THE DEVELOPMENT OF AN ECO EFFECTIVE HOUSING CONCEPT

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ABSTRACT

"Wouldn't it be great if high-rise blocks simply fell apart when we no longer need them? Or if an office building turned back to sand and earth once its occupants moved to a new commercial estate? We have to get away from the idea that we're building for eternity." This idea was the beginning of our lifespan research at the Eindhoven University of Technology in 1990; to develop buildings without waste at the end of their lifetime, was the main focus. During this period we've realised buildings with a lifespan of twenty, five and a hundred years. From 1990 till now we've made interesting steps. We made the step from sustainability to a more ecological approach. The threat is that buildings are no longer only the result of a brief from the client, but become more and more temporary envelops for their occupant's business. At a certain point in time no one can or will use this envelope. Therefore it is very important that the used building materials will become part of either a biological or a technological cycle in order for it not to end up as waste.

Keywords: *cradle to cradle, up cycling, eco-effective*

ABSTRAK

"Bukankah lebih bagus jika blok yang bertingkat tinggi menjadi berantakan ketika kita tidak lagi membutuhkan mereka? Atau jika gedung perkantoran kembali manjadi pasir dan bumi karena penghuninya pindah ke kawasan komersial baru? Kita harus melepaskan diri dari gagasan bahwa kita sedang membangun untuk selamanya "Ide ini adalah awal dari penelitian jangka panjang di Eindhoven University of Technology pada tahun 1990. Untuk mengembangkan bangunan tanpa limbah pada akhir masa hidup mereka, adalah fokus utama. Selama periode ini telah disadari bangunan dengan rentang umur dua puluh, lima dan seratus tahun. Dari tahun 1990 sampai sekarang, telah dibuat langkah yang menarik. Pembuatan langkah yang berkelanjutan untuk pendekatan yang lebih ekologis. Ancamannya adalah bangunan tidak lagi hanya merupakan hasil keinginan klien, tetapi menjadi lebih dan lebih dalam mewadahi sementara kegiatan bisnis penghuni mereka. Pada titik tertentu, saat tidak ada orang yang dapat atau akan menggunakan wadah ini.

Oleh karena itu sangat penting bahwa bahan-bahan bangunan yang digunakan akan menjadi bagian baik dari siklus biologi atau teknologi agar tidak berakhir sebagai limbah.

Kata kunci: *buaian ke buaian, siklus, ekologi effective*

INTRODUCTION

We wanted to develop a sustainable building technology. But what do we mean by sustainable? Sustainability is the capacity to endure. For people sustainability is the long-term maintenance of well-being, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management of resource use. In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for human well-being. Healthy ecosystems and environments provide vital elements and services to humans and other organisms.

Human sustainability interfaces with economics through the social and ecological consequences of economic activity. Moving towards sustainability is also a social challenge that entails, among other factors, international and national law, urban planning and transport, local and individual lifestyles and ethical consumerism. Ways of living more sustainable can take various forms from reorganizing living conditions (e.g., eco villages, eco municipalities and sustainable cities), to reappraising work practices (e.g., using permaculture, green building, sustainable agriculture), or developing new technologies which reduce the consumption of resources.

Sustainability encompasses a broader view than only the technological aspects. It makes clear that we, as technical engineers only can make a difference with our skills. One of the key environmental problems in the Western world at present is climate change.

Increasing CO2 emissions are among the causes of climate change, which has major implications on the world. The EU has signed an agreement recently, in which a variety of objectives are set out to reduce climate change. One of the goals of the European Commission is to reduce CO2 emissions and fossil fuel use by 20% in 2020 with reference to 1990.

Ever since the oil crisis of 1973 the construction industry is known for its high fossil energy use, 30% to 40% of the global energy supply. The food industry followed by residential building are seen as the largest contributors to greenhouse emissions (GHG). An environmentally friendly version of a dwelling will therefore contribute to the objectives of the European Commission to reduce CO2 emissions and to reduce the use of fossil fuels.

Project XX

According to this knowledge we debated in the Netherlands about a new building technology based on sustainable principles. As a result of this long-term debate we came to the idea to find a solution for the waste of buildings at the end of their lifetime. During the past centuries we've seen that many buildings were dismantled and new buildings were erected. The result was 23 million ton waste a year. Motivated by these figures we developed a building without waste at the end of the lifetime. The focus was a flexible building for different clients, so it had to be comfortable, good architecture and all within the predefined budget. During several workshops we came to a concept of a building with a lifespan of twenty years. This specific period was based on the experience that after these years clients are moving to a more up-to-date building. Project XX was born. XX are the Roman numerals for twenty, "plus a double question mark" The project XX was the first building in the world with the principal of zero-waste materialization (Figure 1).

We did material research to develop this building standing for twenty years. After the planned two decades, the construction materials will either be perished or can be readily dismantled for reuse.

Figure 1. Project XX

Children Art Hall

The flexibility of the building is one of the most important aspects to achieve a long lifetime of the building. Within this context other questions occur. Is it possible to develop a building which is adaptable to change? Are there enough possibilities for the client to rearrange/remodel the building at the moment his organisation will change?

The project XX had a follow-up by several new interesting projects, based on the lifetime issue. One of these projects was the Children Art Hall in Rotterdam. One of the issues to last a building is to make the lay-out more flexible. Are there enough possibilities for the client to change the building at the moment his organisation will change. Is it possible to develop a building that is adaptable in the future?

The brief for the Children's Art Hall was to develop a building for a period of five years (Figure 2). The client was not sure about the future. Also the plot was temporary. These uncertain factors asked for a new concept and there was no experience. The client was also unsure about the volume of the building, should it to be small or big? So we developed a building based on steel modular elements with the measurements of 3 x 3 x 6 meter. By using these modular elements it was possible to extend the building, to dismantle parts of it and even to change the layout. Fortunately the concept was a success. The building served the client for five years after which the client had to move to another building because the plot was designated for other buildings. After these five years the building was dismantled and stored as modular elements. Two years later we reused these elements again to build a school. The brief now was an ultimately flexible school. The client preferred to have the possibility to connect all the classrooms together. Because the envelop of the school had a larger volume and also was the layout not the same as for the Children's art Hall we had to use more elements. We've also designed a new facade, because the original facade was materialised to last for only the first five years.

Project XX and the modular buildings proved the possibility of a new sustainable building technology. People like to work in these buildings and the budget is affordable. We have the skills now to design buildings more flexible and materialise it within the zero-waste concept.

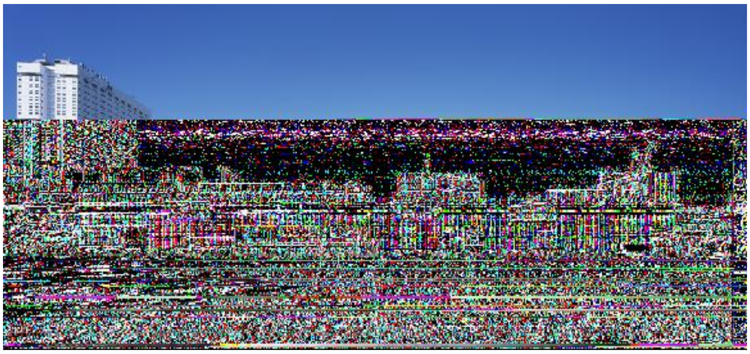

Figure 2. Children Art Hall

Cutting Down on Services

Besides the materials the services are also debet to an enormous influence during the exploitation on the CO_2 emissions of the building.

During the 80's we've seen the importance of services in buildings growing. Technicians tend to deliver more comfort, based on better lighting, better temperature management, safety management, etc. Nowadays 40 to 50% of the building costs are caused by the services. At the same time we've came to conclusions that this comfort push includes also negative aspects. The envelope of the buildings is often to close; you are no more in relation with the nature around you. The connection with the seasons outside has been lost. We've learned from research that it has a negative influence on the personal output. In conclusion we can say that sustainability doesn't always require that kind of perfection: things have to be good enough for the precise period of use we have in mind for them. Anything beyond that are wasted effort, wasted energy and an unnecessary burden on the environment. That doesn't only apply to the consumption of construction materials. We argue that extremes of perfection aren't needed when it comes to the actual usage of a building either. Generally we build offices in which the temperature is always between 20.0 and 22.5 degrees, during winter as well as during summer. This kind of precision is absurd. To achieve it, you have to pack the building with heavy-duty air-conditioning and heating equipment, together with a complex system of pipes and ducts. It's systems like these that account for much of the complexity of our current buildings. But what does it actually matter when the temperature varies a bit? Just put on a sweater or pull the shades. If you accept a certain amount of fluctuation, you can get by with much smaller services which use less energy.

According to the Building Decree a Dutch dwelling should have an Energy PrestationCoëfficient (EPC) of ≤ 0,6. A low EPC stands for a high-energy efficiency. A low EPC, however, says more about the applied building services than the design of the dwelling itself.

By simply adding building services which reduce the EPC, you can achieve a low EPC. This eventually results in more or over-sized services in the dwelling than needed with an energy efficient design of the dwelling itself. Therefore it's important to integrate active natural systems within the direct surroundings (such as sun, wind, water and soil) in the design of a building. To create a higher comfort level, building services can be added in addition to these active natural systems.

From Sustainability to Cradle to Cradle

Since we've realised that we use the materials only for the lifetime of the building it's easy to understand that the next step is a whole ecological approach. All our handlings are part of the nature. If we start from here it will be more and more clear witch decisions we can make. No more toxic materials, more diversity, renewable energy, etc.

An ultimate environmentally friendly building is a building con-form to the Cradle to Cradle® (C2C) philosophy. One of the pillars of this philosophy is 'waste = food'. During the construction, use and even demolition of an entirely C2C designed building there will be no waste, only food. Waste materials will not be dumped in landfills, instead these are used as raw material in a new product or for a different use. This material cycle approach is called ‘upcycling’ instead of ‘downcycling’ or ‘recycling’.

The so-called “Cradle to Cradle” philosophy means a biomimetic ore regenerative approach to the design of systems. It models human industry on nature’s processes in which materials are seen as nutrients circulating in healthy, safe metabolisms. It suggests that industry should protect and enrich ecosystems and nature’s biological metabolism while also maintaining safe, productive technical metabolism for the high-quality use and circulation of organic and synthetic materials. Put simply, it is a holistic economic, industrial and social framework that seeks to create systems that are not just efficient but essentially waste free. The model in its broadest sense is not limited to industrial design and manufacturing; it can be applied to many different aspects of human civilization such as urban environments, buildings, economics and social systems.

RESULTS AND DISCUSSION

Research

Reasons enough to do more and more research about lifespan, flexibility, services and materialisation. Even typology is part of this way of thinking. It all starts with designing the building, there will be taken the principal choices and decisions. This research gave us information and models how to handle with the items about future working and living in the buildings we have to develop. Typology design, sustainnability, flexibility and lifespan are part of the answers for a building technology in a world were the buildings are comfortable without burden our climate.

The last years we’ve focused our research on design tools for Cradle to Cradle buildings. Current successful building methods, services and building materials were analyzed and compared to C2C. These tools are now introduced to the market in order to help the professionals during their decision making process. At the moment there are specific tools for the developing of houses and for industrial area. Qualities of the surroundings can be contributing to the design. The design of the building can also contribute to the surroundings. Surroundings and services are also directly related. For instance in case of hard water, services can soften the water. Overall the services are supplementary to the design. This way the design will optimally use and contribute to its surroundings. The client as well as the chosen C2C possibilities within the model provides input for the manual. This insures the clients to be centralized at all time.

We developed a C2C manual for housing consists of the tabs: ‘Home’, ‘Project data’, ‘Surroundings’, ‘Design’, ‘Services’, ‘Materials’ and ‘Results’. Information on the building project can be filled in at the input fields, choices can be made at the check-boxes and pulldown menus of the online manual (Figure 3). After completing general project data in the manual, location based C2C applications are given on the levels: surroundings, design, services and materials. From the range of applications, choices can be made by means of checkboxes and pulldown menus. These choices lead to a C2C score of the house.

The themes in the manual differ in valuation. The resulting C2C score is built up from: Surroundings 3x, Design 3x, Services 2x and Materials 1x. Also the C2C possibilities which can be chosen within the themes differ in valuation. Setting of the valuation was made with the C2C guidelines in order to maintain a balance between the themes. The overall valuation was tested through pilot cases, among which ‘Recht op Wind’.

Materials have the least influence on the resulting score. This prevents the possible assumption that a C2C building can be achieved solely through the use of C2C materials. In fact materials are only part of the C2C philosophy. Power with renewable energy and respect for human & natural systems are also integrated in the other themes.

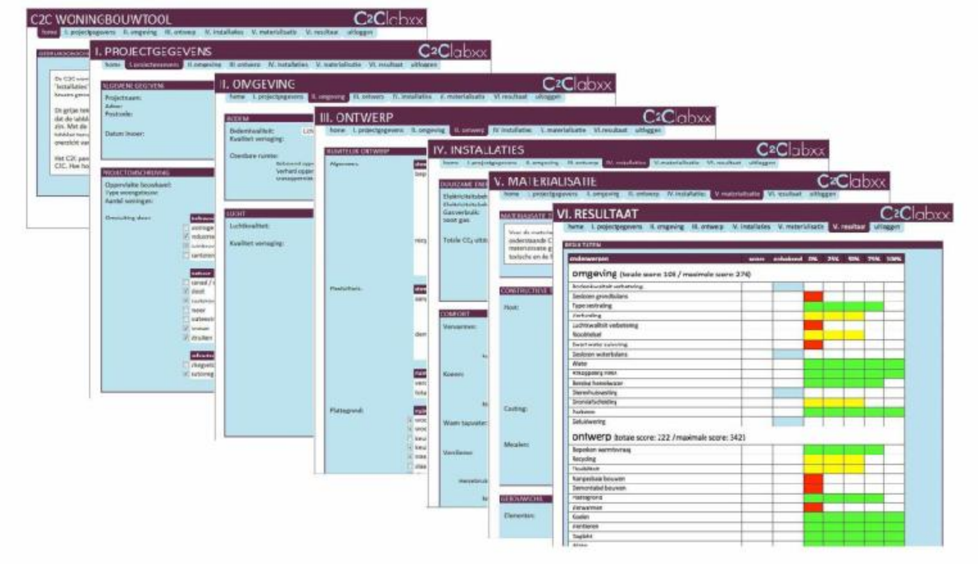

Figure 3. C2C manual

The research is based on the data we’ve collected about materials and systems. These data provide information about the technical aspects and raw materials, the produce evidence and about the level of certification. We wanted to know what the chemistry base of the used materials is and, very important, whether the materials are toxic or not. Furthermore we gained information about the production, the possibilities of re, up and down cycling. Finally we collected data about the lifespan and the opportunities to re-use the rest materials (Figure 4).

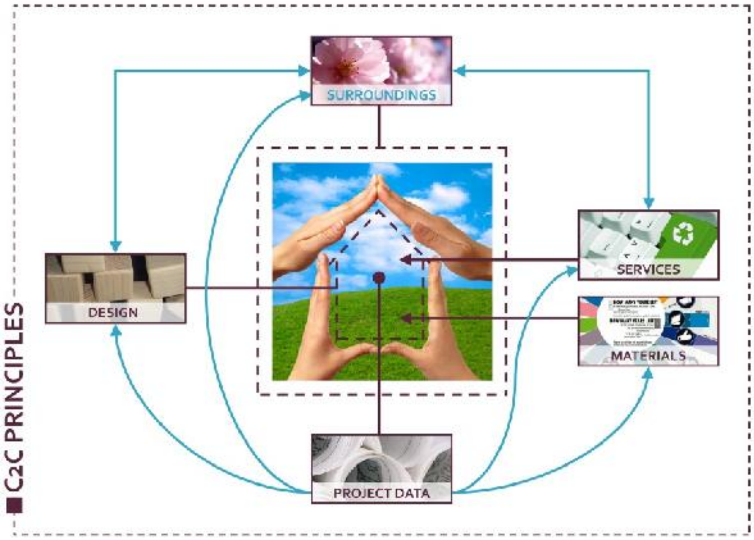

Figure 4. Blueprint C2C manual

The Comfortable House

A comfortable house is based on the C2C philosophy; use non-toxic materials, renewable energy, and diversity and uses only materials which can be part of a biologic or a technical cycle. The housing C2C tool has been filled in on three scales, the macro, meso and micro scale.

The brief was a comfortable house for two persons, a studio, a garage for two cars and some sleeping areas for guests was wanted. The client likes a modern house open to and direct in relation with the nature. The materialisation had to be basic, raw materials and natural energy systems. The sun will deliver the most electrical energy. The warmth of the earth will be used for the floor heating system. The ventilation of the house has to be an all-natural system. Investing in sun- and earth energy systems will lead to the use of renewable energy. The sewage system is based on natural cleaning by plants and algae.

The freestanding villa called 'Recht op Wind' (Figure 5) will be the first Cradle to Cradle dwelling in the Netherlands. The plot (550 m2) is located in Bergschenhoek nearby Rotterdam and is surrounded on the east and south side by the river Rotte and its reservoirs of superfluous polder water. This villa is the pilot project of the C2C manual for freestanding Dutch villas. The construction of 'Recht op Wind' commissioned by the private client and architect prof. ir. J.M. Post will start late 2011. During the engineering of the pilot the C2C manual was used closely in the decision-making on C2C. The result shows a C2C score of 89,4% which is qualified as 'good'. The C2C percentage of the dwelling is the total score which indicates how well the dwelling and its surroundings in total are in line with C2C. The appreciation of the C2C score varies from bad (<25%), quite good (25% till 60%), good (61% till 90%) to excellent (>90%).

By integrating natural ventilation, maximum use of daylight, sun oriented floor plan, high thermal insulation value, sun protection by eaves, sun protection by overhang, demountable joints, etc. in the design of 'Recht op Wind' the high C2C score is obtained. In addition to the integration of these active natural systems, services such as geothermal heat, low temperature heating, re-use of gray water, reuse of rainwater, solar panels, solar collectors, etc. helped to reach a high comfort level.

Figure 5. Recht op Wind

Process

Building a dwelling from exclusively C2C certified materials and services isn't realistic at this moment. Not all materials needed to build a dwelling are C2C certified by EPEA yet. In order to build with materials as close to C2C as possible, all provided materials in the C2C application model are compared to the basic C2C certifying criteria. Even the current materials which are marketed as 'eco-friendly' appeared in many cases, in comparison to these criteria, not to be C2C at all. These materials certainly were 'eco-efficient' (durable) but not 'eco-effective' (C2C).

The design process started one and a half year ago in 2010. The house has been designed during the development of the tools. Nowadays we have a lot more information and data is when we started, so the C2C scan provides a slightly different result. The drawings are prepared in collaboration with the consultants and suppliers. The building will be built in 2012. We are negotiating with the suppliers and try to find out all the data about the materials they use in the building elements.

Realising a C2C building needs another design- and building process. Traditionally has the architect the lead during the first developing phase. The architect coordinates the consultants and prepares the decisions. Having negotiated with the contractor ends up that the contractor takes the lead for the realising of the building. Then the contractor deals with subcontractors, client and consultants. For this project we needed to change this traditional, so-called, vertical process in a more horizontal process. The lead was now by the C2C professional consultant. He had the lead and organised the architect, client and other consultants during the design process. Then a building team was erected to deal with all the different producers, including the contractor. Every participant was able, working in this building team, to bring in his specific knowledge. Often there was a lack of knowledge about the cradle-to-cradle aspects, ore we missed data information. With the help of specialists in this field we had the utilities to optimise our data and the concept.

To give an example, we planned to buy prefabricated wooden insulated elements to close the roof with. In the Netherlands there are several companies, which are able to deliver, these elements. The base of their products is the same; an underlay of pressed wood, some glue, and insulation and on top wood or a water-resistant foil. In between are often wooden lats or ribs as the construction base. We've analysed all the different roof elements from five suppliers. We discussed about the specification of the used materials, like glue, wood, insulation, connectors and so on. Often was the problem that the producers ware very interested to cooperate in this project, but they had to change some producing elements, often the used glue. But then it was impossible for them to guarantee the roof element because of the lack of knowledge and experience with the new materials. That was the reason for the most producers to hesitate for redeveloping their product only for one prototype building. At the end we decided to produce the roof element ourselves, without any glue.

CONCLUSIONS

In this article we've described our research for a new sustainable technology. First based on principles of sustainability, followed by the cradle to cradle theory.From eco- efficient to eco-effective. This research has been tested during the years by prototypes of buildings. The results of these theoretical and practical experiences are not only inspiring buildings but, most of all, an intensive discussion with colleagues.

Lifespan thinking, illustrated by the project XX, (a building really designed with a limited lifespan for twenty years), was for many people an eye-opener. It was a radical initiative and is nowadays an inspiring example for the building industry. Cradle to cradle can be understood as a fort coming thinking about sustainability. Efficient use of materials is not enough; the norm will be effective materials. The biologic- or technical cycles are essential. Toxic materials are out of order.

Prototype buildings help to influence the building industry. These examples prove that it is possible to translate theory in practice. It helps people to understand the theoretical thinking. It is helpful to use the cradle-to-cradle tool, it proves at the same time that it is hardly possible to realise a hundred percent cradle-to-cradle building. The levels macro, meso and micro do help people understand that there are more solutions on a selective scale.

The prototype project so called “Recht op Wind”, has been tested with the C2C tool and is now being erected.

The experience gave enough information that the next step, up grading to the scale of a neighbourhood is realistic and is planned for the next year.

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