Infozentrale auf dem Vollgut – Circular Construction for a Post-Fossil Society

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Abstract. The "Infozentrale auf dem Vollgut" was designed and realised by a group of 36 students as part of the BUILDinG CYCLE design studio from the Natural Building Lab at the Technische Universität Berlin. In co-operation with the research project RE4 [1], a building embodying circular construction principles was realised from waste materials as a DesignBuild project, offering an answer to questions relating to resource-positive construction in an urban context and embodies a new method of architectural production for a post-consumer society. In the opening weeks of the project the student groups undertook a material research, where innovative low-tech constructive elements were created using a wide range of waste materials Through this research the groups established a network, through which they were able to source larger amounts of the waste materials used for the building – recovered timber and cardboard. The load bearing structure of the building is formed from timber recovered from local demolition sites and a dismantled architectural installation from the International Garden Festival 2017, thus providing a second usage cycle for this valuable resource. The 5.5m x 7.0m roof structure is formed by a pre-stressed grid of layered and interlocking re-used timber beams with reversible connections designed for disassembly. For the wall elements an experimental system was developed utilising stacked upcycled cardboard fruit boxes filled with shredded paper as insulation and covered with recovered large format posters and plot drawings – common waste materials within the architecture faculty. The project embodies circular construction principles and serves as a prototype for a LowTech post-fossil architecture based on the realities of resource scarcity and climate change.

Keywords: Community based trans-disciplinary design, DesignBuild, Building from Waste, Circular Construction, Timber, LowTech

1. Introduction

The building sector produces around 50 % of all CO_2 emissions in Europe. After working over decades on energy efficiency, the focus in the future must be on material resources. Around 60 % of the waste in Europe is generated by the building sector amounting to a total of 750 million tons per year [2]. Modern buildings of the fossil age generally use a complex mix of materials and resources mostly joined inseparably in a one-way collection of compound materials. For the coming decades our focus for the build environment must be on the efficient reuse of existing resources, the design of circular elements, constructions and buildings and the use of renewable resources.

The "Infozentrale auf dem Vollgut" was designed and realised as a 1:1 prototype for a post-fossil building in an urban setting, based on the principles of circular construction. These principles were applied in a holistic and comprehensive manner; in the sourcing of building material, developmet of construction principles and the inclusive and collaborative way of working with manifold actors following a transdisciplinary design approach. The project was carried out by the Natural Building Lab at the Technische Universität Berlin [3] in an interdisciplinary team, headed by a group of 36 students taking part in the BUILDinG CYCLE [4] design studio. The Natural Building Lab is active in the fields of architectural teaching, research and practice related to the use of natural building materials and the challenges facing our society on the path to a post-fossil future. The studio was run as a collaboration with the chair of TEK – Trangwerksentwurf und –konstruktion and GtE – Gebäudetechnik und Entwerfen at the TU Berlin, the EU-funded research initiative RE4, as well as a multitude of actors (Akteursrunde) active on the Vollgut area in Berlin Neukölln – in one of the economically weakest neighbourhoods of the German capital.

The aim of the project was to develop as far as possible the elements of the building from only recycled and environmentally friendly materials. This would ensure that the building positioned itself clearly as a prototype for sustainable construction and that its constituent materials would remain in an ecological cycle of use and re-use. This aim required new methods and techniques to be developed, to allow constructive elements to be designed reversibly and their base materials separated and returned to their own use-reuse cycles. The team of students were asked to take the learning experience into their own hands and to explore solutions and materials outside of the usual palette used in bachelor design studios. The challenge was to realise an entire building that could test these and other techniques in consultation with it´s future users.

2. Methodology and Aims

The project was set up as an academic DesignBuild [5] project at the school of Architecture at TU Berlin. As such it included interlacing elements of research, design and realization and a wide array of transdisciplinary collaborations. From the outset the studio collaborated with the research initiative RE4 (REuse and REcycling of CDW materials and structures in energy efficient pREfabricated elements for building REfurbishment and construction) [1], in which Berlin based ZRS Architekten Ingenieure are investigating the potential of timber as a circular construction resource and developing prototypes of new circular constructive elements made out of recovered timber. With this research background a design studio was initiated that started in October 2017 with 36 students in the 5th semester of their bachelor degree. An immanent goal of the design phase was to take the design far enough to enable the realisation of a prototype building starting in February 2018. The intention was to develop a LowTech construction that would make it possible for the group of students as non-professional construction workers to construct the building with their own hands. The space itself was intended to be used as an activating meeting and information point for the neighbourhood and the actors working on the site - a future hub for cultural, educational and social activities later on.

3. The Building Cycle Principle – Material Experiments

In the opening weeks of the project, the group was introduced to the concept of circular construction and set a first task requiring them to develop a concept for a constructive building element using a recovered material of their choice in groups of 4. They began by developing a type of manifesto,

which would allow them to better formulate decisions relating to their material choices. For instance the group set rules that materials for the first phase could only be recovered from certain sources, i.e. found material on the street or in building waste containers, from initiatives, from household waste or leftover materials from shops, crucially no newly purchased materials were eligible for the first phase.

The results of these experiments were diverse with groups choosing materials including PVC pipes, aluminium dry wall C-profiles, paper, glass, timber and even cigarette butts. The end result was 10 innovative circular construction systems. Though many of the systems developed were further developed and used in the construction phase, the one that we will discuss here in most detail involves paper, as this formed the main constructive elements of the finished Infozentrale.

One group developed a window/wall system called Plakat + Glas (figure 1.) using recovered posters, a common resource in Berlin where in many areas promoters will layer upwards of 20-30 posters on top of each-other advertising the latest events upcoming in the city. The posters have a self adhesive reverse surface which is then pasted onto the surface that they are displayed on. The group found that by re-wetting the posters, it was possible to remove them intact and even to re-adhere them to new surfaces or to each-other. The recovered material is very flexible and workable using simple tools. In this case the group decided to combine it with another common waste material – broke glass panes. They reasoned that the flexibility of the posters made it suitable for the containment of panes of broken glass, that would normally only be suitable for recycling – an extremely energy intensive process. Their system used layered posters as the external weather-proof cladding with two layers of glass and an insulation layer from corrugated posters. The system is a novel use of an extremely characteristic Berlin waste material, the posters especially became a resource which was key to the completed project. A second group investigated insulation materials, crucially involving the use of shredded paper, which was later combined with the Plakat system to form the wall modules.

Figure 1. The Plakat + Glas group's raw material and wall innovative system.

4. Design Phase – System Development and Synthesis

The next task required the students to develop a pre-design for the pavilion using the systems that they conceived during the first phase. At this point a number of new considerations were required especially how to produce a feasible LowTech structural system using only recovered materials, that could be realised by the students themselves without the need for complicated tools and connections. As with the first phase the results were extremely diverse, one of the crucial ideas that emerged from the pre-design phase involved the use of timber.

The Elementare Bedachung (Elementary Roofing) group focussed on the difficulties of working with recovered timber in new construction, specifically the difficulty in finding large format sections. The group reasoned that this could be used to the concepts advantage and developed a regular lattice-grid roof structure using small timber sections, allowing them to cover a reasonable span without using large section timbers. This concept and system were further developed to form the main structural system of the pavilion.

Out of this background of diversity and experimentation it was necessary to develop one concrete design, which could become the finished pavilion. This required the students to develop formats and processes for collaboration beyond those normally required in their previous projects. This group dynamic was critical to the project as it allowed the best aspects of all of the pre-designs to be synthesised and further developed for use in the final design.

Figure 2. Visualisation of the final design showing the paper wall modules and lattice grid timber roof.

As this process unfolded ideas were torn-up, reformulated, discussed and reintegrated into the design. As it became clear that timber and paper/cardboard were the most promising resources for the structure of the pavilion (figure 2), numerous processes were required to run in parallel. Groups were delegated to proceed with the sourcing of materials, while others proceeded with the development of the wall system and others with structural calculations for the timber structure and detailing.

5. Timber – Sourcing and Preparation

Many of the challenges facing the timber group had been identified by the RE4 project [6] previously and transdisciplinary input from this practice-based context helped the student group to overcome a number of difficulties quicker than would have otherwise been possible. As the design developed it became clear that the roof structure would require large amounts of recovered timber to cover the spans being proposed. As such the material and design group became extremely dependent on each-other with information about possible sources and section sizes being gathered on the ground and directly integrated into the design discussions and structural calculations.

The group harvested material from a wide range of sources including from two building sites in the region where houses were being demolished providing timer beams from roof constructions. Furthermore the group negotiated to use materials including some large timber sections recovered from an architectural installation about recycling called “Sammlers Traum” that had been temporarily constructed for the International Garden Exhibition 2017 in Berlin-Marzahn.

Timber is crucial resource for the post-fossil economy, in Berlin especially huge amounts of waste timber are produced by the renovation of pre-war housing stock, especially the renovation and extension of timber roof structures. Wood in the form of solid timber beams usually goes into thermal recovery, as the contractors expect the sections to be contaminated by chemical protection treatments which render it un-usable in new construction [7]. However by removing 3mm of the top surface it is possible to also eradicate any potentially contaminated timber. The harvested beams were reworked in the timber workshop of the Architecture Institute, the sections were sorted, cleaned and then checked for nails, screws and other metallic components using a metal detector. The beams were then processed using jointer, band-saw, and planer into sections of 11x6 cm for integration into the roof structure (figure 3). The produced material was classified by the team based on DIN 4074 [8].

Figure 3. Timber harvested from a demolition site and reworking.

6. Paper – Development of the Wall Modules

In parallel another group proceeded with the further development of the non-structural wall modules using cardboard and paper, which would form the boundaries of an indoor space beneath the independent timber roof. Here a number of the experiments and aspects of the pre-designs were combined to produce a highly novel and characteristic circular construction system.

The use of recovered posters as a cladding and shredded paper insulation were ideas born out of the material experimentation process, this was complemented by the use of fruit and vegetable boxes made from cardboard as an internal support structure (figure 4.). Such boxes are a common sight at the many food markets around the city and are often disposed of after each days produce has been sold. The sourcing group made a number of contacts including the Berlin wholesale market and number of larger supermarkets, where they could harvest these boxes free of charge. The boxes were stacked on top of each-other to form a series of modules, some straight and some including corners, that could be combined to create the form desired. To increase stability hard cardboard tubes were cut open and used as connectors to join the stacks together. One of the biggest difficulties was that no standard height for the boxes exists, meaning that to reach the required height, different combinations of boxes had to used, a complicated tetris-like puzzle in three dimensions.

Figure 4. Development and installation of wall modules from cardboard.

For the insulation sources were found closer to home, within the Architecture Faculty huge amounts of paper waste are produced, especially after presentations as students are expected to present their projects on large format plots, which become redundant after the presentation. Other sources were found around the campus from other faculties and surrounding office buildings. Frustratingly many firms are not able to give away their paper waste (even if it is already shredded) due to

confidentiality issues. Initially the group attempted to shred the paper using standard format paper shredders, this proved to be totally inadequate, as the shredders tend to overheat after a relatively small number of sheets. Thus they were forced to locate a professional paper shredding firm who agreed to shred large amounts of paper on their industrial large-format machines.

The weather-proof outer skin was formed from 6 layers of posters, the process of recovering posters from the street proved to be extremely time intensive and unfeasible for the amount of material required. However after inquiry it became evident that many promoters have to dispose of large amounts of unused posters once they become out of date. Thus a new source was found with the potential to provide the volume required.

To determine the characteristics of the wall modules a number of practical tests were undertaken. The loading capacity (wind loads) of the modules was tested using water canisters added until the breaking point of the module was reached. The load capacity determined from testing was three times higher than needed, so the test was successful. Furthermore the fire resistance of the modules was tested practically, it as found that even without a protective coating of linseed oil, the modules would not ignite even after 5 minutes of exposure to a medium sized open flame.

7. Construction Phase – Detailing and Execution

From the outset the aim had been to design a reversible and temporary building, this posed numerous challenges in the detailing and assembly of the timber structure. As the design developed it became clear that the lattice grid roof would be structurally independent of the interior walls and supported on 4 cross-formed timber columns outside of the main heated envelope of the pavilion. One of the main challenges facing the team working on the structural design (figure 5.) was how to categorise and calculate the characteristics of the recovered timber. Although the strength and quality of the sections was clearly evident on physical inspection, based on DIN 4074 [8]. The resulting values meant that in some areas the recovered sections had to be complemented by new timber sections to satisfy the formalities of the structural design. In the end the lattice grid was made up of eight layers of timber running perpendicular to one another (figure 6.).

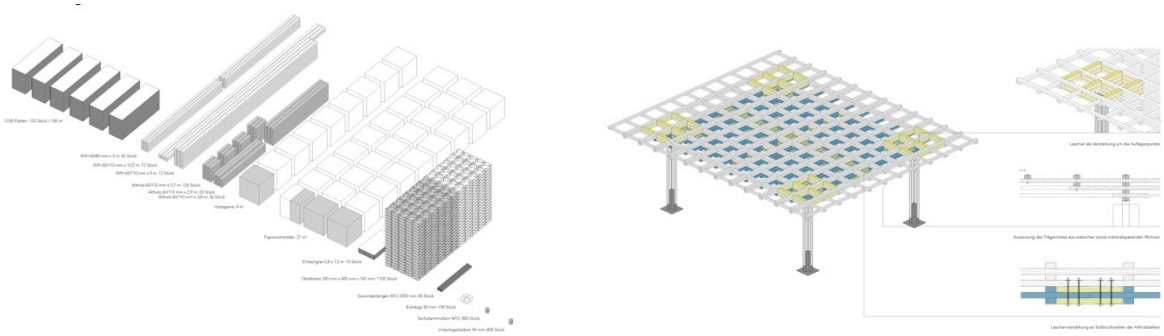

Figure 5. Material inventory and axonometric view of timber structure.

Once the raw structure was completed, the roof and floor structures were filled with insulation composed of the wood shavings that had been harvested during the processing of the timber beams. In parallel the wall modules were being prepared, these would then form the heat-insulated envelope of the finished Infozentrale.


Figure 6. Assembly of the recovered timber lattice-grid roof structure.

8. Conclusions

Considered as a process, the project offers a vision of resource-positive construction in an urban context and embodies a new method of architectural production for a post-consumer society. By placing value on collaboration and experimentation throughout the design and realisation phases, the group were able to conceive innovative circular construction systems using waste materials, which were developed up to a level that allowed them to be physically realised. This process required them to overcome many difficulties, many typical of the challenges facing the building sector on its path towards becoming a post-fossil economy. From the lack of standardisation in cardboard boxes to the difficulties in classifying the strength of timber sections, the project served as a microcosm of the problems facing larger projects and thus serves as a hugely valuable experience for young architects.

Yet in other aspects the project set new standards for the Natural Building Lab's work and achieved feats above and beyond the aims set at the project's outset. The entire pavilion utilised connections and materials that could be easily executed using hand tools and with the minimum of previous experience, as such the building sets a standard for a LowTech building system that can be adapted and reformed by the end user. Thus the project sets itself up as an alternative to the standard and highly commercialised standard methods of architecture production typical of the fossil-economy. Furthermore the project succeeded in establishing a number of new material networks and cycles within the neighbourhood, connections which have been documented and can be further built upon in further projects. As a DesignBuild project the studio succeeded in integrating a wide range of inter-disciplinary collaborations both within the university and with actors on the Vollgut Areal and from the surrounding neighbourhood. The finished Infozentrale (figure 7.) serves as an embodiment of these principles and as a built prototype for a post-fossil architecture based on the realities of resource scarcity and climate change.

Figure 7. View of the completed timber structure.

9. References

[1] REuse and REcycling of CDW materials and structures in energy efficient pREfabricated elements for building REfurbishment and construction, www.re4.eu
[2] European Comminsion, ENV.A.2/ETU/2014/0049 - Resource Efficient Use of Mixed Wastes
[3] Natural Building Lab – constructive design and climate adaptive architecture, Technische Universität Berlin, Architecture Faculty, www.nbl.berlin
[4] nbl.berlin/BUILDinG-CYCLE
[5] N Pawlicki, M Kestel, The collateral effects of academic DesignBuild: students and community. aae conference 2017: architecture connects - proceedings. Oxford Brookes University, Oxford
[6] RE4 Project, 2017, D1.3 Overview on the current status of construction of prefabricated elements with recycled materials, P28-32
[7] Waste wood ordinance, 2002, Ordinance for requirements in relation to the utilisation and disposal of wood waste, KrW-/AbfG 6.20.
[8] DIN 4074, Sortierung von Holz nach der Tragfähigkeit