Resource-productive Material Use

Niklaus Kohler and Abdol R. Chini

Resource use in sustainable buildings

The built environment lies at the origin of a majority of the mass and energy flows directed by humanity. It absorbs large economic resources and embodies considerable cultural capital. Although form and composition may vary from place to place, the built environment invariably constitutes a principal societal resource in the modern world. Sustainable development of the built environment is an idea that tries to enhance this resource -as an economic asset- while simultaneously achieving many related ecological, social and cultural objectives. Sustainable development serves to combine the interests of both present and future generations, and of populations in the North and South. The principal objectives are to enhance equity and quality of life over the long-term. However given the scale of the resource flows and corresponding impacts posed by the built environment, sustainable development is ultimately about transforming the built environment in ways that make our long-term survival possible.

One of the central objectives of sustainable building is the optimal use of resources in a long-term perspective. Primary resources are materials, energy, water, and land. Secondary resources are existing buildings and human cultural landscapes. The use of resources is determined by the quantity of resources, their life time in the building stock, the level of reutilisation after deconstruction and in general the attempt to avoid down cycling (and raise of entropy).

The question of how mass and energy flows make a building sustainable has been discussed in earlier SB conferences, in particular, at the GBC'98 in Vancouver conference when green buildings from different countries were compared. Every comparison has to take into account absolute quantities of mass and energy flow as well as local targets (how far from the average or best local solution). The advantage of using absolute flux data is that the ecological footprint of buildings and towns can be calculated and that large international differences in impacts for comparable functional units will appear. The comparison of buildings in their national context (relation to the "average" building) does not demonstrate the fact that the specific environmental impact of human being can enormously vary according to the society in which they live. Models of the urban metabolism have given very interesting insights into the large differences. In some cases they have even led to operational tools. There have been several attempts to define transdisciplinary approaches to the study of town development, in particular urban sprawl, regional development, urban and rural mass-flow and cultural issues. Furthermore analogies between urban development and wild ecosystems have become a promising subject of recent research. Energy and material flows through human settlements are conceived as urban metabolism, in which material inputs are transformed into useful energy, physical structure, and waste. Principles of ecosystem succession can be used to explore ways in which city development differs from that of wild ecosystems.

Strategies of resource- productive material use

Input oriented strategies:

The objectives are to use a minimum of materials, to assure a long-term use, to choose materials that do not have large environmental burdens and to design buildings so that they can be easily maintained, refurbished and deconstructed. This last approach enables building parts and materials to be reused, re-manufactured or recycled at end of life (closed loop). This also might involve that the product manufacturer maintains the ownership of the product through its life, repairing and upgrading the products as required (extended producers responsibility- EPR). Unlike the implementation of EPR in the German automobile industry, which is resulting in near closed loop behaviour for that industry, buildings are far less likely to have their components returned to their original producer for take-back at the end of their life cycle. However, EPR could be applied to components that are routinely replaced during the building life cycle and are readily able to be decoupled from the building structure (chillers, plumbing fixtures, carpet).

Stock oriented strategies:
Once the materials are part of a building, it is important that they can be used as long as possible on a high level. Strategies imply optimal maintenance, appropriate technologies in refurbishment and control of the risks due to the use of materials. The transformation of the building stock has to take into account its value as a “cultural” resource. Combined long term strategies for material and cultural resource conservation should be developed.

Output oriented strategies:
When a building has reached the end of its life span, a deconstruction strategy has to be chosen. The objective is again to assure the highest level of reuse as a building or as part of a building. Not only does deconstruction and materials reuse conserve landfill space, it can reduce the demand for new materials, decrease the environmental strain caused by the mining of raw materials, and preserve the original energy spent in the creation of building material. The logistic aspects of deconstruction and of distribution of used parts and recycled materials have to be developed. The next level would be to recycle waste materials. Scenarios for the transformation of building wastes into new materials have to be verified by life cycle and risk assessments.

In the different strategies mentioned above a multitude of technical, quality control, administrative and economic problems are encountered and have to be solved in a consistent way to give birth to new “life cycle material chains”.

National and regional differences:
Sustainable building means to share the objective of conserving resources and protecting the environment and human health for today and for the coming generations. The application of sustainable building principles will however vary considerably from one country and continent to the other. Referring to resource productive material use and the input/stock/output aspects several typical situations can be identified:

The relation between input- and output flows and the time constant of the building stock is different in industrial societies (Europe, North America, Japan), in rapidly growing societies (Asia, South America) and in slowly growing societies (Africa). In Europe, for example, the mass flows going into the built environment (buildings, infrastructures, cities) are approx. five times higher than the building waste. Therefore, the objective is to maximise the quality (the performance) of the built environment and to minimise the throughput. This means that both input and output flows have to be considered as well as the time constants of the stock. Resource productivity refers in this sense to different forms of resources (cities, neighbourhoods, buildings, components), which should be used as long as possible on a high level. Improved deconstruction is the last, important step after the attempts to continue to use the existing resources. In certain Asian societies (typically China) the management of the input flows (and the resulting environmental impacts) seem to be quite dominant. In countries where rural societies are dominant the flows from the biosphere to the antroposphere are much smaller and the energy and building material flows are often similar to domestic flows (food).

It should be an objective of the conference to have contributions that represent different situations, showing how sustainable building strategies can take different forms in the domain of resource productive material use.

Design, Construction and Maintenance

The necessity to use materials in a productive way is a common objective of the different players in the Life Cycle of a building. In their specific decision making situations they need however different tools and reference values. Building owners and clients are interested in reference values for the procurement of a building. Due to the multitude of situations it is not possible to give general quantitative values. It is preferable to specify a level of energy consumptions, principles of material choice (renewable materials, non toxic materials) and of design requirements (maintenance friendly, reverse engineering, deconstructable etc.). For the design and construction phases it is possible to use integrated LCA techniques combining energy consumption, mass-flow, environmental assessment and cost calculation during the life cycle. Maintenance and deconstruction process can be simulated through reverse engineering methods already in the design phase. Full (life cycle) cost calculation will include deconstruction and disposal costs as well as other external costs. Specific tools for LCA simulation and Construction process simulation should be used. During the building process on site a very strict management of the input and output flows (building waste) must be prescribed and controlled.

Deconstruction is emerging as an alternative to demolition around the world. As its primary purpose, deconstruction seeks to maintain the highest possible value for materials in existing buildings by dismantling in a manner that will allow the reuse or efficient recycling of the materials that comprise the structure. Deconstruction of buildings has several advantages over conventional demolition and is also faced with several challenges. The advantages are an increased diversion rate of demolition waste from landfills; potential reuse of building components; increased ease of materials recycling; and enhanced environmental protection, both locally and globally. Deconstruction preserves the invested embodied energy of materials, thus reducing the input of new embodied energy in the reprocessing or remanufacturing of materials. A significant reduction in landfill space can be a consequence.

The challenges faced by deconstruction are significant but readily overcome if changes in design and policy would occur. These challenges include: existing buildings have not been designed for dismantling; building components have not been designed for disassembly; tools for deconstructing existing buildings often do not exist; dismantling of buildings requires additional time; re-certification of used components is not often possible; building codes often do not address the reuse of building components; and the economic and environmental benefits are not well-established. Again, these challenges generally fit into one of two categories: design or policy.

Possible themes for contributions:

- Long (national) Resource management

- Comprehensive, long term approaches in input minimisation
- Material allocation between different sectors
- Reverse engineering, Design for deconstruction

- Resource value of buildings and building stocks
- Energy- and Mass-flow models of buildings stocks
- Maintenance strategies
- Cultural and material resource conservation

- Downstream resource management
- LCA of downstream /recycling and reuse process
- Logistics of deconstruction
- Examples of downstream chain management