Junk

Reuse of waste materials

Daniel Baerlecken¹, Judith Reitz², David Duncan³
¹Georgia Institute of Technology USA, ²Peter Behrens School of Architecture Germany,
³Georgia Institute of Technology USA.
¹³http://www dbl.gatech.edu/, ²http://arc fh-duesseldorf.de/
¹Daniel.Baerlecken@coa.gatech.edu, ²reitz@bfrlab.com, ³dduncan6@gatech.edu.

Abstract. The paper presents a series of design build studio that investigate the role of waste as building material. The series develops proposals for constructions that use CAAD and CAM tools in combination with traditional fabrication tools to design and build an installation out of waste materials. The first construction uses waste to create two installations that questions human consumption, The second project is a future project, that intends the use of waste as an actual building material. Recycling is in the process of becoming an integral part of sustainable architecture. However, there are very few digital design projects that use re-used or recycled materials in combination with their architectural and aesthetic qualities and potentials. The potential of such an investigation is explored within these design build studios. What is junk? What is a building material? What are the aesthetics of junk?

Keywords. Education in CAAD; digital fabrication and construction; practice-based and interdisciplinary CAAD; parametric modeling.

INTRODUCTION

In this paper two projects are discussed which investigate waste in different ways as a construction material. The first project, the junk tower, questions human behaviour patterns of consumption and actualises itself in two installations. The second project, the design and future construction of a housing project in South Africa, studies junk as actual building material and discusses problems and potentials of an attempt with special focus on used shipping containers.

Both projects use digital tools for construction and/or simulation of performative parameters.
JUNK TOWER
In January of 2011 a student competition was introduced which sought to enhance complex holistic thinking in a sustainable context through a challenge to the participating schools: Build a tower using only local materials and your hands as a symbol of your region, or university.

STUDIO APPROACH
William McDonough and Michael Braungart (2002) explain in Cradle to Cradle that nature operates according to a system of nutrients and metabolisms, in which there is no such thing as waste; one system’s waste is another system’s food. Therefore, waste equals food. Humans, however, have found more and more ways to manipulate materials to increase...
their effectiveness in use, without considering their performance as waste. According to Braungart and McDonough these types of engineered materials have an abnormal conversion to base components and cannot safely be returned into earth’s surface. Thus, in their view humans have created waste that cannot be converted to food.

In light of this, the project aspires to repurpose a waste product whether or not it could be “recycled”. Some of the earliest precedents of repurposed materials are the mammoth bone huts built between 16,000 and 10,000 BC. The huts were 20 feet in diameter and made from interlocking mammoth bones.

Instead of bones the project focuses on plastic as a material as a dual installation. The first idea is an amalgamation of modules of plastic clothes hangers. The second idea is a tapering cylindrical tower of plastic soda bottles, directly representing the amount of plastic waste by the university community over a given period of time.

**THEORY AND VISION**

Though both are made of polyethylene terephthalate (PET) soda bottles and clothes hangers have different means of consumption. On the one hand, soda bottles have become an icon of recycling and sustainability. They have increasingly become more recyclable, using lesser amounts of plastic per bottle, and they have even started using plant material to improve biodegradability of the bottles. Individual consumers use the bottles personally. On the other hand, clothes hangers are used by private stores, which typically reuse the hangers. When stores receive new hangers, they amass old hangers, which are thrown out or sometimes, depending on the store, recycled. This consumption is hidden to the individual, unlike the consumption of the bottles, for which the individual is directly responsible. Given a single material with two starkly different stories of consumption, the project showcases the different physical properties of the items through two installations as a parallel to the different modes of consumption.
However, as different as the two installations are on a material level, they share a common vision of experience for a user. Each installation immersed the user amongst towers of waste generated by flawed human consumption patterns. The users were not only exposed to, but were surrounded by physical representations of their wasteful behaviour.

TOWER MORPHOLOGIES
The concept for the bottle installation was three towers composed of roughly the same amount of PET that the university community threw out, rather than recycled, in a typical week. 19,000 bottles gives an idea of the enormity of waste produced by a campus in a week, which could be avoided. Capturing the enormity of waste in a physical form, the design of the bottle installation included three towers of different heights and widths, with the central tower being the largest at 25 feet tall and 15 feet in diameter.

The hanger installation is conceptualized as a grid of inverted towers reaching down to various heights from a suspended surface. The 9x18 grid of
hanger towers begins 12 feet high and the individual towers vary in length.

**MATERIALS/ SYSTEM DESIGN**

**Bottle tower**
Greg Lynn’s installation “Blob Wall” is one of the few installation that investigates recycling, digital design and fabrication at the same time. The “Blob Wall” is designed from recyclable plastic blob units, or “bricks”, which are different from each other in the way that they attach to their neighboring units. The variation lies in the intersection of two units.

In the case of the bottle towers the variation results not from the units, but from the variation of the joints, of the in-between spaces. The system deforms through the gaps allowing for curvature in plan and tapering in elevation. But it also allows for transformation: When the diameter becomes too small, “bricks”/bottles are skipped.

**Hanger tower**
Four hangers formed the top “plane” of the cube, with 2 hooks reaching towards the outside and two hooks reaching towards the inside, and four hangers formed the bottom “plane”. Combining the modules into towers involved interlocking the hooks with the neighboring modules on the top and bottom respectively.

**PARTS FABRICATION**
Construction of the bottle towers began with the plastic rings, which were designed to reflect the profile of the bottles. This also allowed the rings to act as a template for sandwiching courses of bottles: each profile in a ring would have a bottle banded above and below, establishing the number and placement of bottles in each course around the ring.

A VB script, that populated a given Nurbs geometry with bottles, calculated the number of bottles needed for each layer. Assembly began according to the banding system as described in the digital file.

Prefabrication of the hanger installation involved creating the previously described 12-hanger modules out of the 6000 hangers collected. The modules were assembled first and then each joint was zip tied for security.

**JUNK AS BUILDING MATERIAL**
The two installations did not intend to focus on the invention of an actual building material or building component from waste products. But the investigation of that process is certainly interesting to study. There are a number of different examples for the re-use of materials: the rural studio projects in Alabama, that uses tires filled with earth as construction material and carpets as a façade material, the re-use of bricks by Amateur Architecture Studio for the Historical Museum in Ningbo, the use of wood waste and car screens for the shoe shop Duchi by the Dutch office 2012 architecten and other examples (Kaltenbach, 2010).

In the context of the installation it seems appropriate to begin with bottle houses. Early examples of bottle houses like Grandma Prisbrey’s Bottle Village, a folk art piece in Simi Valley, California, use glass bottles and a binding material like cement, stucco, clay, plaster, mortar etc. to play with colored light effects. The more recent projects use plastic bottles. There are numerous examples, where earth-filled plastic bottles have been used for the construction of passive solar houses as bricks (for example projects by Andreas Froese/Eco-Tec in Nigeria and Honduras). These projects are often situated in tropical climate zone and rural, less prosperous areas. Next to architecture in development countries we can find another example for a plastic bottle building in the EcoARK Exhibition Hall, Taiwan, by Arthur Huang, which uses the POLLI-Brick system by Miniwic. POLLI-Brick, made from recycled Polyethylene Terephthalate Polymer, is a system of interlocking, especially engineered bottles with improved thermal and sound insulation. Obviously, we are leaving the field of re-used materials with the POLLI-Brick and enter into the world of recycling products, which are highly engineered.
RE-USE OF EXISTING STRUCTURES

If we move to a larger scale – from reusable materials to reusable structures -, it is interesting to look at old unused shipping containers, which are placed in junkyards all over the world and are left to rust and rot. In a joined project of 4 universities the possibility of recycling junk materials to build structure in conjunction with natural sustainable materials in third world countries are studied. The project intends to develop a housing prototype, which is quick to assemble and cost effective. To date this alternative method of using shipping container has been used in different climate zones for youth center’s, classrooms, office spaces, artist’s studios, live/work spaces, nurseries and retail spaces.

One of the buildings, which will be setup in summer 2013, will be a neighbourhood centre in the Langa township in Cape town, South Africa. The Georgia Tech, USA, the Peter Behrens School of Architecture in Düsseldorf, the RWTH University in Germany and the University of Witswatersrand in Johannesburg, South Africa are testing, how old unused shipping containers can be dismantled and combined with natural local materials into sustainable buildings.

In the past the RWTH Aachen University has built a kindergarten, a science lab and a community hall for the Ithuba Skills College in Gauteng, South Africa. Wood and steel base constructions were tested in combination with lightweight stray and clay construction or hydroformed bricks. The wood or steel base construction increased the building cost significantly, whereas the lightweight clay walls as well as the hydroformed bricks could be created.
from local materials and soil that was found on site. The new project tries to eliminate the extensive base construction cost by using junk steel from old shipping containers and recycled telephone wire, while it still aims to create sustainable structures, which use solar impact for heating and cooling.

Used shipping containers have a list of potentials such as strength, durability, availability, and cost, but their problems need to be addressed as well:

1. The architectural challenge is to create connections and openings between containers – horizontal and vertical – and to the exterior to avoid a feeling of being boxed-in.
2. A major problem of the containers is insulation.
3. In some cases the coating contains harmful chemicals.

The first problem will be addressed through an architectural study of spatial configurations and has to be balanced against the loss of structural integrity through the cuts.

The second problem can be solved by using local materials such as straw and clay in various forms. For the reuse of existing structural units (such as unused shipping containers) we are testing on the one hand the adding of exterior layers of earth, clay, concrete, cement and wood compounds, but also variations in the disaggregation of the containers – in vertical and horizontal directionality - are examined, and the possible increase in the functionality of in-between spaces through lightweight textile and tensile structures. Combining these techniques could be to:

1. Hydroformed bricks: ecological structural modular hydroformed clay/ cement bricks: using locally available sands, with blocks made either with a Cinva-ram press or using a diesel-powered block maker or using even handmade forms. The interlocking blocks allow for dry laid construction (without mortar) of a high standard, even with unskilled labour. This technique also allows for ease of modification and extension with complete recycling of the blocks.
2. Straw clay wall or bricks: Existing clay from the building site is mixed with affordable straw and compacted in sliding formworks or in handmade brick forms. After drying, a clay-lime plaster is applied to the surface. Thus all building materials are locally available.

Both techniques allow an ecological modular building, which is necessary to work time and cost effective. Lightweight straw - clay walls provide excellent insulation and create a comfortable interior climate in winter and summer. The thick straw clay layer keeps the heat in the summer out, but works also as energy mass to balance an equal necessary temperature level in winter. Exact sizes and positions of openings have to be calculated through energy analysis software, so that the building concept is ful-
ly functional without mechanical heating and cooling. For the recent project, the Ithuba Science lab the clima engineering company Transsolar Stuttgart did digital extensive studies, which influenced the design from the beginning. Transsolar used parametric design models to test several window configurations and floor/ceiling thicknesses in summer and winter.

The third problem of harmful materials has to be studied based on a case-by-case practise.

**AESTHETICS AND JUNK**

The experience of waste as beautiful and pedagogically positions the projects in proximity to current movements in sustainable architecture, which proclaim a hedonistic sustainability (Ingels, 2008). One example is the waste management plant for Copenhagen in Denmark, which was designed by BIG. The plant incinerates waste for heat and electricity generation and provides a ski mountain with 3 different slopes with a total length of 150 m at the same time. According to Ingels the project demonstrates that “sustainability is not a burden” (Ingels, 2008), that sustainability can be fun. Or to formulated it less provocative: Sustainability can enriched architecture aesthetically and functionally / socially.

**REFERENCES**

