

Sustainability from Form to Material

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Abstract

This research project highlights public seating units from form to material. Design is serving mother nature with products that maintain the health of the environment by the implementation of green materials. Designing a product is a process that consists of two phases, the form which is responsible for the user's interaction and experience with the outer surface of the product. On the other hand, the material which is responsible for the durability and sustainability of the product in terms of functions and stability. The main objective of this project is to balance out the implementation of green materials in user centric seating units to minimize the negative effect of normal materials on mother nature. The use of green concrete and palm wood stood out to be the main characteristic of this design project. Following along in the design process, qualitative and quantitative research methods took place to analyze the user's needs. For the material understanding, desk research, testing and production took place to validate that different green concrete composites can replace standard concrete composites. The outcome of this process showed out results that validated green concrete composites, as for the green concrete with marble waste, the outcome is environmentally sustainable, power efficient, benefiting the Egyptian culture and cost efficient.

Introduction

In this study, the problems of seats used in the public open spaces were considered: the connection of the general body and the wooden or metal structure is prone to vandalism and theft. In addition, public seats are often perceived as dull and cheap showing a bad quality product and less responsible sourcing. As the material is playing a vital role in designing not only a vandal-resistant seat but also could provide compatibility with the surrounding environment – in terms of shape and texture. Prefabricated concrete street furniture is widely used due to reliability and beauty, and reducing maintenance costs. It also offers the possibility of creating a unique visual style and meets the outdoor character. Recently, green concrete or concrete recycling made out of waste products are used efficiently in producing street furniture items such as bollards, benches or planters. It is a concept of thinking environment into concrete, considering every aspect starting from raw materials manufacturer over mixture design to structural design, construction and service life. Taking Egyptian resources into consideration, green concrete will be cost efficient due to the localization and availability of raw materials. It will have less impact on the environment and improve environmental awareness. This research aims at examining how the material properties and green concrete's production process can lead to innovative sustainable public seats considering the functional and aesthetics aspects with respect to the concept of tactility. This project however is meant to create a discourse in determining the specific demands of the seating placement, location, and shape configuration related to the external conditions. This project was part of a collaboration between the university of Osnabrueck and GUC.

Literature Review

In the design research and how users interact with public seating units; Aysel Yavuz, Nigün Kuloglu (2010) conducted a research dedicated to public seating units and specifically how the public interacts with the street furniture, and the reasons behind vandalism and damage behavior. It was found in the results that a huge impact relies on the industrial designers to increase the resistance of the public seats against actions considering the damage on the equipment (figure2). Moving on to bionic structures, Viktoria Sugar, Peter Leczovics,

Figure 1



Material: Green concrete composite of marble waste

Figure 2



Ergonomics for the seating unit

However, the material of the seating unit was revolutionary since it is green concrete, Neraj Agarwal (2018), gave in her thesis how green concrete is very often cheap to produce because waste products are used as a partial substitute, charges for the disposal of waste are avoided, energy consumption in production is lower, and durability is greater. There are so many composites of green concrete that underwent testing, Elhem Ghorbel (2011), explained in her thesis -Use of waste marble aggregates in concrete- that, a high volume of marble production has generated a considerable amount of waste material; almost 70% of this mineral gets wasted in the mining, processing, and polishing stages which have a serious impact on the environment. The results obtained show that the mechanical properties of concrete specimens produced using the marble wastes were found to conform with the concrete production standards and the substitution of natural aggregates by waste marble aggregates up to 75% of any formulation is beneficial for the concrete resistance. All of those literature reviews influenced the creation of a sustainable and practical public seating unit.

Methodology

In a set of experiments, two characteristics of design research were conducted. First, the form giving process has been developed based on different usage scenarios highlighting the act of vandalism and how the design can communicate with the user to avoid aesthetic harm that may be caused by the user to the public unit. This intention is focusing on both the shape and the usability aspect of the product as an iterative process - not straightforward - because of the interconnectivity between form, function, and the material.

The second characteristic of design research is that the engineering thinking process offers a variety of materials for seating units. Materials that are currently the trend of sustainability, for example, recycled wood, clay, recycled plastic and green concrete. After a back and forth research process, the chosen material is green concrete, as it shows different varieties and composites that integrate locally produced materials like marble, ceramics and glass wastes.

After several design configurations, a final design was selected to be produced in the GUC labs and workshops with a collaboration of the faculty of civil engineering.

The testing process started by forming a blue foam mold that visualizes the form of the seating unit to verify the dimensions and increase the accuracy aspect in the 1:1 model. The blue foam mold was tested using gypsum. The final mold was then produced to a scale of 1:1, using isolated counter wood with the thickness of 2.5 cm. The shape of the mold included two rectangular shapes from the inside to reduce the material used inside the final model.

The mold was made using angular technique to ease the process of deconstruction of the wooden parts after the green concrete mold is finished. PVC pipes were sanded and fixed inside the mold to offer fillet edge effect to the sides of the model.

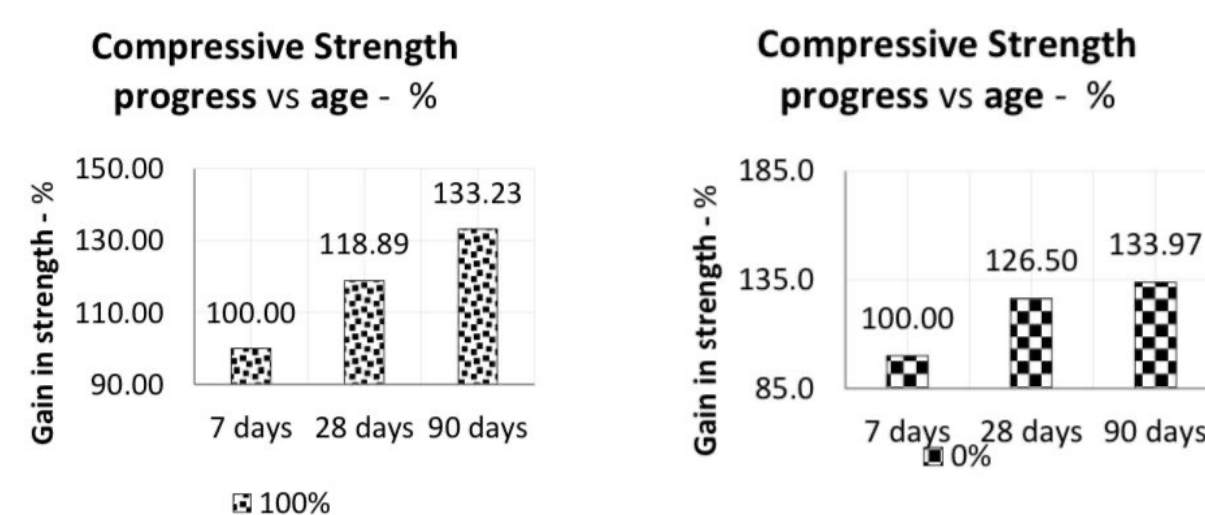
Results

(A)



Modular seating unit made out of green concrete composite of marble waste. The seating unit consists of hollow trapez as a plantary and the seats are topped with palm wood stripes.

(B)



Compressive test results of marble waste concrete

All the sides of the mold were varnished with car engine oil, this step offers better surface quality and less harm for the sides of the model after deconstructing the wooden walls.

The production of the green concrete took place in the concrete lab of the GUC. under the supervision of the engineering team from the faculty of civil engineering. Calculations, ratios and materials were provided to start with the mixing process. The use of cement 42.5N, sifted sand and crushed marble waste. The materials were clustered and weighed to the provided ratio. Then the materials were transferred to the concrete mixer for 3 min and 30 sec. A sample of the mixture was gathered and a slump test was proceeded. The test showed a result of GOOD. The results were successful to proceed with the mixture. The mixture was then transferred to the wooden mold and left for 5 days to dry out. Through those 5 days, every 12 hours the mold was undergoing curing technique which is splashing water droplets on the surface of the mold to help in the drying process. On the 5th day, the mold was partially ready to be out of the mold and start working on the surface quality. Sanding the surfaces using marble sander and finishing the surface with marble wax to offer a smooth surface (figure1).

The last step of the production process was in the wood workshop of the GUC. with the help of the wood workshop supervisors, placing the palm wood on the top surface. This process included cutting, sanding and polishing the wood to offer a high quality surface for the user.

Conclusion

Recapping the process by understanding the two characteristics of design. The first design aspect which focuses on the user experience with the final product to enhance the usability and increase the sustainability of the product. This aspect highlights in addition the act of vandalism that is caused by the user and how the design language communicates with the user to neutralize this act. The second design aspect is engineering related, focusing more on the materials of the product and how the materials can be an adding value to the final outcome, while serving the environment and the climate at the same time. The implementation of the green concrete - final material - to the designed product was intentionally placed to serve the climate, as the material is causing less harm to the environment, saving raw materials, power efficient, benefiting the Egyptian culture and most importantly cost efficient. The fusion between those two characteristics generated several design outcomes and futuristic applications that can offer a new trend in the design field. This fusion additionally resulted in several aspects that benefit the manufacturers and the user. While in the testing process, the outcome served the design with different aspects, as it showed that the material is cost efficient, locally produced - reflecting on culture aspect-, power efficient, light weight and finally aesthetically pleasing. In the field of product design, introducing green materials that can be used as an alternative for raw materials is a futuristic approach for this project. Green concrete and palm wood are materials that can be implemented in various design models and act as heroes and not alternatives.

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