Green Building Handbook Volume 3

Scope and Flexibility for End-of-Life Options

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Introduction

"When one talks about adaptation, one talks about accepting the reality of these impacts and putting in place technological and policy measures by which we're able to manage the problem. That's absolutely essential."

— Nobel Prize winner Rajendra Pachauri, head of the Intergovernmental Panel on Climate Change

The pursuit of sustainable development brings the construction industry, and specifically the building industry component thereof, into sharp relief. The built environment is a major component of contemporary life. Over half the world's population is now urbanised and by 2050 that proportion will have reached two-thirds (UN-Habitat 2008). The urban population of South Africa was already at 56 per cent in 2001 (StatsSA 2006).

Buildings and structures form and alter the nature, function and appearance of the natural and built environment: it impacts on rural areas, villages, towns and cities. Buildings are known to have a long life: many of the buildings still in use around the world are many hundreds of years old. Their construction, operation, repair and maintenance and demolition consume energy and resources and generate waste in excess of any other industrial sector. Construction activity is a consumer of materials and scarce resources (water and energy), is a significant contributor to global warming emissions (including CO_2 from the burning of fossil fuels), contributes to air pollution (smoke and dust pollution), generates vast quantities of waste, contaminates the soil, and destroys existing vegetation (van Wyk, 2005).

Yet buildings are a crucial part of a strategy aimed at improving the quality of life: buildings constitute the infrastructure through which health care, education and housing are provided. The economic, social and environmental benefits that may result from a more efficient and sustainability-led industry are not difficult to imagine. Achieving a 10-20 percent reduction in consumption and waste patterns will have a significant and ongoing societal benefit.

Building activity varies significantly between developed and developing countries: whereas more of the building work in developed countries is orientated around renovation and maintenance (33 percent and rising in Europe), activity in developing countries has more to do with new construction (CICA 2002). Both activities must recognise that buildings are a resource that must be adapted rather than demolished.

Resource Use

As much as 50 percent of all materials extracted from the earth's crust are transformed into construction materials and products (Edwards 2002). In the United Kingdom over 90 percent of all non-energy minerals extracted are used to supply the construction industry with materials. Issues to be considered go beyond the aesthetic requirement of materials. Consideration must be given to the impact of extraction, manufacturing, transporting, assembling, repairing, disassembling and recycling. The selection and use of material must generate the greatest benefit over the longest time.

The Rocky Mountain Institute believes that a fourfold improvement in productivity can be achieved without consuming further resources. This will require the use of leaner technologies, greater use of recycling, better design and improved management (Edwards 2002).

Waste Minimisation

Apart from accounting for almost 50 percent of all materials extracted, these same materials constitute some 50 percent of all waste generated prior to recycling or reuse or final disposal. In the United Kingdom, some 70 million tonnes of construction and demolition materials and soil end up as waste (DETR 2000). Some 13 million tonnes of that waste is made up of materials delivered to sites and discarded unused. Construction waste has emerged as a larger waste stream than demolition waste and constitutes the largest waste stream by weight in the EU. Disposing of these waste materials is presenting increased difficulties in many parts of the world. Increased emphasis needs to be placed on waste minimisation through the use of such strategies as waste-prevention planning and design, recovery-orientated construction, reparability (design for disassembly and repair in the factory) and recyclables (used products to be returned to their producer) and reuse.

Appropriate Building Technology

Construction products and building technologies underwent a significant change during the Industrial Revolution: the development of iron and steel in particular created new ways for spanning large spaces and transferring loads to the foundations thereby freeing up the façade to be lightweight and adaptable. Prior to the development of iron and steel, structures relied on heavy timber sections to span spaces and heavy mass structures to transfer loads to the foundations. This resulted in a plan form consisting of many rooms aimed at reducing suspended floor and roof assembly spans.

The Modern Movement in architecture was quick to capitalise on the new iron and steel technology with Walter Gropius, Mies van der Rohe and Le Corbusier emerging as the leading protagonists. The house for worker's designed by Le Corbusier in 1914 best illustrates the use of the new technology to free up the floor plan for adaptive use (Figure 1). The design separates the load bearing structure from the super-structure thereby enabling the enclosing envelope to be constructed to reflect the internal use of the facility. It also enabled the enclosing envelope to be adaptable since external enclosing components could be removed without impacting on the structural integrity of the frame.

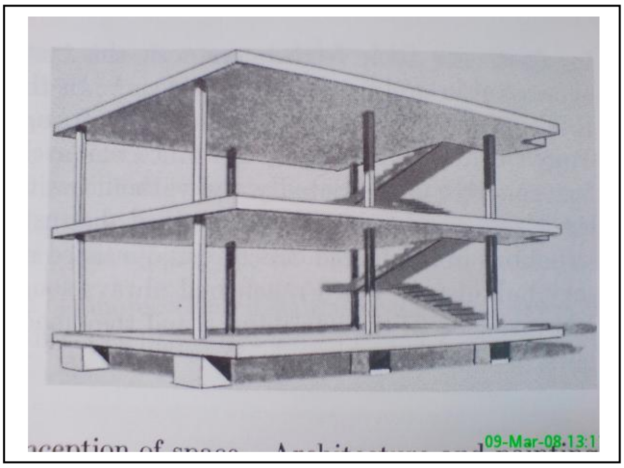

Figure 1: Maison Dom-ino, Le Corbusier, 1914. (Source: Wikimedia)

This approach substantially formed the foundation of Le Corbusier's work over the next ten years, and is clearly evident in the design of the Center Le Corbusier (Heide-Weber-Museum) built in Switzerland in 1967 (Figure 2). In this application the roof and supporting structure is completely removed from the structure enclosing the useable spaces thereby enabling the enclosing structure to be changed as and when required. Clearly the technology used to construct the enclosing structure has to be able to facilitate adaptations as and when required.

Figure 1: Centre Le Corbusier (Heidi-Weber-Museum), Switzerland. 1967. (Source: Wikimedia)

Adaptive Structures

A recently launched initiative by Buro Happold and Hoberman Associates, the *Adaptive Building Initiative (ABI)*, aims to promote the design of a new generation of buildings that optimize their configuration in real time in response to changing environmental conditions (http://www.adaptivebuildings.com/). While ABI focuses substantial attention on the building envelope, it does also include adaptive structural systems designed to provide operable control over the building's shape and structural configuration. Applications include retractable coverings to allow spaces to change from indoor to outdoor, transformation of interior spaces, and rapidly deployable structures.

Open Building

Open Building is a concept that recognises that the built environment is both stable and changeable: buildings constituting the built environment remain in place for many years, sometimes centuries, but are subjected to alterations and renovations on an almost ongoing basis throughout that period (Kendall, undated). Buildings – and thus cities for that matter – are always in transition.

Advocates of open building also recognise that the design, construction, operation and maintenance, and finally disassembly or demolition is not the decision of a single person – there are many stakeholders involved in every step of the built environment's formation. Thus the open building movement seeks to develop ways of making decisions that avoids conflict between the parties involved at any one point in time in an effort to balancing common interests with individual interests.

One of the protagonists of this movement is the architectural practice of Shu-Koh-Sha who applied these principles to an apartment block in Osaka, Japan (Figures 3 & 4).

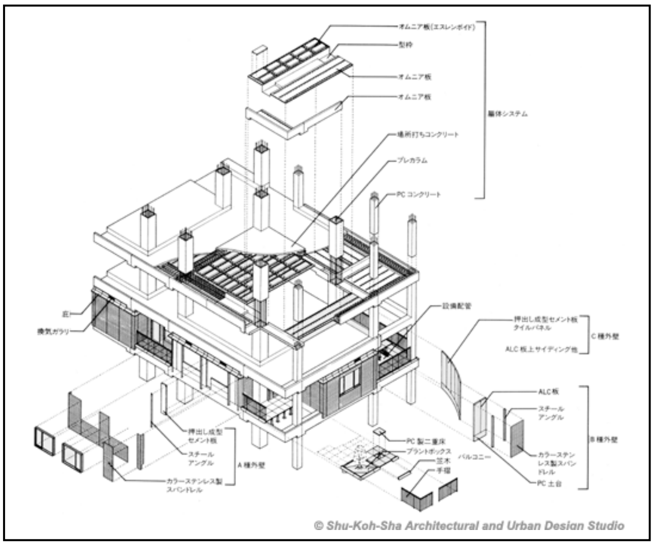

Figure 3: NEXT21 Apartment Block, Osaka, 1993. Shu-Koh-Sha Architects and Urban Designers.

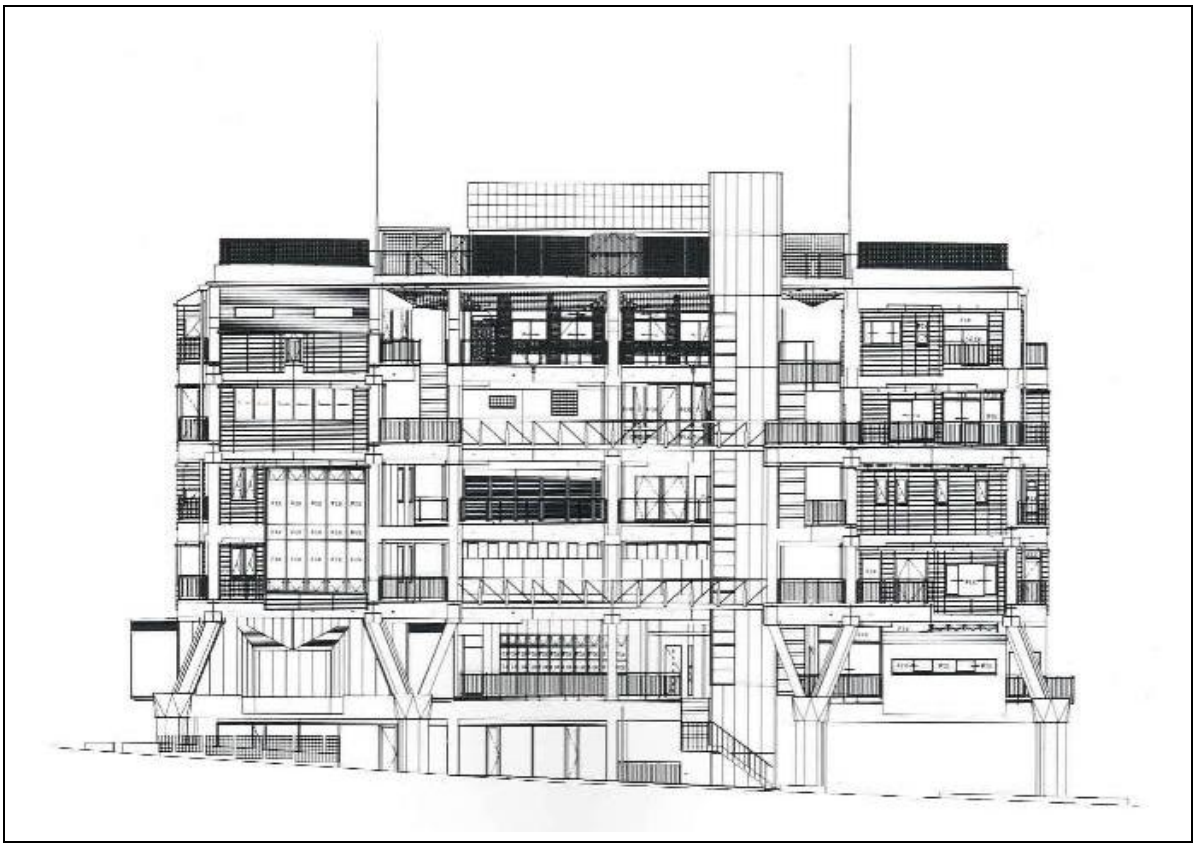

Figure 4: NEXT21 Apartment Block, Osaka, 1993. Shu-Koh-Sha Architects and Urban Designers.

NEXT 21 was completed in 1993 in Osaka, Japan as an experimental multi-family housing project demonstrating new concepts in multi-family housing that incorporated sustainable design methods and advanced technologies (Kim, Brouwer & Kearney, 1993). The building system used is based on the integration of a number of independent subsystems that allowed the building to be technologically flexible, facilitated components such as mechanical equipment to be easily replaced, and enabled adaptive reuse in response to the changing needs of the occupants. Figure 3 in particular demonstrates most clearly the design strategy and, while it is again focused on adaptability during the life span of the building, the approach serves the principle of disassembly equally well.

Design Strategies

Based on all of the above, the following design strategies will assist the designer to design buildings that are efficient and adaptable and thereby extend the life of the building.

1) Choose a structural system that provides flexibility in locating exterior walls and interior layouts, and that is based in a module so that various individual units can be harmonised to form an integrated building.
2) Aim to make the system robust enough to accept both standard and non-standard construction products to enhance the individuality of the users.
3) Choose a building assembly method that delineates building systems into distinct subsystems to create the necessary flexibility to adapt to future technological changes by enabling easy replacement of subsystems as they become outdated.
4) Assess the ability to make the spaces as multifunctional as the brief will allow to facilitate flexibility in use for end-of-life of the designed facility.
5) Evaluate whether non-useable spaces can make a meaningful contribution to the overall useability of the facility in terms of the brief while facilitating flexibility for end-of-life of the facility.
6) Design the building to accommodate modifications and upgrades that will satisfy changing programmatic, spatial and infrastructure needs and to facilitate flexible occupation at the end-of-life of the building.
7) Evaluate what opportunities exist within the brief for multiple uses and users at the end-of-life.
8) Evaluate what design interventions would be required at the end-of-life to extend the useability of the facility beyond the particular brief.
9) Aim to employ technologies that have a proven track record for robustness and durability.
10) Ensure that the design and the technology to be used is compatible to the level of construction technology available locally and design for the level of local expertise and capability.
11) Aim to standardise, simplify and integrate elements as far as possible.

Conclusion

Sustainable design methods – design for life cycle and design for disassembly – can meet resource conservation imperatives in a significant manner. This approach has a significant impact on the way buildings are designed and assembled. In order for this approach to be successful, a careful assessment of the technology to be used – both material and assembly – needs to be done having both the adaptability of the building during its life cycle in mind, and its disassembly at the end of its life. Both considerations will have a positive impact on liveability and sustainability.

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