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Making Light Benches by Combining Transparent and Highly Durable Bio-based Plastic (DURABIO) with Large-scale Textured 3D Printing—Developing a New Method to Create Outdoor Spaces

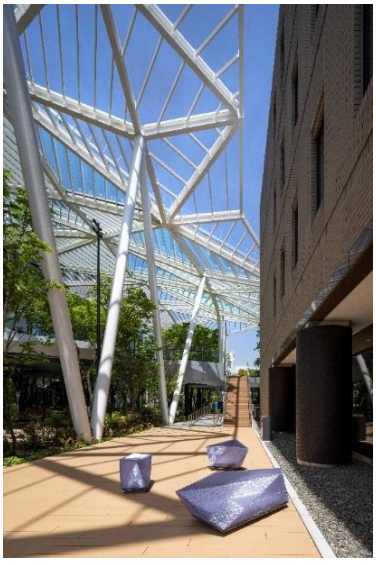
Mitsubishi Chemical Group Corporation
Takenaka Corporation
Slab Inc.
Hiroya Tanaka Laboratory, Keio University

The Mitsubishi Chemical Group, Takenaka Corporation (Head office: Osaka City, Osaka Prefecture; President: Masato Sasaki), Slab Inc. (Head Office: Kyoto City, Kyoto Prefecture; President: Seiichi Yuyama), and the Hiroya Tanaka Laboratory at Keio University Shonan Fujisawa Campus (SFC) (Head Office: Fujisawa City, Kanagawa Prefecture; Professor: Hiroya Tanaka) have jointly produced and installed 3D printed plastic benches made from DURABIO™, a bio-based engineering plastic, on the grounds of the Science & Innovation Center, the Mitsubishi Chemical Group's R&D site located in Yokohama City in Kanagawa Prefecture.

On September 28, 2022, the largest research building of the Mitsubishi Chemical Group was newly opened at its Science & Innovation Center, surrounded by abundant nature as a place to create innovation. Formed in the shape of a triangular polyhedron to match the folded-plate structure built along the shape of the zelkova trees beside the new research building, the benches produce an integrated outdoor space together with the characteristic new building. The benches were produced and installed through an integrated process, from material selection to shape designing and arrangement, to fit into the surrounding environment as part of the new research building rather than simply being produced as individual pieces of furniture or objects.

The selected material, DURABIO™, is the Mitsubishi Chemical Group's bio-based engineering plastic, whose main raw material is plant-derived isosorbide. Compared to conventional polycarbonate resin, it features high transparency and excellent optical properties, as well as excellent durability and weather resistance despite being a plant-derived polymer. DURABIO™ has been adopted in a wide array of fields, such as mobility interior and exterior parts, optical and electronic devices, and daily goods.

DURABIO™: https://www.m-chemical.co.jp/en/products/departments/mcc/pc/product/1201026_9368.html



To leverage the material characteristics of DURABIO™ and make a bench design that is in harmony with the architecture, Takenaka Corporation created nine 3D models with different shapes by employing a tool called parametric study[*1] based on angles between neighboring polyhedra and the drainage slope of the seating face. Consisting of triangles and forming organic shapes that are somewhere between natural and artificial objects, the benches blend in with the surrounding similar landscape, including zelkova trees, the large roof, and the building facade[*2].

Tool path designing that enables 3D printing, and texture designing that produces special effects on the surface to create patterns on the benches were implemented by the Hiroya Tanaka Laboratory at Keio University SFC, while the molding was performed by Slab Inc. with an ultra large pellet extrusion 3D printer called "*Chashitsu*[*3]," which means "traditional tea house."

Lighting was designed by Takenaka Corporation to match the shapes of each bench. Casting soft light, the benches scattered throughout the site produce a soothing outdoor space during the night.

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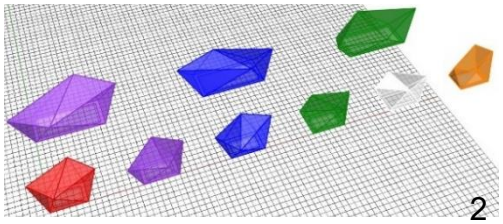
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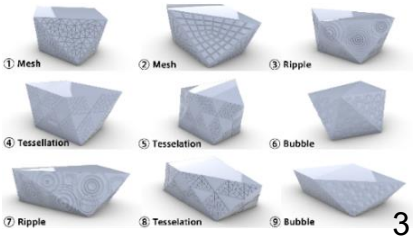

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1. The Mitsubishi Chemical Group's DURABIO™
2. Takenaka Corporation's parametric study on shapes
3. Surface texture designing implemented by the Hiroya Tanaka Laboratory at Keio University SFC
4. 3D printing molding with "*Chashitsu*" performed by Slab Inc.

In addition to commercialization of the 3D printed plastic benches themselves, we will continue engaging in co-creation activities with all of the organizations with a view toward also proposing space designs that are integrated with architecture by digital fabrication.

[*1] Parametric study is a form of optimization that is implemented by quantifying various conditions related to analysis modeling as parameters and performing analyses by changing the parameter values.
[*2] Building facade refers to the appearance of a building when viewed from the front.
[*3] "*Chashitsu*" is a pellet extrusion 3D printer that uses plastic pellets, which allows for large-scale molding in a short period of time. Slab Inc. launched its development work in 2013 and has obtained a patent. (It has been sold as the GEM series since 2019.) In 2021, the ultra large pellet extrusion 3D printer was completed under the development code name "*Chashitsu*," with a molding size of three meters each in width, depth, and height.

"*Chashitsu*": https://slab.jp/releaces/20210709/

Website links for each company, institute, and product
• Mitsubishi Chemical Group Corporation: https://www.mcgc.com/english/
• Takenaka Corporation: https://www.takenaka.co.jp/takenaka_e/
• Slab Inc.: https://slab.jp/
• Hiroya Tanaka Laboratory, Keio University SFC: https://fab.sfc.keio.ac.jp/
• Texture design for large-scale 3D printing to produce optical effects of reflection, transmission, and refraction: https://sig4dff.org/conference/2022/proceeding/OP33.pdf
• Video of molding a 3D plastic bench: https://www.youtube.com/watch?v=EYhLu-Irajo

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