REFLECTION

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GRADUATION PROCESS
General reflection
A big thing that struck me is the change of course throughout the thesis. Initially I aimed to create a switchable facade using 4D printing techniques. As I gather more information on smart materials and became more practical it did not seem to be the most effective way.

3D printing in combination with pressure driven actuator was than thought to be the best suited. However, when I started to design I realised that there are simpler and cheaper production methods for some of the designs I made. This realisation came after I already made a choice in material. I limited myself to materials which are easy to 3D print. During the process I could have never know that other production techniques could achieve a mono-material switchable insulation. This makes me realise the importance of designing to gather knowledge.

Because 3D printing is not really needed, there is a potential to use other materials which are not suitable for 3D printing. However, 3D printing was necessary to answer some of the questions I had during the design process (mainly to test the movement and sensitivity to production errors of a design). It would have been very hard to test this without a 3D printer.

Another thing I want to reflect on is the order of things I did. In hindsight I would have done the Failure mode and effects analysis earlier as this shaped the final design (I currently did it halfway P3 and P4, but doing this right after P3 would have been better). Moreover, I would have first tested the force to collapse different auxetic structures as this seem to be a bottle neck of the design. I should have done this when selecting an auxetic structure.

How is your graduation topic positioned in the studio?
My graduation topic is about developing a mono-material façade element with a switchable insulation. This topic is an intersection of façade/product design, building physics and computational design. The latter because 3D printing techniques were used to develop the design.

How did the research approach work out (and why or why not)? And did it lead to the results you aimed for? (SWOT of the method)
The objective of the research is developing a responsive façade element with switchable insulation that is easy to recycle

The research approach was research by design. This was generally effective in addressing the research objectives. This was because it allowed me identify problems and find solutions. Identifying problems was done by sketching. While sketching some questions occurred to me: like how thick should this panel be? Where should the auxetic structure be placed inside the wall? How big should my wall element be?

Finding the solutions was done by a combination of research and design. The research approach forced me to explore multiple solutions. This is useful, because usually the first solution is not the best solution. By developing multiple solutions to a problem you can select the best one based on some criteria.

Strengths:
- Multiple solutions can be explored
- Encourages innovation: Open-ended, exploratory nature allows for creative and non-linear thinking

Weaknesses:
- It takes a lot of time

Opportunities:
- Real-world impact: Prototypes or proposals can influence policy or convince investors

Threats:
- Risk of aesthetic bias: Visually compelling outputs may overshadow critical analysis or flaws in reasoning

How are research and design related?
In this research, design and research are closely connected. Research informs the design criteria and builds understanding of core concepts, while the designed solutions reflect and refine that understanding and design criteria:

Design criteria (research) + (need for) understanding of core concepts (research) <-> designed solution(s)

This is best showed using an example:

The design criteria were derived from research and my vision for a mono-material switchable façade element. Some criteria, like fire retardant, UV resistance and water proof were derived from research on criteria for facades in the Netherlands. All the design criteria shaped the design. But before a design could have been made the core concepts of heat transfer through cavities needed to be researched in order to develop the design strategies. Using these design strategies, four different designs were made for the switchable insulation. During designing, research needed to be done on other core concepts like soft robotics and auxetic structures. Moreover, the design process also shaped the criteria - for example, during the process it was discovered that a mono-material façade element with switchable insulation does not have to be 3D printed which used to be a design criterium.

SOCIETAL IMPACT
To what extent are the results applicable in practice?
The developed façade element is a proof of concept. However, when it comes to the applicability of the façade element more research needs to be done. As of now, the force needed to collapse the structure, and therefore switch the insulating state, is regarded to be too high. Moreover, some proper force testing needs to be done on the façade in a relevant environment.

To what extent has the projected innovation been achieved?
The goal of this thesis was to develop a mono-material façade element with a switchable insulation. Both of these elements can be found in the final product. Therefore the projected innovation has been achieved.

Does the project contribute to sustainable development?
Yes, this is because the switchable insulation saves operational energy of a building. Moreover, the façade element is designed to be easy to recycle by since it is mono-material.

What is the impact of your project on sustainability (people, planet, profit/ prosperity)?
The façade element ensures a comfortable indoor climate by cooling the building when it is needed. Moreover, it can save operational energy and it is easy to recycle, which is good for the planet. These savings in energy are also indirectly cost savings, increasing profits for building owners.

What is the socio-cultural and ethical impact?
The developed façade in this thesis is made out of soft plastic (although a recommendation is to research other materials for the developed concept). This is a relatively rare material for the outer layer of a façade in the Netherlands where brick is the dominant material. Moreover, one can question if we should really design for recycling when you can also design for reuse?

What is the relation between the project and the wider social context?
The project is a unique façade solution for buildings. What is making it unique is that it is easy to recycle and that it can save more operational energy than most façades. This is because it is mono-material and because it can switch its insulation value between low and high, allowing to passively cool the building when it is needed.

How does the project affects architecture / the built environment?
The project promotes the circular economy in the building sector since it is designed for recycle. Moreover, the use of plastic as material allows the architect for a wide range of colours to be used for a design. Next to the esthetical value of the product, the product also allows for energy savings in the built environment because of its switchable insulation. This is important since the built environment has a large share on (operational) energy usage in the worldwide energy consumption.