WP 2.1 Guidance for design for deconstruction
(Suunnittelu uudelleenkäyttöä ja kierrätystä varten)

ReUSE: Reusing of building components
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BACKGROUND
Definitions

- **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.
Over 50% of buildings in the year 2030 will have been built since 2000 (Seattle Guide)
DfD - Design for Deconstruction

How buildings should be designed and constructed in order that they can be easily deconstructed to facilitate reuse and recycling

Design for Deconstruction

- Designers’ responsibly to manage end-of-life building materials to minimize the consumption of raw materials
- Recovery of materials to reuse them in another construction project or recycle them into a new product
- Architects and engineers can contribute to this movement by designing buildings that facilitate adaptation and renovation

Design for Reuse

- Instead of cradle-to-grave thinking to a more ideal cradle-to-cradle thinking
- Designers not only optimize the use material but they also maximize the opportunity for reusing the structural components
- Reused elements are less energy intensive and they have lower embodied energy than elements made of new or recycled material
Building Resource Efficiency - Key Principles

- 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.
- Aim to minimise waste by designing elements for maximum diversity of options when reused.
- 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.
- Aim to minimise waste by increasing the number of times a construction element can be re-used.
- Minimise transportation by allowing building to be fully adaptable with the minimum use of new resources. Avoid excessive transportation of materials.
- 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.
Embodied carbon

- It is important to consider the embodied carbon in addition to the emissions associated with the operational energy.
- In warehouses, which generally have a low operational energy, the embodied carbon may make up as much as 60% of the whole life carbon of the building.
- The embodied carbon makes less of a contribution in office buildings, but nonetheless can make up as much as 45% of the total life cycle carbon.
- A standardised method for measuring embodied carbon should be agreed (Sakura)
Buildings have different life-spans

<table>
<thead>
<tr>
<th>Category</th>
<th>Design Service Life</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Temporary   | up to 10 years      | • Non-permanent construction buildings, sales offices  
|             |                     | • Temporary exhibition buildings               |
| Medium Life | 25 to 40 years      | • Some industrial buildings                    |
|             |                     | • Parking structures                           |
| Long Life   | 50 to 90 years      | • Residential, commercial and office buildings |
|             |                     | • Health and educational buildings             |
|             |                     | • Industrial buildings                         |
| Permanent   | minimum 100 years   | • Monumental buildings (ex. museums, art galleries, archives) |
|             |                     | • Heritage buildings                           |
Warehouses, schools and supermarkets offer the most potential for reducing environmental impact when designed for deconstruction.

<table>
<thead>
<tr>
<th>Building</th>
<th>Construction Type</th>
<th>Embodied Carbon Saving per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse</td>
<td>Steel Frame</td>
<td>16.0%</td>
</tr>
<tr>
<td></td>
<td>Concrete/timber Frame</td>
<td>9.3%</td>
</tr>
<tr>
<td>School</td>
<td>Steel Frame</td>
<td>24.8%</td>
</tr>
<tr>
<td></td>
<td>Concrete Frame</td>
<td>9.4%</td>
</tr>
<tr>
<td></td>
<td>Composite Steel Frame</td>
<td>16.3%</td>
</tr>
<tr>
<td>Supermarket</td>
<td>Steel Frame</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>Timber Frame</td>
<td>10.3%</td>
</tr>
<tr>
<td>Stadium</td>
<td>Composite Steel Frame</td>
<td>9.8%</td>
</tr>
</tbody>
</table>
DESIGN FOR DECONSTRUCTION
Relevance of design principles for different project players

<table>
<thead>
<tr>
<th>Design Principles</th>
<th>Owners</th>
<th>Architect</th>
<th>Engineer</th>
<th>General Contractor</th>
<th>Specialty Subcontractor</th>
<th>Fabricator Manufacturer</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design for prefabrication, preassembly and modular construction</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Simplify and standardize connection details</td>
<td>medium</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Simplify and separate building systems</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Consider worker safety during deconstruction</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Minimize building components and materials</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Select fittings, fasteners, adhesives and sealants that allow for quicker disassembly and facilitate the removal of reusable materials</td>
<td>medium</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Design to accommodate deconstruction logistics</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Reduce building complexity</td>
<td>medium</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Design to reusable materials</td>
<td>medium</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Design for flexibility and adaptability</td>
<td>high</td>
<td>high</td>
<td>medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Guidance for design for deconstruction

Ten Key Principles for DfD

1. Document materials and methods for deconstruction
2. Select materials using the precautionary principle*
3. Design connections that are accessible
4. Minimize or eliminate chemical connections
5. Use bolted, screwed and nailed connections
6. Separate mechanical, electrical and plumbing (MEP) systems
7. Design to the worker and labour of separation
8. Simplicity of structure and form
9. Interchangeability
10. Safe deconstruction

* The essence of the principle is that when probabilities cannot be calculated with reasonable precision (i.e. it is a situation of uncertainty), then decisions that could potentially lead to great harm should be postponed or avoided.
Deconstruction Detailing Principles

- Materials
- Assemblies
- Building systems

elementtisuunnittelufi

newsteelconstruction.com/wp/quiconwn-wins-contract-at-ikea/

constructionphotography.com

architectmagazine.com
Components

- **SITE**: > building
- **STRUCTURE**: 60-200 yrs
- **SKIN**: 30-60 yrs
- **SERVICES**: 5-30 yrs
- **SPACE PLAN**: 5-20 yrs
- **STUFF**: 5-15 yrs
Materials

- Avoid materials that later became environmental hazards for workers and for disposal
- Choose components that are durable enough to be repaired or reused
- Choose materials which will not be destroyed in deconstruction so that they can be reused or recycled
- Maximize the number of times the components and materials can be reused
- If more material types are necessary, the separation of the materials in deconstruction should be carefully considered
- If prefabricated modules and components are used, they should be dimensioned for reuse
Assemblies

- Use of connectors that are accessible and do not cause damage in the process of separating materials
- Consider the weakening and de-stabilization of a building during the deconstruction process
- Remember that the building assembly process may render materials un-reusable or un-recyclable via drilling, cutting, and use of binders, adhesives, and coatings - especially hazardous materials
- Document the information which includes construction drawings & details, identification of materials and components and structural properties
Building Systems

- Install HVAC, electrical and plumbing so that they do not prevent the separation of building components.
- Specify components with sizes that are suitable for handling and transportation.
- Remember that dismantling or upgrading one system can affect another system.
- The enclosure, structure, infill, substructure, mechanical and electrical systems can be separately installed with no dependency to each other.
Benefits of DfD

- Reducing resource-use and waste starting early in the building design process and as integral to the entire building life
- Meeting market demand for flexible and convertible buildings (changes in internal spatial usage)
- Allowing for ease of maintenance and repair of components and assemblies and enabling product leasing and take-back
- Reducing potential future liability and waste disposal costs
- Obtaining Green Building Rating System Innovation credits
- Enabling future adaptation and building removal that reduces the site environmental impacts of destructive demolition, such as dust, noise and mechanical equipment emissions
- Preserving the embodied energy that is invested in building
- Making the deconstruction industry more cost-effective
Key construction materials: Re-use potential

- Steel: Although there is extensive recycling of steel, re-use is still relatively uncommon, with most steel frames dismantled using thermal lances or shears, rendering them unusable in their original form.
- Masonry: There is a strong tradition of re-using stone, tiles and bricks in construction, prompted by the heritage industry, but surprisingly there are still no official standards relating to re-use.
- 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.
- 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.
ENVIRONMENTAL ASSESSMENT METHODS
DfD in Environmental Assessment Methods

LEED

- Within LEED for New Construction there are specific points awarded for reusing parts of existing buildings on site and for general material reuse, all these points can be found within the Materials and Resources category.

Green Star

- Green Star seems to address and reward the minimisation of the embodied energy of materials more than both BREEAM and LEED. There are six points available for building reuse.

BREEAM

- No specific points to be gained in BREEAM for designing for deconstruction. There are however parts of the point system where credit may be gained if deconstruction is considered to be appropriate.
Green Demolition Certificate, proposal

- A certificate for use by government agencies or building owners to reward green demolition
- The stated goals of this certificate are to recover materials for reuse or recycling, thus removing demolition material from the waste stream that goes to landfill.
- It is a credit based system and in a similar way to LEED assessments there are a series of prerequisites that must be fulfilled. In addition to this, at least twenty-five credits must be earned, out of the fifty-two available.
- The certificate could potentially be a very effective way to encourage deconstruction and material reuse in existing buildings, as well as helping demolition contractors develop a more sustainable way of thinking.
Potential demolition recovery indices (DRI) / targets

<table>
<thead>
<tr>
<th>Material</th>
<th>Standard DRI %</th>
<th>Good practice DRI %</th>
<th>Best practice DRI %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>75</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>Ceramics (e.g. masonry bricks)</td>
<td>75</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>Metals</td>
<td>95</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Timber</td>
<td>57</td>
<td>90</td>
<td>95</td>
</tr>
<tr>
<td>Inert (e.g. subsoils)</td>
<td>75</td>
<td>95</td>
<td>100</td>
</tr>
</tbody>
</table>
Legislation as a way to promote deconstruction

- There is nonetheless a difficulty in convincing clients to pay slightly extra for their project to be designed for deconstruction, when the benefit is not incurred until some point in the future.
- Increased legislation would encourage a reduction in construction and demolition waste and an increase in recycling.
- Most legislation just doesn’t mention deconstruction, however some actually comes close to discouraging it – in New South Wales, Australia, if one wants to use second hand materials within a new build, every item must be listed as part of the building application. One could imagine this might discourage architects, engineers or clients actually specifying reused materials, even if they were considering doing so.
- In the future all new buildings should be designed for deconstruction.
DfD - Deconstruction Plan

A comprehensive Deconstruction Plan will insure that designed-to-be-reusable building elements will be recovered as intended.

1. Statement of strategy for DfD relating to the building
2. List building elements
3. Provide instructions on how to deconstruct elements
4. Distribution of DfD Plan
Summary - What needs to change

1) Recertification procedure for reused elements
   - Removes suggestions that the materials might not be suitable for structural reuse
   - How to minimize the cost of recertification procedure

2) Requirements and incentives for design for deconstruction
   - The legislation could require a detailed end of life consideration
   - An alternative to legislative requirements is to incentivise design for deconstruction and material reuse. Incorporating additional credits within environmental assessment methods
EXAMPLES
Example - Demountable steel building

- Volumetric modules under the Free-Dom system are connected by means of special, multiple-use joints and bolted connectors, thus the building can be disassembled, its modules moved to another place, and erected again.
- During the design life period of the building that amounts to at least 60 years, such changes can take place many times. However, the economically justified cycle of such changes is 10-20 years.
Example - Demountable concrete building

- New technology in seismic and component-based concrete construction
- The PRESSS system uses prefabricated components meaning site operation is assembly focussed
- Being demountable also allows for future deconstruction and re-erection elsewhere if required.
Example - Demountable timber building

- Huntly Crescent is a purpose-built “towards zero carbon” mixed use development, comprising of commercial shop units at the ground floor with residential accommodation above
- The whole CLT structure is easily demountable and fully recyclable
- The systems is simple and easy to understand and install
RIL 216-2013 RAKENTEIDEN JA RAKENNUSTEN ELINKAAREN HALLINTA
RIL 216-2013 Rakenteiden ja rakennusten elinkaaren hallinta

- Rakennusten ja rakenteiden käyttöikäsuunnittelu
- Elinkaaren taloussuunnittelu
- Elinkaaren luonnontaloussuunnittelu, luonnontalouslaskelmat, energiataloussuunnittelu, energia- ja olosuhdesimuloinnit
- Laatuluokitus- ja sertifiointijärjestelmät
- Suunnittelut muuntojoustavuutta ja käyttötarkoituksen muutoksia varten
- Suunnittelut uudelleenkäyttöä ja kierrätystä varten
- Terveellisyys- ja turvallisuussuunnittelu
- Säilyvyysuunnittelu ja käyttöikämitoitus
- Vanhanaikaistumisen hallinta
- Monitavoitteinen päätöksenteko
- Ympäristöselosteet
Kiinteistön elinkaaren energiakulutus (RIL 216)

**Energiankulutus**
- Valmistus- ja rakentaminen
- Vaipan lämpöhäviöt
- Huolto- ja korjaus
- Muutokset
- Uusimiset
- Purkaminen, kierrätys ja hävitys
- Säästö: Rakenteiden lämmönvaraamiskyvyn hyödyntäminen lämmityksessä ja jäähdytyksessä

![Graph showing CO2 emissions in passive apartment life cycle (kg/m²/v)](image-url)
Yleisperiaatteet rakennuksen purkua ja uudelleenkäyttöä varten (RIL 216)

- Kantava runko, pintarakenteet sekä installaatiot ovat selkeästi eroteltavia erillisiä rakenteita
- Jokainen osa on purettavissa erillisinä, esim. rungon liitokset helposti purettavia, vaippa ja täydentävät helposti irrotettavissa
- Osat ovat yleisten mm. kooltaan standardien mukaisia ja ovat mahdollisimman homogeenisia
- Rakennusosat ovat pitkäikäisiä ja hyvin säilyviä
- Suunnitteluratkaisujen tulee olla joustavasti muunneltavia, pitkäikäisiä ja helposti huollettavia
- Tietyntyyppiset rakennukset, esim. hallit, suunnitellaan siirrettäviksi
- Rakennepiirustukset sekä materiaali- ja kuormitustiedot tulle olla dokumentoitu
- Laaditaan kirjallinen selostus purku- ja uudelleenkäyttötoimenpiteistä, joka liitetään rakennuksen huoltokirjaan
### Rakennusjätteen uudelleen- ja uusiokäyttö (RIL216)

<table>
<thead>
<tr>
<th>Vaihe</th>
<th>Selitys</th>
</tr>
</thead>
</table>
| 1     | Alustava selvitys uusio-, uudelleen- ja energiakäyttöön kelpaavasta materiaalista  
|       | Hyötykäyttövaihtoehtojen ja -kohteiden etsiminen  
|       | Ongelmajäteselvitykset ml. asbestikartoitus  
|       | Suurissa kohteissa aloitettava 6 kk ennen aiottua purkuaiakaa |
| 2     | Tarvittavien viranomaislupien hakeminen ja ilmoitusten tekeminen |
| 3     | Neuvottelut ja sopimuksen hyötykäyttökumppanien kanssa  
|       | Määrä, laatu, aikataulu, hinta ja sopimusosapuolten velvollisuudet |
| 4     | Lajitteleva purkutyö materiaalien hyödyntämistavan vaatimusten mukaisesti  
|       | Toimitukset uudelleen, uusio-, tai energiahyötykäyttöön, välivarastoon, kaatopaikalle tai ongelmajätelaitokselle  
|       | Kirjanpito eri toimitusten sisällöstä |
| 5     | Tarvittaessa loppukatselmus sopimuskumppanien kanssa |
Laadunvalvonta uudelleen- ja uusiokäytössä (RIL 216)

- Uusiotuotteen valmistajalla tulee olla ohjeet vastaanotettavan materiaalin laadulle
- Mikäli toimitettava materiaali ei ole vastaanotto-ohjeiden mukaista, toimittaja vastaa mahdollisista kustannuksista
- Uusiotuotteen valmistaja vastaa tuottamansa tuotteen laadusta
- Uusiotuotteella tulee olla tuoteseloste tms, jossa kerrotaan tuotteen ominaisuuDET ja mahdolliset käyttökohteet
- Uudelleen- tai uusiokäyttöön materiaalia luovuttavan on pyydettäessä todistettava luotettavalla tavalla tuotteen puhtaus ja kelvollisuus
- Uusiotuotteita käyttävä rakentaja vastaa rakennustyön laadusta aivan kuin perinteistäkin materiaalleja käytettäessä
- Romuliikkeen tulee olla selvillä niiden materiaalien ja tuotteiden laadusta, joita hän toimittaa uudelleen- ja uusiokäyttöön
VTT creates business from technology