Hook-and-Loop fastener – application for the technical building equipment

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Hook-and-Loop fastener – application for the technical building equipment

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Abstract. The Hook-and-Loop fastener (better known for its commercial name Velcro®) is omnipresent in many fields today. Astonishingly it is far from utilizing its full potential in the construction industry although its properties could have a variety of positive effects on the industry.

Contents and Objectives

Commonly the building installation lines (such as electricity, water or ventilation, to name just a few) are walled-in, screwed, or glued at the construction site. Would these instead be assembled and mounted using the hook-and-loop similar fasteners, the following effects with corresponding consequences could arise:

- Simplified assembly processes: They would decisively accelerate the construction phase of a building and would additionally be less prone to performance-related quality deficiencies.

- Flexible mountings and adaptability: They would enable the building to react to short-notice planning changes as well as to adapt to a new spatial program more efficiently.

- Damage-free connections - both for the base-surface and for the component to be fastened to it - would enable a pure separation of different materials and thus easy re-use. The possibility of easy re-use of specific components could prolong the component's in-use phase of the lifecycle, which would contribute to sustainable usage of resources.

The aim of this exploratory project was thus to develop concepts for the production of surfaces with hook-and-loop-compatible surfaces in buildings, which could serve as a base-surface for simplified mounting of building`s installation lines.

1. Starting point/Motivation

The Hook-and-Loop fastener (better known for its commercial name Velcro®) is omnipresent in many fields today. Its potential lies in the astonishing strength of the bond between two compatible layers, which can in addition be loosened and re-fastened tool-free for several hundred times with very little influence to its strength and durability. Astonishingly it is far from utilizing its full potential in the construction industry although its properties could have a variety of positive effects on the industry.

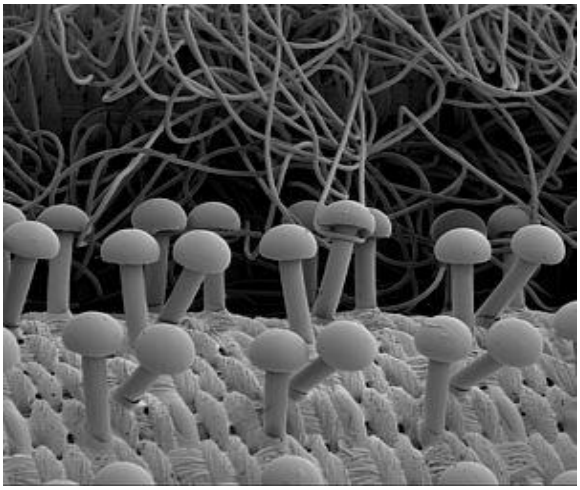

Figure 1. Hook-and-loop fastening principle [1].

The project facade4zeroWaste which includes the development, architectural design relevance, grants of patents, results of pre-certification testing's and the product publication in the time frame from 2009 till now ongoing. Aim of the research project facade4zeroWaste was the idea of a recyclable facade insulation system that can easily be dismantled after its lifetime and reused thanks to an innovative grip fixing system consisting of mushroom-shaped heads and loops - Grip fixing instead of adhesive. The project won numerous prices and awards like the EQAR - Recycling Prize 2015 or the Innovation Award for Architecture and Building 2017. The project is a contract research project tasked by Sto SE & Co. KGaA, Germany and Sto GesmbH, Austria and the Institute of Architecture Technology, Austria. The façade system was presented to the public in January 2017 as the product Sto Systain R (R = render: seamless plaster layer surface) on the building fair BAU 2017 in Munich. StoSystain has been developed by the authors of this paper.

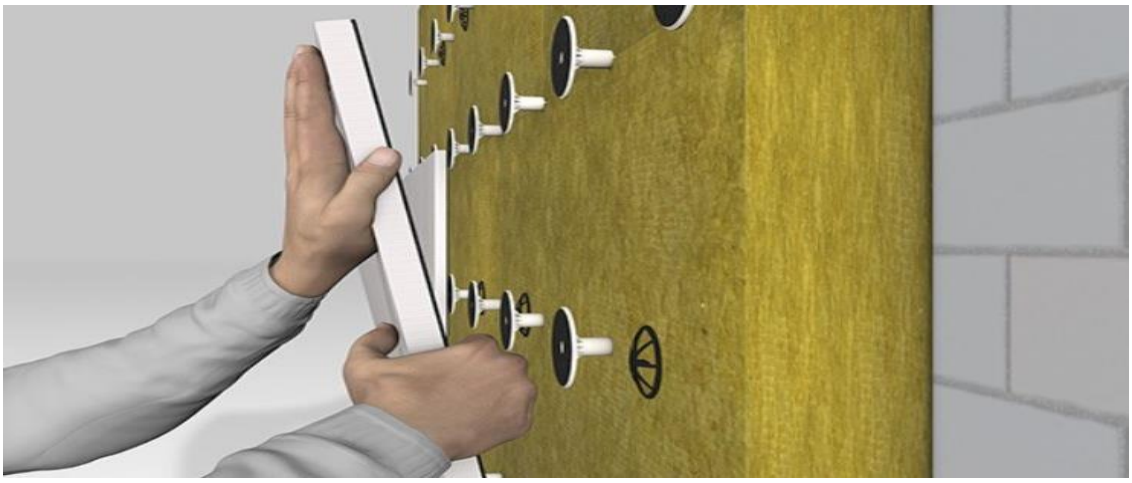

Figure 2. Façade panel and mechanical fixation element (round shaped) during assembly [2].

Figure 3. StoSystain R on the building fair BAU 2017in Munich [2].

Figure 4. Sorting by component-type for recycling + reuse and Transportation, StoSystain façade system [2].

2. Contents and Objectives

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Figure 5. Polyethylene-pipe insulation, self-adhesive [3].

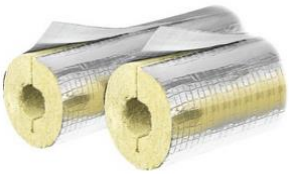


Figure 6. Stone wool pipe shell aluminium-laminated, self-adhesive [4].

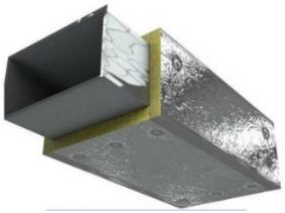


Figure 7. Mineral fibre aluminium-laminated [5].

Figure 8. Damage of insulation at ventilation ducts as a result of fixation [6].

Figure 9. Drilling and chiselling work on the construction site for electrical installations and water pipes with popular tools [7].

Figure 10. Dirty tools on the construction site [8].

3. Methods

The exploratory project was not limited to the consideration of a single material or a trade, but aimed at the widest possible field of view in order to uncover potentials that could lead to more extensive and more product-specific research projects in the near future.

The development of conceptual connections between different construction base-surfaces and hook-and-loop components was carried out by a thorough investigation and professional assessment of existing connections. Two innovation matrices were created. The developed concepts were then evaluated by means of evaluation sheets and team discussions. Promising concepts have been physically tested by the Laboratory of Structural Engineering at Graz University of Technology.

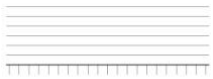
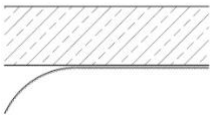
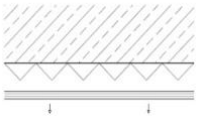
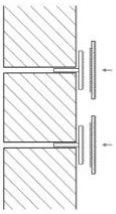
A – Shell Construction Material				
wood	concrete		steel	brick
H1.8 - Fasern 	B1.1 - Kleben 	B3.5 - Einlegen 	S2.2 - Klemmen 	Z3.4 - Einspannen 
Substance to substance bond	Substance to substance bond	Frictional connection	Interlocking connection	Frictional connection

Figure 11. Promising concepts - Connections between different construction base-surfaces and hook-and-loop components [9].

Figure 12. Experimental Setup of the peeling and pull-out tension test with Loop-Fastener. The width of the test strip is 5 cm. [10].

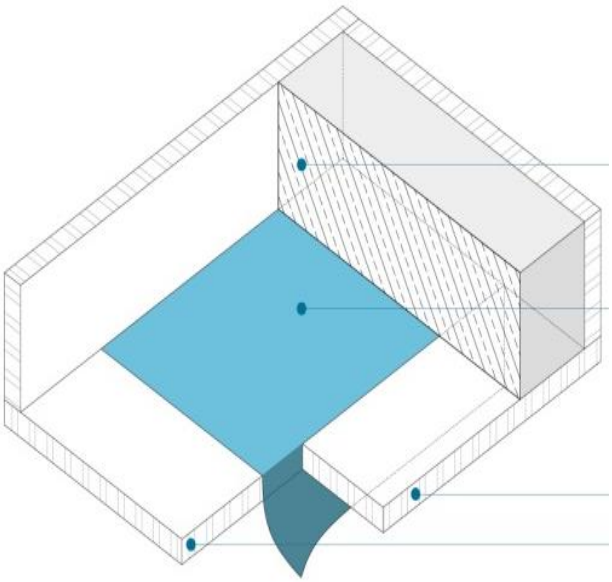


Figure 13. Testing concept, Fixations of the inserted Hook-and Loop-fastener [11].

4. Results

Based on the innovation matrix, a total of 143 concepts for connections between Velcro and building materials were developed. Due to their particularly high innovation content, five of these concepts were handed over to the Research & Technology House at the Graz University of Technology, which is currently examining their patentability.

Two key findings form the basis for further research projects. On the one hand, to achieve the envisaged flexibility, the aim is to provide a large hook-and-loop-compatible base-surface of a building (e.g. wall or slab). To achieve the hook-and-loop compatibility, the material of choice here would be either velour or fleece, because they are both webbed materials and thus more economical and available in large rolls. The specific properties of the material and its processing specifics must be taken into account for further development.

Secondly, the timing of production of hook-and-loop-compatible base-surfaces is of crucial relevance. Whether during prefabrication, during the construction phase, or during reconstruction / remodelling, each intervention requires a different approach.

During the construction phase of reinforced concrete walls or slabs for example, the hook-and-loop-compatible base-surface could be achieved in a variety of ways. Following the manufacturing logic of reinforced concrete, velour or fleece mats could be inserted into the formwork before the concrete is poured. Challenges, such as precise position fixation during the pouring process, or the protection of mats from contamination, need to be addressed. However, completely different approaches are required when the load-bearing construction is already finished or when refurbishment of an existing building is in question. In the last two cases, largely independent of building materials, we found out, that production of hook-and-loop-compatible base-surfaces is the most efficient when it is done with one of the various available gluing techniques. They are relatively easy to handle, but with disadvantages when it comes to dismantling a building. Namely, the ability to separate building materials at the end of their

life-cycle (ideally the velour or fleece mat could be completely separated from other materials), is of great importance for the evaluation of the different concepts.

In addition to these considerations, building materials and construction composites were examined for their potentially inherent hook-and-loop compatibility. First and foremost, these include various fibrous materials which, due to their structure, could under certain circumstances form loops. Such concepts are convincing in terms of material homogeneity and thus complete purity. Nevertheless, tests have shown that the strength of such bonds is far from that of commercially available hook and loop fasteners, which limits, but does not preclude their potential use and development.

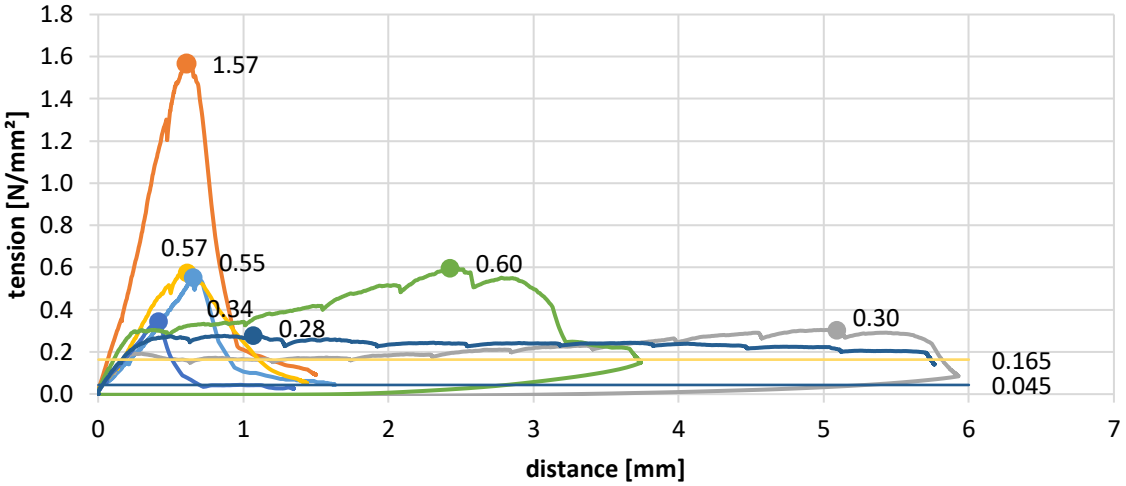


Figure 14. Complete overview of the results pull strength test „Insert Loop-fastener into concrete" [12].

5. Prospects / Suggestions for future research

The exploratory project has shown that it is possible to produce large hook-and-loop-compatible base-surface areas in buildings. This represents a solid foundation for the future achieving of the formulated objectives. Within the institute an in-depth basic knowledge has been created, which provides optimal conditions for further research and development work on the way to the damage-free assembly and disassembly of building's technical installations. The entire project team gained new knowledge in the field of building services, connection and fastening types, and the production & application of hook-and-loop products.

Great potential lies in the exploration of the following topics: Concrete and hook-and-loop surfaces, hook-and-loop-compatible fiber insulation, and alternative connection systems for conventional hook-and-loop-fasteners. The further development either in the form of a state-funded project or together with corresponding and well-known partner companies will therefore be the focus of the future research work of the Institute of Architecture Technology.

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[10] Source: Test report „Hook-and-Loop fastener-application for the technical building equipment“, Laboratory for Structural Engineering, Graz University of Technology, Austria.
[11] Source: Institute of Architecture Technology, Graz University of Technology, Austria
[12] Photo: Test report „Hook-and-Loop fastener-application for the technical building equipment“, Laboratory for Structural Engineering, Graz University of Technology, Austria.