

REFLECTION PAPER

RESEARCH TOPIC: EFFICIENT AND SUSTAINABLE BUILDING WITH MARTIAN REGOLITH

THE RELATIONSHIP BETWEEN RESEARCH AND DESIGN.

The main research question of this graduation thesis is:

How to sustainably construct on Mars with regolith and energy efficient in-situ fabrication process?

To answer this question and several sub-questions, in order to make a design according to the objectives and conditions, the research was divided into two main focuses. First one, related to material science and structure mechanics, was aiming to determine the production process and construction method for the design. The second focus, was oriented towards the sustainability aspect, to ensure, that the design was implementing and proposing sustainable and responsible solutions.

To explore these two aspects of the project, research methodology was divided into two parts: literature study and experimental research. The literature review had to be very broad, due to multiple factors influencing programme of requirements as well as fairly explored topic of building and sustainability on Mars. The material had to be characterised in detail to ensure, that the prepared simulant would match the properties and relevance. The second part of the research – experimental, was also based on literature review of ongoing researches related to the topic. The main goal is to support the conclusions based on literature review with quantifiable values and to determine the properties of building material and production process in order to design the habitat.

The design of the habitat focused mostly on proposing the construction method according to the requirements and results from the research. To limit the equipment, payload and energy, the construction is based on dry-stacking, which doesn't require additional adhesive to be produced. The interlocking system was proposed to build the vault structure and keep it easy to demount and recycle.

THE RELATIONSHIP BETWEEN GRADUATION TOPIC, THE STUDIO TOPIC, MASTER TRACK (BT), AND MASTER PROGRAMME.

The Architecture faculty is encouraging students to implement innovation and interdisciplinary approach into the projects. The topic of building on other planet requires merging skills in the built environment by combining different fields of studies as architecture, civil engineering and aerospace. The research and experiments for this project, were going beyond the architectural and building technology knowledge.

The graduation topic, despite the futuristic and currently fiction character, is strongly related to master track – Building Technology. Material Science and structural design, which are the aspects of the thesis are also one of the main fields in the BT programme. Moreover, the experimental and hands-on approach of the research are related to the strategy for scientific research, which is commonly used in the track.

The sustainability aspect is a significant part of the research and an important factor in decision-making process. This approach matches with the studio topic – Sustainable Design Graduation Studio, and the TiSD programme (Technology in Sustainable Development), which the thesis project is part of. The sustainability on Mars was never investigated in the way that is presented in this research and the conclusions, might have an influence on the aspects of sustainability in space.

ELABORATION ON RESEARCH METHOD AND APPROACH CHOSEN BY THE STUDENT IN RELATION TO THE GRADUATION STUDIO METHODOLOGICAL LINE OF INQUIRY, REFLECTING THEREBY UPON THE SCIENTIFIC RELEVANCE OF THE WORK.

The graduation studio – Sustainable Design Graduation Studio is focusing on sustainable and innovative research in the field of building industry. The topic of building on Mars is going far into the future with the context and the sustainable approach for the design. One of the chosen methodologies to research this broad topic was literature review of multiple aspects related to space missions, Mars and building technology. The complex combination of the conclusions gathered from different fields like geology, chemistry, architecture and structural design was the base for the next part of the research, which was experimental research.

Experimental research is strongly connected to the building technology studio, as it pushes student towards innovation by trial and error approach. The experiments were supported by tests and analysis done based on the knowledge gained

from structural design and material science. However, it was extended by microscopic analysis, which helped to push the results and conclusions even further. They allowed to understand the changes in microstructure of the material due to production process and optimization. The new method of adjusting the composition of regolith to optimize the production process and structural performance of the final component is the main novelty of this research, which might be beneficial for future research on building on Mars.

The final part of the research was research by design. To start with the design, the requirements from literature review and the results from experimental research were used. The innovative results gathered during experiments as well as the sustainable approach resulted in new design proposal for a Martian building. The complexity and the attempt to combine more disciplines is a design process, that is learned and executed in the chosen graduation studio.

ELABORATION ON THE RELATIONSHIP BETWEEN THE GRADUATION PROJECT AND THE WIDER SOCIAL, PROFESSIONAL AND SCIENTIFIC FRAMEWORK, TOUCHING UPON THE TRANSFERABILITY OF THE PROJECT RESULTS.

The societal relevance of the research is mostly related to the sustainability topic. The main goal of this part of the research was to start a discussion about our approach towards space environment and its resources. During the study, it was noticeable, that the aspect of sustainability is related only to Earth and its orbit. Therefore, it is important to analyse the possible impacts of human exploration in space and determine the approach for responsible exploration and manufacturing.

The research on understanding of sustainability in space showed, that there is a misunderstanding of this term among space agencies and private companies, that are planning to start a mining or manufacturing industry on other space objects. The lack of sustainability topic in their programmes might lead to issues with public opinion, which is changing due to the rising awareness regarding sustainability on Earth. The space industry needs to prepare for new requirements and coming regulations.

From the scientific point of view, the important result of this research is a programme of requirements regarding building on Mars, which was gathered from broad and multidisciplinary aspects. However, there are many other factors, that weren't considered in this research, the literature review conclusions can be used and extended by other researchers. Additionally, the sustainability approach was included in these conditions, which brings a new perspective into space building industry.

At the end of the thesis, further research topics were proposed which might develop the topic even further. The mentioned optimisation method and construction system could be new potential concepts for building on Mars. This research was however just an introduction to the research.

THE ETHICAL ISSUES AND DILEMMAS YOU MAY HAVE ENCOUNTERED IN DOING THE RESEARCH, ELABORATING THE DESIGN AND POTENTIAL APPLICATIONS OF THE RESULTS IN PRACTICE.

The main ethical issue related to that research is the definition of the sustainability on Mars. However, for the purpose of this thesis, the definition was determined, it didn't cover all the aspects influencing sustainability, like economy or politics. Moreover, our civilization needs to answer the question, which will have a major impact on the future: "Should we use space only as a source of material and energy to increase the sustainability on Earth or the space environment should be protected for future generations as part of our world?" It will start a discussion about the regulations for space mining or space colonization.