Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

Personal information	
Name	Noah Jakob Amos van den Berg
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Studio	
Name / Theme	Building Technology, sections Design Informatics and Structural Design
Teachers / tutors	P. de Ruiter and Dr.ir. F.A. Veer
Argumentation of choice of the studio	The studio was presented by Paul as a unique subject of its own, pushing the material PET and the currently available technology as far as we can go. The chair of structural design is needed to test the prototypes that will be created to test their usability and to calculate for material fatigue. As the structural properties of 3D printed components is very anisotropic.

Graduation project	
Title of the graduation project	Opening the bottle: designing openable surfaces in a mono material construction of recycled PET
Goal	
Location:	The Netherlands (Not of direct relevance to the project)
The posed problem,	It is no secret that the building industry is one of the most pollution heavy industries at the moment, while innovation is slow. Then way of current day construction is in dire need of innovation while newer and more sustainable building materials should be explored. One of the possible unexplored materials comes from the consumer industry, with a slow decrease in the popularity of one time use plastics and the rise of alternatives a possibility emerges that these plastics could be used for a more long term function. By tapping into the waste stream of the consumer industry we can obtain previously disregarded building materials such as PET (polyethylene terephthalate). PET is mostly used as packaging consumable products most commonly seen as plastic bottles. A big advantage that PET has is the ability to be used for 3D printing. An example of the potential of

	PET as a building material comes from The Plastiki, a catamaran mode form PET bottles that made a journey from San Francisco to Sydney in 2010. With the technological advancements of additive manufacturing and 3D printing in the building industry the idea of using recycled plastic as a material becomes an option. However it has to be said that it will take a quite some time before both the consumer and building industries are ready to make this transition. None the less it is an interesting direction for us to explore and research. Because the technology is relatively new and the material has not been used before on a large scale in construction the application for this research will be a tiny house. As it forces us to take into account all modern day requirements of construction but protects us from having to solve structural challenge of adding a second floor. It also makes it so that the printing time is drastically reduced making a 1 to 1 prototype more feasibly in the long run. Because we this tiny house will be completely 3D printed from PET everything we know about buildings has to be reevaluated as the new production technique and material will have a big influence on the geometry and functionality of the components that make up a house. One of the things that people interact with daily in their houses are the openable surfaces, this research is how the approach of mono material construction in PET redefines the design of openable surfaces.
Research questions and	How can an openable surfaces be included in a mono material 3D printed tiny house, using robotic 3D printing? • How can geometry allow for a surface to be moved? • What are the criteria for an openable surfaces? • What are the physical and structural properties of recycled PET? • How can one optimize geometry for robotic 3D printing? • How does a 3D printed openable surfaces hold up under use? • How does the openable surfaces connect to the structure of the 3D printed tiny house?

Design assignment in which these result.	The challenge is to redesign an openable surfaces for a 3D printed mono material tiny house, due to unique geometry that will be needed to create structural integrity of the 3D printed structure the assumption is made that the door in itself will have to function in a multicurved wall.

Process

Method description

Literature research

- Looking ate existing literature will give insight into the possibilities and limitations of 3D printing. As well as options of how the door will be made openable.

Design

- From here on, the design criteria found in the literature study will be applied to the 3D printed door. The structural properties will be analytically tested using FEM

Prototyping

- After the FEM results are satisfactory a small scale prototype can be printed and tested using a robotic arm to see how the door would hold up under extended use. This information is then used to tweak the design and a full scale prototype can be printed and tested.

Literature and general practical preference

- Howell, L. L., Magleby, S. P., & Olsen, B. M. (Eds.). (2013). Handbook of compliant mechanisms. Retrieved from https://ebookcentral-proquest-com.tudelft.idm.oclc.org
- Lobontiu, N. (2003). Compliant mechanisms : Design of flexure hinges. Boca Raton: CRC Press. doi:10.1201/9781420040272
- Smith, S. (2000). Flexures : Elements of elastic mechanisms. Amsterdam: Gordon and Breach Science.
- Safai, L. (2019). Fatigue Testing of 3D-Printed Compliant Joints. Geraadpleegd van http://resolver.tudelft.nl/uuid:7df15c93-e792-4a35-9b16-a74b0fdb7ea7
- Gao, W., Zhang, Y., Ramanujan, D., Ramani, K., Chen, Y., Williams, C. B., … Zavattieri, P. D. (2015). The status, challenges, and future of additive manufacturing in engineering. Computer-Aided Design, 69, 65–89. https://doi.org/10.1016/j.cad.2015.04.001
- Diegel, O., Singamneni, S., Reay, S., & Withell, A. (2010). Tools for Sustainable Product Design: Additive Manufacturing. Journal of Sustainable Development, 3(3). https://doi.org/10.5539/jsd.v3n3p68
- Ishak, I. B., Fisher, J., & Larochelle, P. (2016, August). Robot arm platform for additive manufacturing using multi-plane toolpaths. In ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (pp. V05AT07A063-V05AT07A063). American Society of Mechanical Engineers.

Reflection

Relevance

The idea behind this graduation is to push for innovation in the building industry which is known to be extremely slow to change. By going into an 'uncertain' future scenario we can push the current knowledge and usage of common materials such as PET in a new direction.

Through the choice of the mono material limitation the need is created to truly push the limitations of the material. Forcing the material to take on tasks it is not perfect for makes it so that we as designers need to step out of our comfort zone and use different means to get the intended result.

This project combines design with a technical approach, taking into account fabrication and function. The challenge of using new materials an utilising innovative production techniques, resulting in anisotropic structural properties, make this project fitting for the Building Technology master.

	November				December				January					February				March				April					May				June				July	
important dates	P1 (12 Nov)								P2 (9 Jan)											P3 (??)								P4 (??)							P5 (??)	
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Research																																				
Research question formulation																																				
Door types																																				
PET material research																																				
Compliant mechanisms																																				
Hinges																																				
Pivots																																				
Defining design criteria																																				
Tool path optimisation																																				
Prototyping and testing																																				
Material test																																				
Designing door prototype																																				
Designing wear and tear test setup																																				
Printing small scale prototype																																				
Wear an tear test using robotic arm																																				
Printing with the Comau*																																				
* To be scheduled with other users and the clay printing graduation																																				