# Demountable construction enables structural diversity

## University of Luxembourg's Prof. Dr.-Ing. Danièle Waldmann-Diederich explains how demountable construction responds to changing structural demands

Buildings are often demolished due to a needed conversion or change of the architectural design, although the supporting structure remains completely undamaged and fully intact. This leads to huge quantities of waste which need to be discharged on mining tips. Thus, the building sector is generating a large amount of $CO_2$ emissions, resource consumption and waste production. Given the high resource-intensity and $CO_2$ emissions of the sector, new eco-construction approaches are needed.

**Demountable construction**

Demountable building constructions are defined as structures which allow destruction-free dis- and re-assembly responding to changing structural demands, revitalisation or removal. This could only be reached by designing modular, flexible, adaptable and upgradable structural components with detachable connections. But it is not sufficient to consider only the erection phase of the elements, they must be optimised in terms of materials ageing and energy consumption in an integrated situation within an overall building concept. The idea of developing construction systems which are demountable is not new. Although, many precast structures have been erected in the meantime, the reuse of complete structural elements is still not practiced. The advantages of reuse, with a saving of energy consumption, raw material and $CO_2$ emissions are obvious. Furthermore, no waste is produced which is needed to be discharged on building rubble dump. So the question rises why the idea of demountable construction could not been pushed forward until now.

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The raisons are manifold. One major reason is certainly that this kind of construction needs a change in philosophy: first of all, the architect is limited in his design as he has to align to a given grid. So the development of architectural typologies and adapted constructive principles are necessary to permit the reutilisation of whole elements after one life cycle. Furthermore, these architectural principles should also allow a reuse of the building in case of conversion. Then new deconstruction methods have to be developed: e.g. renders, insulation, floor covers, screeds are fixed to the structure so that an easy disassembly is not anymore possible. Here, new techniques have to be developed which allow after the first live cycle of the building an easy disassembly and cleaning. Another major reason is certainly that after the first life cycle of a building often the information about the load bearing structure and other performance criteria is not any more available. Retracing the information about one single load bearing element with its reinforcement position, grade, diameters, concrete cover and concrete class etc. is difficult. Often the documents of the statics and the structural design are not anymore available.

Furthermore, a condition assessment of these elements must also take place to assess the remaining load bearing capacity. Another major aspect is that no circular economy market is yet installed which would provide schemes and solutions for the deconstruction, transport, condition assessments, temporary storage and reuse of whole structural elements. Thus, the systematic integration of large quantities of elements in new buildings needs new concepts on different levels and a change in the building process without forgetting the client who must accept to invest in a new building which load bearing structure is a conglomerate of old structural elements.

All these aspects are currently addressed in research projects of the Institute of Civil Engineering and Environment (INCEEN), a sub-structure regrouping the civil engineers of the research unit of engineering sciences at the University of Luxembourg. The overarching mission of INCEEN is to solve scientific questions and to develop new scientific and technical methods for sustainable buildings. By doing so, it aims to advance the level of scientific understanding in key-

domains relevant to the next building generation, including modular construction, applying principles of the circular economy. Further INCEEN aims to catalyse interdisciplinary research collaborations in the areas of structural engineering and the environment, as well as contributing to solving sustainability challenges of the built environment sector responsible for a large amount of $CO_2$ emissions and resource consumption. INCEEN has strong research experience in the design of reinforced/prestressed concrete, steel and composite structures and structural health monitoring.

The current research of INCEEN is driven by the aim to reduce energy and resource use throughout the entire life-cycle of buildings and their components. By showing how buildings can be used as material and component banks, the research projects of INCEEN seeks to trigger a paradigm shift in the construction sector. The research also analyses the possibility of business models based on loaning materials and components to customers. Therefore the applicability of monitoring systems in structural components by internal electronic chips (RFID) which are readable from outside guaranteeing a provision of all relevant information for a reconstruction or reutilisation in future reuses will be developed and tested.

To sum up, the concepts to be developed are based on the investigation of a wide spectrum of factors, taking into account different (often competing) technical, ecological and economic constraints imposed by planning, design, pre-fabrication, on-site operations, in-use consumption and emissions, as well as requirements for refurbishment and demolition/recycling at the end of a building's life-cycle. Understanding sustainable construction as an important component towards the reduction of the total resources-related footprint of a building, it is evident that only an integrated and inter-disciplinary approach to such a multi-objective constrained optimisation problem can be successful.

UNIVERSITÉ DU LUXEMBOURG

**Prof. Dr.-Ing.**
**Danièle Waldmann-Diederich**
**Head of the Institute of Civil Engineering and Environment**
Head of the Laboratory of Solid Structures
Faculty of Sciences, Technology and Communication at the University of Luxembourg
Tel: +352 46 66 44 5279
daniele.waldmann@uni.lu
www.uni.lu