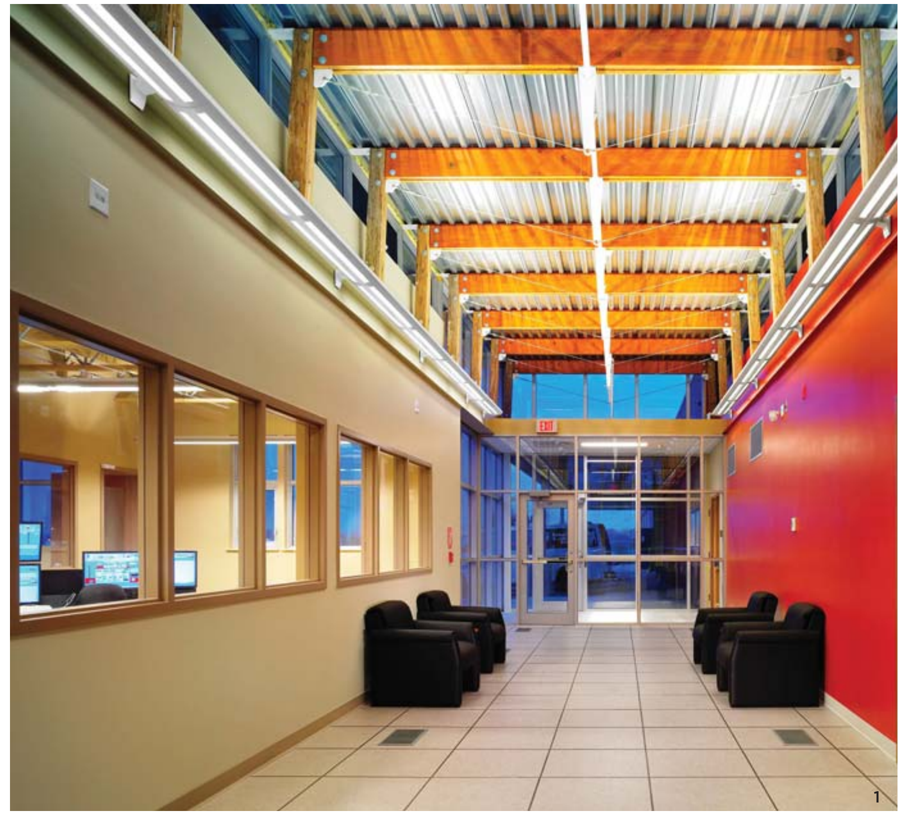
DESIGN FOR DISMANTLING

Early planning means an economic afterlife for buildings

VINCE CATALLI

The traditional model for the design, construction, operation, decommissioning, demolition and disposal of a building is a linear, sequence in which new materials, products and building systems are created at the beginning of a project and discarded at the end. To achieve the goal of sustainability we must move to a cyclical model in which building components and indeed entire buildings are designed to be adaptable, demountable, reusable and recyclable.



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SCOPE AND DEFINITIONS

This article looks at DFD/A at a material, systems and detail level while demonstrating the significant role of DFD/A for enhanced environmental performance benefits. For the purposes of this discussion disassembly and adaptability are defined as follows:

Disassembly is the ability to take building materials, systems and equipment apart for better maintenance and operation; as well as for resource recovery (reuse or recycling) in a renovation or deconstruction scenario.

Adaptability is the ability to accommodate multiple occupancy uses throughout the day and in the future to extend the life cycle of the building – in short, the ability to accommodate functional change. The ultimate goal is to create buildings that can be used 24/7.

With respect to building fabric, the objective of DFD/A is to be more effective in the use of resources, and thereby to reduce the environmental impacts associated with resource extraction, processing and manufacture. The potential benefits are significant. For example, research carried out by Morrison Hershfield Engineering using the ATHENA Life Cycle Assessment [LCA] model determined that for every cubic metre of precast double-T concrete that can be reused there will be:

- 1.23 GJ of energy savings.
- 147 kg reduction in CO_2 production,
- 50% reduction in water emissions [compared to using a new double T], and
- 50% reduction in air emissions [compared to using a new double T].

THE STRUCTURAL STEEL FRAME USES ALL BOLTED CONNECTIONS. OPEN WEB STEEL JOISTS HAVE A WOOD TOP CHORD TO PERMIT SCREW FASTENING OF THE METAL DECK. LATERAL RESISTANCE IS PROVIDED BY HEAVY GAUGE STEEL STUDS MECHANICALLY FASTENED TOP AND BOTTOM. MASONRY VENEER AND STUCCO PANELS ARE MECHANICALLY FASTENED BACK TO THE STRUCTURE. WOOD SIDING IS FASTENED WITH SCREWS. DESIGN: MCCALLUM SATHER ARCHITECTS, HAMILTON, ON

Published in 2006, CSA Z782, 'Guideline for Design for Disassembly and Adaptability in Buildings,' provides a framework for reducing building construction waste through design for disassembly and adaptability [DfD/A] principles.

LEVELS OF ANALYSIS

The guideline identifies five levels within the building design process at which analysis should be undertaken:

Systems: Analysis at this level is generally applied to adaptable buildings that can change over time to suit changing requirements. In some cases, largely in Europe at present, entire modular buildings can undergo wholesale disassembly, relocation movement, and reuse.

Elements: Analysis at this level focuses on a major building part, such as a roof, foundation, wall, or raised flooring system, as well as designs for modular and panelized elements that can be readily fitted into common dimensional standards.

Component or Assembly: At this level, analysis is focused on combinations of several subcomponents that are non-structural: "layers" of the building. These layers or systems should be designed to allow upgrading, repair, and replacement. The replaced products can then enter the recycling loop or be used again in some form. An example of a component or assembly is a carpet system consisting of carpet, backing, and adhesive.

Subcomponents: Analysis of subcomponents breaks down a component into its smaller pieces, e.g., the duct systework m of a heating or cooling system, or the glazing used for curtain walls.

Materials: When a product has been stripped back to its most basic materials, these can be reused or, at a minimum, serve as a feedstock in the recycling process to produce other materials.

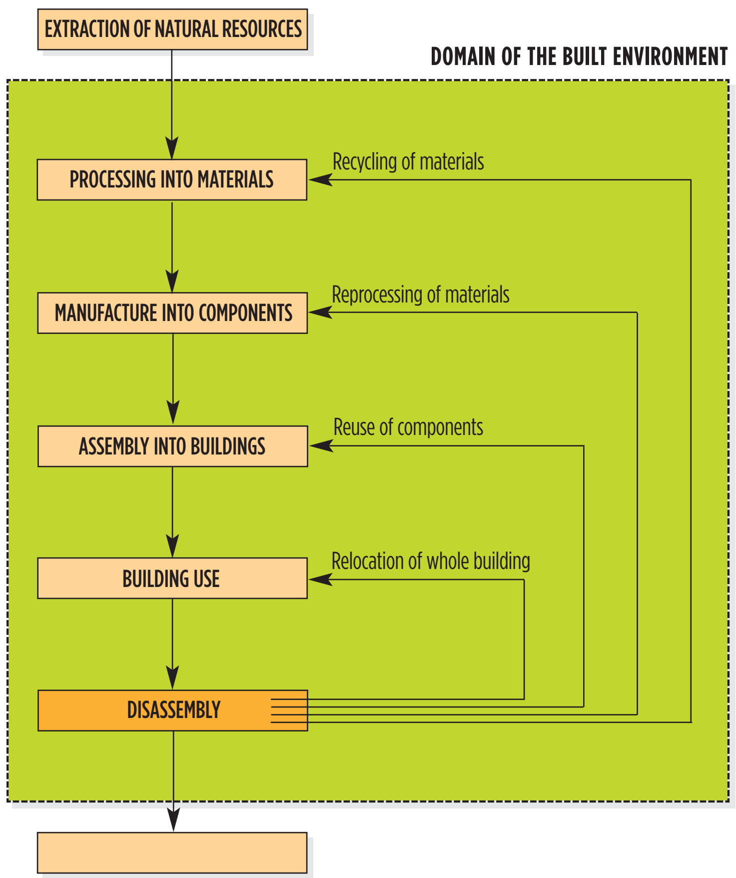
PRINCIPLES OF DFD/A

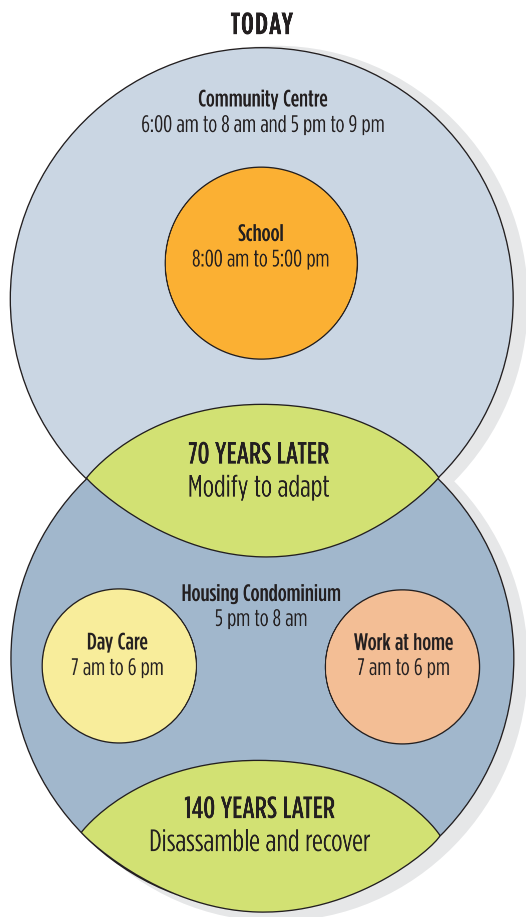
While the details of disassembly and adaptability vary from one building to the next, as well as between the various components within a building, there are some principles that apply to all design choices related to adaptability and disassembly. These principles fall into two categories: those related to adaptability, and those related to disassembly. Generally, adaptability principles deal with functional use of space, while disassembly principles deal with the material base.

Generally, adaptability design principles affect the long-term utility of a building from a functional perspective. They include:

- Versatility,
- Convertibility, and
- Expandability.

Disassembly principles apply to assemblies and systems within a building that can be disassembled at the end of the building's life cycle, or renovated, with the potential for components of the assembly to be used for other environmental purposes. The principles expand on the familiar tenets of 'reduce, reuse, and recycle' and include:





- Accessibility,
- Documentation of disassembly information,
- Durability,
- Exposed and/or reversible connections,
- Independence,
- Inherent finishes,
- Recyclables,
- Refurbish ability,
- Re-manufacturability,
- Reusability, and
- Simplicity.

Several of these concepts are discussed below, and a full explanation can be found in the CSA guideline.

APPLYING AND MEASURING DFD/A

When employing these principles and strategies the design team should evaluate their applicability for use in non-traditional applications – for example, versatility and convertibility in residential dwellings to accommodate the life stages of the average family unit. [A young couple moves in; a family is formed; the children mature and move away; the couple retires and movecouple retires and movesd away to a smaller unit or takes in a tenant to occupy the same space.]

An LCA tool has been developed to determine the degree to which a particular design solution meets the overall goals of DFD/A. The options a can be evaluated by applying a metric to each one of the 14 principles listed above, at each of the five levels of consideration. The metrics vary according to the principle under consideration – but are by and large objective and quantifiable. To get the most from this methodology, it is important for designers and those commissioning buildings to think 'outside the box' of traditional practice.

ADAPTABILITY

The principles of Versatility, Convertibility and Expandability are inter-related and mostly impact the organization and programming of space, and the design of the structural system for the building. For example, the volumetric needs of a gymnasium and a community theatre or performance space can be quite similar and, if attention is paid to issues of acoustics, lighting, staging, temporary seating and of course programming, a single space could fulfill both functions on an alternating basis. Consider the benefits of combining the budgets of a school board and a municipally-funded theatre group – the result could be a higher quality facility for less money overall.

Versatility can be measured by the percentage of floor space or building footprint that has multiple uses on a daily, weekly, or monthly basis, without requiring changes to the main features of the space.

Convertibility on the other hand concerns itself with the possible conversion of a space from one use to another at a point some time in the future when user requirements might change. Convertibility anticipates minor reconfiguration of non-structural components to adapt a space to another use, and implies careful attention to the initial design of the building structure. Considerations include:

- Long spans and post-and-beam construction reduce interior structural elements and allow for structural stability when removing partitions and envelope elements, while allowing for flexibility of interior fit-ups.
- The structure should be designed to accommodate the widest variety of interior design, fit-up, and building adaptation possible, and should, therefore, employ the most versatile structural grid and floor-to-floor height.
- Base/support elements (the rudimentary shell of a building) should be constructed in a generic way to facilitate a wide range of infill possibilities.

LKFJSD;GJI OWEIJ FWEOJF J D;KCJ L KCJ F;OEJ FI JC JDLK JDOI FJOIFJ EHDARUGTUH-GRNVM C .JCC LKJFOIAJROG IJ VKCN VLD-FKN VF;LJ VNFL VNFLK NA;FKV ;OXCVLZF;LSDJAE;ORGHOIGJ VL;KVJAORITUO GJFL VKAFLKR GAR IAJ;JVNKJ VNF VBJPTU HVJOAFGJ

Tech Note

- Realistic tolerances should be provided to allow for movement during disassembly. The disassembly process can require greater tolerances than the manufacturing process or the initial assembly process.
- Prefabricated elements or components and a system of mass production should be used to reduce site work and allow greater control over component quality and consistency.

Convertibility can be measured by the percentage of building space that has been designed to be converted easily to multiple uses.

Expandability can be considered either horizontally (which requires one or more exterior walls to be designed for disassembly) or vertically, which requires foundations and superstructure to be designed for additional future loads. Vertical expansion can be measured either by the number of floors, or by the total floor area that can be added. A “yes or no” assessment of horizontal expandability can be made: does the design lend itself to rapid expansion of floor space while recycling or reusing 75% or more of the material “disassembled”?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FOR THE POINTE VALAINE COMMUNITY CENTRE IN OTTERBURN PARK QC, ARCHITECTS SMITH VIGEANT USED 13 PRECAST CONCRETE INSULATED PANELS SALVAGED FROM THE RETROFIT OF TWO NEARBY CANADIAN TIRE STORES. TOTALING ABOUT 35M³ OF CONCRETE, THE PANELS MAKE UP MORE THAN 40% OF THE EXTERIOR WALLS. THE PANELS WERE TRIMMED TO THE REQUIRED LENGTH BY GROUPE TREMCA , BUT RETAIN THE ORIGINAL CONNECTION DETAIL AT THE TOP. FOR MORE ON THIS PROJECT SEE SABMAG ISSUE 18.


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DISASSEMBLY

While the principles of Adaptability relate to strategic functional requirements, the principles of disassembly relate more to the choice of materials and the detailed design of building components.

Typically the structure, fabric and service systems of a building have different anticipated maintenance cycles and service lives. To facilitate economic and efficient maintenance, and replacement, all components (and particularly those with short service lives) should be readily accessible. Independence from other components will minimize damage during these processes. The accessibility and independence of alternate design approaches can be evaluated using an ordinal numerical scale that ranges from ‘Not Accessible’ to ‘Highly Accessible”

To extract maximum benefit from the DFD/A approach, the aspects of the design that permit disassembly and adaptability must be clearly identified in specifications and construction sequence drawings – and this information transferred ionto as-built drawings, into a disassembly manual or other medium that can be easily accessed and updated. Documentation should include instructions on the disassembly of specific components, and the reusability and recyclability of materials.

Materials specified should be durable, with integral or non-toxic finishes, and their source of supply or manufacture, and constituents identified by labelling. This will assist future building users to obtain any additional information they might require to refurbish, recycle or reuse the material. Durability may also be quantified using an ordina lnumerical scale as suggested by LEED or other standards.

Connection design is also critical to easy disassembly of building components. Exposed corrosion resistant, reversible [eg. screws or bolts rather than nails or welded] connections are to be preferred.

Many of these principles suggest an approach to building that relies more heavily on prefabrication and shop manufacture of components, and less on site-built construction. Manufacture under controlled conditions tens to improve both the quality and consistency of components while reducing waste. It also tends to be quicker and more efficient, enabling multiple operations to be carried out simultaneously in different locations, rather than sequentially on the building site.

COSTS AND BENEFITS

While there would at first appear to be a design and capital cost premium associated with DFD/A buildings, closer analysis reveals these can be offset against increased value, as these buildings:

- Are less costly to repair/upgrade,
- Allow worn materials to be removed and replaced before failure without destroying other materials in the process,
- Allow the life of other components to be prolonged,
- Minimize waste generation, and
- Increase resource utilization/recovery while significantly reducing various environmental impacts.

There is a pressing need to apply longer term thinking to the design of our built environment, and to introduce Life Cycle Assessment into our decision making processes. This need brings with it considerable design challenges.

We need to rethink our buildings and infrastructure designs to be more durable, flexible, and adaptable. At a more detailed level, the design and construction industry must work with the material supply chain to produce environmentally, socially and economically sustainable solutions; and to work on connection details, especially between different materials.

The potential benefits are considerable, and include not only more efficient utilization of resources and reduced environmental impacts; but also a greater degree of control over the construction process with a consequent increase in building quality. ◂

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AIBC CONTINUING EDUCATION SYSTEM

BUILDING DESIGN FOR DISASSEMBLY AND ADAPTABILITY

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Read this article and Self-Report to the AIBC to receive 1 Core Learning Unit

SELF-REPORT FORM : www.aibc.ca/member_resources/professional_dev/Flyers/AIBC_Self-report_a1.pdf
SELF-REPORT ONLINE : www.aibc.ca/member_access/ces/index.html

PRINT AND RETAIN COMPLETED QUESTIONNAIRE

Non IABC members should copy the questionnaire, fill it in and submit to their respective architectural association to receive a CLU

ANSWERS FROM THE TEXT ARE:

1-d, 2-a, 3-d, 4-d, 5-d, 6-c, 7-b, 8-b, 9-a, 10-b

1. What emerging discipline has developed with a view to maximizing the service life of buildings and building components?
   a) Open space planning
   b) Life cycle costing
   c) Design for sustainability
   d) Design for disassembly and adaptability

2. What is the primary objective of designing for disassembly and adaptability (DFD/A)?
   a) More effective use of resources
   b) Improve the re-sale value of a property
   c) Improve the long-term durability of a building
   d) Heritage preservation

3. Which of the following is **not** a potential benefit of designing for disassembly and adaptability
   a) Reduction of emission of greenhouse gases
   b) Reduction of habitat degradation
   c) Conserving energy
   d) Lowest construction cost

4. Which of the following is **not** one of the 5 levels at which analysis should be undertaken?
   a) Systems
   b) Major elements
   c) Component or Assembly
   d) Cost
   e) Materials

5. What principle does **not** apply to all design choices when considering adaptability?
   a) Versatility
   b) Convertibility
   c) Expandability
   d) Stability

6. By what device might one best evaluate quantitatively a proposed adaptability strategy?
   a) An LCA (Life Cycle Assessment) tool
   b) A numerical scale
   c) An applied metric that takes into account the relative importance of certain variables.

7. The primary reason one might want to include longer structural spans in a design for adaptability is:
   a) Cost
   b) Reduce interior elements
   c) Facilitate initial construction schedule

8. Control over component quality is best achieved by:
   a) Simplicity and economy of design
   b) Manufacture under controlled conditions
   c) Detailed micromanagement of the production process

9. The introduction of which of the following fastener types would contribute best to disassembly?
   a) Bolts
   b) Adhesives
   c) Welds

10. Increase in building quality is achieved by which of the following in DFD/A?
   a) Inexpensive materials that can be easily removed or demolished
   b) Greater degree of control over the construction process
   c) Durability of materials