have to be re-used together (with replacements made at exactly the same size as the originals) and there could be problems with concrete decay and difficulties with fixings (removing in the first place and then re-fixing). One possibility for reuse might be for the re-use of the structure and internal components only (simpler fixings and no decay / weathering problems) with a new external finish and insulation. This is perhaps more likely than complete re-use due to the poor visual quality of concrete external panels and the inevitable requirement for increased insulation levels.

Thus the only realistic re-use option for this form of construction is refurbishment of the original building, and to this end the main priority (not noted in the details) is that adequate floor to ceiling heights are formed which can be assumed to be acceptable for a variety of future occupation requirements.

It was anticipated that the use of dry gasket seals, in place of the silicone-type sealants conventionally specified, would have gone some way to help render the detail more easily re-used. However, the low likelihood of re-use, and the fact that it makes very little difference which sealants are used (in terms of dismantling), that no other sealants are considered as effective as silicone, and that no other exponent of this technology could be found in the UK means the issue does not appear.

Roof membranes and insulation are prioritised because of the volumes involved, while carpet and ceiling tiles prioritised because of the frequency of their replacement under normal circumstances.

HIGH PRIORITY

Floor to Ceiling Heights

Adequate Floor to Ceiling Heights will enable multiple occupational functions to be accommodated and so potentially extend the life of the building.

Some care needs to be taken with regard to cill and window head heights relative to changing floor and ceiling levels.

MEDIUM PRIORITY

Recyclable Roofing (h)

Mechanically fixed roofing membranes can be more easily removed and recyclable materials effectively represent a zero waste option.

Higher first costs.

Carpet Tile Adhesive (b)

A relatively weak adhesive will allow tiles to be removed easily and without damage to other components.

An improvement on this is to use leased, recycled tiles.

Durable ceiling Tiles (g)

Durable tiles, for example metal or some mineral options, will withstand repeated disruption and reduce waste.

First costs will be higher than eps alternatives.

LOW PRIORITY

Floating / Unbonded Screed (a)

Separating the screed simplifies eventual deconstruction and allows the floor system to be separately re-used if necessary.

Edge insulation is important to ease deconstruction without undue damage to adjacent components.

Agreed Fixing Locations (c)

It is possible that fixings or their locations could prevent re-use of components and this should be avoided.

Discussion to be had at the same time as locations are agreed with Engineer.

Mill finished Metal (d)

Mill finished metals increase the efficiency of recycling through reduced costs and pollution.

Though there may be aesthetic implications.

Unreinforced Concrete Panels (e)

Metal reinforcement complicates the process of recycling of concrete elements.

There is not a huge difference in cost, but different machines are needed, with fewer companies able to supply so costs are bound to be slightly higher.

Untreated timber (f)

Timber only needs to be treated when there is a risk of decay.

Important principle but of minor concern here due to the low volumes involved.

Costs

Most of the cost implications of the alterations in this detail are marginal.

It is more difficult to lay a creed over insulation, but in practice it is likely that the costs for this alteration would be the same.

The cost difference between mill finished or coated metalwork is marginal and is likely to depend more on the particular system chosen. Similarly, the choice of carpet tile will be more significant than the specification of a particular adhesive system.

An unreinforced panel is likely to be cheaper than a reinforced one, given the costs associated with steel generally, but again this is likely to depend more on the particular product and system chosen.

At the time of this study untreated timber was approximately £30 / cubic metre less to purchase than treated timber.

A more durable ceiling tile is likely to be around 30% more expensive while the recyclable mechanically fixed roof membrane was around twice the price of the asphalt.

Defects Liability / Insurance Issues

No additional issues have been raised regarding the alternative details although further details and confirmation would be required regarding the weather-proofing of the panels, particularly regarding the joints, as well as their capacity to allow for thermal and moisture-related movement.

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(a) **Unbonded or Floating Screed** (Specification Item 2, 5)
A cementitious mix is more compatible with other likely waste for crushing, but the depth may be reduced to 35mm or less if polymer added to mix (eg. Ronacrete: 01279 638 700). To cater for movement of the screed and to offer a degree of insulation around the edges and so reduce 'cold bridging' it is important to position an edge strip of a material like eps, woodfibre board, dense mineral fibre or similar. This edge strip also helps in the ultimate dismantling of the screed.
Contact: eg. RMC Readymix (0117 977 9534)

(b) **Carpet Tile Adhesive** (Specification Item 6)
Rigid floor finish tiles may be clipped or mechanically held down to much the same effect.
Contact: Best Image (0870 350 2602 / www.best-image.com), Construction Resources (0207 450 2211 / www.constructionresources.com)

(c) **Agreed Fixings Locations** (Specification Item 10)
Significant fixing locations into the concrete beams, column and panels will have to be agreed between Architect, Engineer and Contractor / Manufacturer in any case, so this really means adding another criteria to that discussion, whereby the locations do not prejudice any future possibilities.
Contact: n/a

(d) **Mill finish Metal** (Specification Item 11, 13, 14, 27)
Most sheet metals used in construction are coated in one way or another. These coatings tend to be either metallic, for example zinc plating (galvanising), anodising or similar, or plastic based, for example, polyester powder coated, pvc, enamel and so on. All coated sheet metal CAN be recycled (it is very rarely re-usable) but the various coatings do complicate and therefore increase the cost of reclaiming the metal. The most cost effective recycling of metal is clearly when there is no contamination by coatings, glues etc. This being the case, the best practice when using sheet metal – from the point of view of recycling – is to use unbonded (mechanically fixed) uncoated sheet. Steel cannot easily be used without some form of protective coating, whereas aluminium, copper and some others can be used with a mill finish which requires no additional coating and is nonetheless extremely durable.

(e) **Unreinforced Concrete Panels** (Specification Item 18)
There is not a huge difference but it is worth trying to avoid reinforced components for this reason.
Contact: Any Concrete Panel Manufacturer.

(f) **Untreated Timber** (Specification Item 20)
There is no such risk here and this means the timber used can be safely composted at the end of its service life.
Contact: n/a

(g) **Metal Ceiling Tiles** (Specification Item 22)
Suspended ceilings are advantageous from the point of view of Design for Deconstruction as they enable considerable amounts of services to be hidden, yet easily accessible for maintenance and alteration. This advantage is somewhat reduced if ceiling tiles are easily damaged and need frequent replacement.
Contact: Several Manufacturers and Suppliers.

(h) **Mechanically fixed, Recyclable Roofing** (Specification Item 24, 26)
A number of Manufacturers produce roofing membranes, usually of TPO or EPDM material. Some TPO membranes have been shown to last for as long as 40 years under test conditions, generally EPDM membranes are cheaper and arguably of less durability. TPO membranes may be heat welded which gives greater comfort at difficult junctions, whereas EPDM membranes may be more suitable for siple roof applications.
Contact: eg: TBS Elastomers (01698 464 620 / www.tbselastomers.com) Flag (01428 604 500 / www.flag.it)

(i*) **Using PFA in Concrete** (Specification Item 3, 4)
Using PFA (Pulverised Fuel Ash) in concrete reduces the amount of (virgin) cement required and utilises a waste product in its stead.
Reducing the amount of cement used is valuable because of the very high energy requirements of cement manufacture. Up to 40% of cement in concrete may be offset by PFA with additional advantages in waste reduction. PFA improves the flowing characteristics of concrete, fills in voids better and also improves the performance of concrete in its hardened state. It is not generally used however for cladding panels externally because of difficulties in overcoming colour variations which are more readily resolved with 'purer' cement based batches.
Contact: Any cement Manufacturer.

(j*) **Recycled or Leased Carpet Tiles** (Specification Item 6)
Recycled material tiles reduce the waste stream, reduce resource use and often reduce energy and pollution associated with manufacture of components. Leased components return to the Manufacturer for recycling.
Contact: eg. Interface Carpets (01274 690 690 / www.interfaceeurope.com)

(k*) **Using Recycled Material Membranes** (Specification Item 19)
Using recycled material reduces both resource use and waste.
We know of three manufacturers who utilise recycled content in their damp proof membranes and courses. Visqueen in Oxfordshire [01993 776346 / www.visqueenbuilding.co.uk] provide both dpms and dpcs with between 60% and 97% recycled LDPE. Frank Mercer in Lancashire [01942 841 111 / www.toughsheet.co.uk] manufacture dpms and dpcs with 98% post consumer recycled LDPE and claim a cost saving and improved performance over conventional materials. Capital Valley Plastics Ltd. in Gwent [01495 772 255 / www.capitalvalleyplastics.com]] supply dpms with 100% recycled, mostly post consumer LDPE. All three are potentially recyclable at end of life but no apparent measures are in place to ensure this happens.

(l*) **Recycled Ceiling Tiles** (Specification Item 22)
Recycled material tiles reduce the waste stream, reduce resource use and often reduce energy and pollution associated with manufacture of components.
Contact: eg. Armstrong Ceilings (0800 371 849 / http://ceilings-eu.armstrong.com/CeilingsHome.asp)

Caveat

It is important to emphasise the scope and purpose of the following drawings and specifications.

They are included solely to show practitioners the sort of alterations that can be made in order to enable buildings to be repaired, altered and disassembled without undue damage to adjacent elements or the elements themselves, to afford as much re-use as possible and to increase the ease and cost effectiveness of re-use and recycling in construction generally.

Their purpose is not to offer approved details in any sense, but to illustrate the difference between details and specifications which do not address deconstruction issues, and those that do. It is the differences between the originals and alternatives which is intended to be illustrative, not necessarily the alternatives themselves.

The original details have been taken from conventional details and specifications we believe to be broadly representative of their construction types. We hope the principles shown, and the specific references made will assist designers in making similar changes in their own work, but it goes without saying that SEDA cannot take responsibility for any work undertaken as a result of the use of these details.

Specifically, these details are not intended to show best practice in any sense, nor are they even intended to be up to date. We have striven in the preparation of these details and specifications to keep as close to the original as possible. We have done this in order to show that some quite fundamental alterations – in terms of deconstruction - may be made with the minimum of visual or functional impact on the original. Where these original details and specifications do not meet current standards or aspirations, the alternatives given are likely to be similarly wanting. To re-iterate, the purpose is not to produce approved details, but to illustrate the process of improvement – in terms of deconstruction only – that may be made.

Acronyms

BPEO	Best Practical Environmental Option
BRE	Building Research Establishment
CIBSE	Chartered Institute of Building Service Engineers
CIRIA	Construction Industry Research and Information Association
DfD	Design for Deconstruction
EC	European Community
EU	European Union
MRN	Material Recovery Note
NBS	National Building Specification
NGO	Non-governmental Organisation
RIAS	Royal Incorporation of Architects in Scotland
RIBA	Royal Institute of British Architects
SEDA	Scottish Ecological Design Association
SEPA	Scottish Environmental Protection Agency

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Further Reading

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Sassi, P. (2004),*Designing Buildings to Close the Material Resource Loop*, in Proceedings of the Institute of Civil Engineers*, Engineering Sustainability 157,* Issue ES3, September 2004, pages 163-171

Useful Contacts

www.cf.ac.uk/archi/dfr/ - the most relevant site for design for deconstruction
www.salvo.co.uk – the number one site for reclamation of construction products
www.smartwaste.co.uk – BRE's "BREMAP" helps to locate local salvage yards for reclaimed materials
www.greenspec.co.uk – for helpful advice and examples of environmental specification
www.seda2.org – the premier NGO in Scotland for Ecological Design
www.sust.org – a variety of useful Scottish sustainable design initiatives on line
www.cce.ufl.edu/affiliations/cib/4-2003.html -for CIB Task Group 39 publications on deconstruction

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