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Sand Lab: Transforming Desert Sand Into Glass

SINGAPORE & ZÜRICH – Emerging selective laser sintering technology applied to an hitherto untapped resource – desert sand – opens new possibilities in the development of lightweight, durable, and recyclable construction materials at the Future Cities Laboratory's Sand Lab.

Sand – An (In)finite Resource? Sand is one of the world's most sought after resources. It is the megastar of the industrial and digital era, with wide-ranging applications from the production of concrete, to glass, computers, detergents, and even toothpaste. Our culture is literally built on sand.

Unfortunately, sand is also finite: Since a couple of years ago, the global demand for sand has not been met naturally through erosion and sedimentation.

Gigantic Business with Aquatic Sand. The global demand for aquatic sand makes it a scarce resource. According to John Milliman, mankind mines twice as much sand as what is produced naturally. The global market for sand is estimated at 15 billion tonnes per year with a value of USD 70 billion. The United Nations Environment Programme's (UNEP) estimate is double, at 30 billion tonnes, while the actual figures might be even higher. Today, 50% of the sand is being mined from rivers before it even reaches the sea.

The exploitative forms of sand mining are widespread around the globe. Beaches in North Africa are being depleted, rivers are being dredged and ocean floors scraped. Landmasses around mining areas collapse and islands erode. The ecological consequences reach far beyond the actual mining area, leaving devastating traces in wider areas.

The sand shortage leads to increasing illegal quarrying and trade in developing countries. 'Sand wars' and 'sand mafia' are commonplace terms in the media to describe the phenomenon. These developments lead to the need to seek alternatives to sand as a construction material.

Unsuitable Desert Sand. Sand is mostly composed of quartz, a mineral form of silicon dioxide that is the most abundant material on the earth's surface. But not all sand is equal: the construction industry requires fixed grain sizes and rough edges that are usually found in fluvial and marine sand. Desert sand is presently unsuitable to the construction industry becuase wind erodes and polishes individual sand particles and reduces their frictional qualities. In construction, desert sand is simply too smooth and spherical to bond within the concrete matrix.

Sustainable Alternatives. Developing countries use almost 90% of the global cement production (and twice as much sand as aggregate in concrete) and 70% of the global steel. The rapid pace of urbanisation in Asia, Africa and South America and the urban design challenges that go along with it question the sustainability of current building materials and methods. The regions mentioned above face gigantic building tasks. Thankfully, the demand for sand can be reduced through recycling, substitution and synthesis.

Laser Sintered Sand Structures (L3S). Laser Sintered Sand Structures (L3S) at the Sand Lab of the Assistant Professorship of Architecture and Construction Dirk E. Hebel at the Future Cities Laboratory in Singapore emerge from material science and rapid prototyping technologies. The application of selective laser sintering to sand material yields new, lightweight, and durable glass structures. The computer controlled laser technology further allows the design of the mesostructural geometry of the material, enabling material properties to be customised, which also aids the distribution of materials. To date, sintering of silica and ceramics has produced high-precision casting moulds and high-tech materials for aerospace and medical use. In the digital design and fabrication of components, sintering allows bio-mimetic design imitating lightweight bone and cartilage structures.

Laser Sintered Sand Structures (L3S) can be developed from any type of sand, including the abundant and previously unusable desert sand. Desert sand is smaller in grain size and therefore has a higher laser absorption rate and requires lower energy input than larger sized conventional sand. The sintered material is also higher in definition and resolution. The range of L3S applications are vast. Highly specific materials can be engineered to meet required attributes such as weight, strength, and durability in the field of aerospace, automotive, medical, and construction industries.

DIRK E. HEBEL & AUREL VON RICHTHOFEN

References

Boden, George and Oliver Courtney (2010). 'Shifting Sands', Global Witness.

Delestrac, Denis (2013). Sand Wars. La Compagnie des Taxi-Brousse.

Milliman, John D and Syvitski, James PM (1992). 'Geomorphic/tectonic Control of Sediment Discharge to the Ocean: The Importance of Small Mountainous Rivers', The Journal of Geology: 525–544.

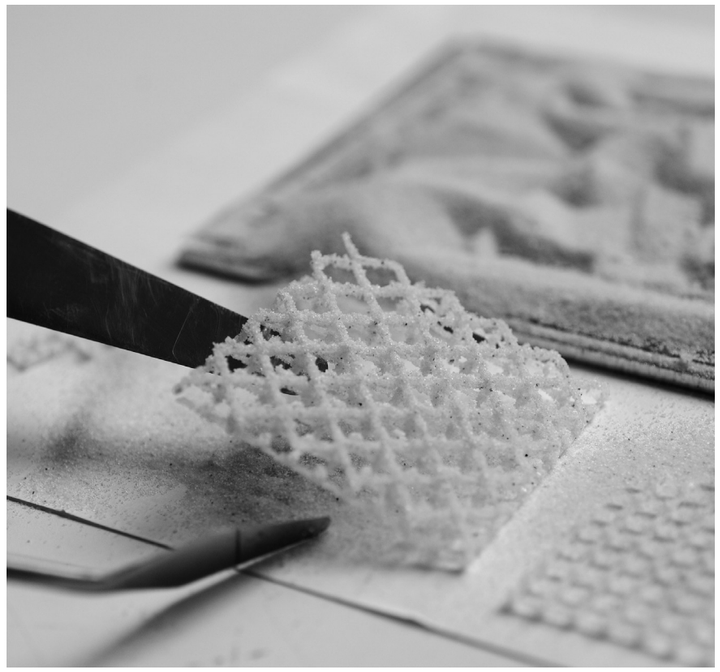

Figure 1. L3S wafer (Carli Teteris)

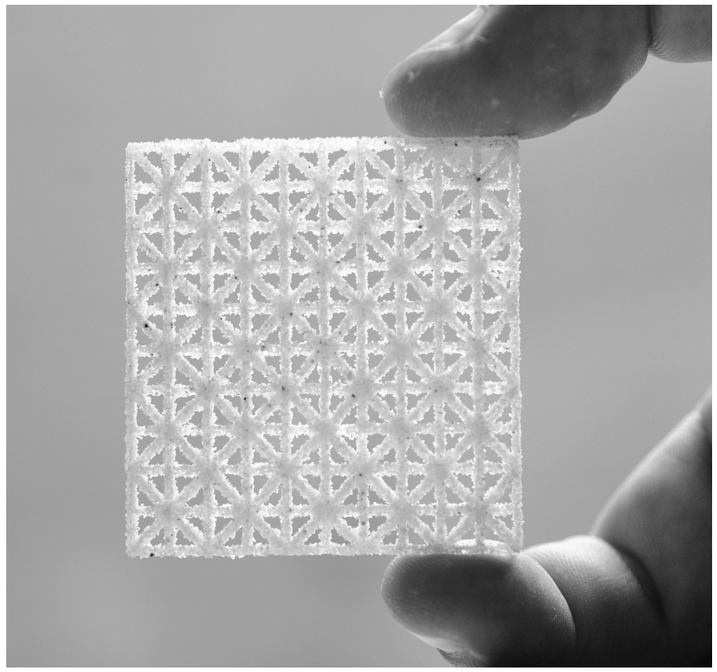

Figure 2. Finished L3S-wafer (Carli Teteris)

A Cross-Cultural Theory of the Urban Passive House: SNSF Professorship for FCL Researcher

SINGAPORE -- FCL Researcher, and current Co-ordinator for the Territorial Organisation Module, Sascha Roesler was awarded a Swiss National Science Foundation (SNSF) professorship in March this year. An outline of his proposed research follows. EDITORS

The weak point of today's theory of passive climate control is its focus on individual buildings and self-sufficiency, which must be overcome by focusing on interdependence and synergy effects that operate on an urban scale. In this research project, the "passive house" is to be rethought as an "urban passive house" and conceptualised as part of the political ecology of the city.

The project's investigation is at the intersection of architecture, ethnography, and science and technology studies. It examines the complex relationship between the climate and the city, as it is rendered most evident in global passive climate control strategies.

The future conception of the urban passive house relies on coordinated "combinations" between the different "agents" of passive climate control. Therefore at the very centre of this project is the investigation of meaningful "associations" of spatial structures, socio-cultural practices, and political regulations. The control of climate is conceived as a politically influenced cultural practice.

SASCHA ROESLER

Contemporary culture is, as Dirk Hebel and Aurel von Richthofen argue, quite literally built on sand. The production of everyday materials such as concrete, glass, detergent and even toothpaste, all involve sand. This *FCL Gazette* features their exploratory work on one rarely used kind of sand – desert sand – and how it might be a viable building material.

We also report on Sascha Roesler's upcoming appointment to an SNSF Professorship, recent PhD defences by Kashif Shaad and Derek Vollmer (both of Module 7, Landscape Ecology). We are also pleased to note visitors to FCL, including Paris-based architect and urban planner Jean-Pierre Pranlas-Descours, and FCL involvement in the URA exhibition 'Drones: Changing the Way We See the World'.

STEPHEN CAIRNS

(FCL) FUTURE CITIES LABORATORY 未来城市实验室

GAZETTE

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PhD Abstract

Development of a distributed surface-subsurface interaction model for river corridor hydrodynamics

Kashif Shaad

Examiners
Prof. Dr Paolo Burlando
Prof. Dr Vladimir Nikora
Prof. Dr Mary Hill
Prof. Dr Paolo Perona

Thesis Abstract
The River-Urban-Ecosystem nexus will likely be one of the defining challenges for water management and policy in the 21st century. In the 2014 Intergovernmental Panel on Climate Change (IPCC) technical report, direct human impact such as land-use change and pollution is identified as the dominant stressor on fresh water ecosystems. Unless steps are taken to build adaptability and resilience in these systems, their physical and biological capacity to sustain native species and its ecosystem services is under threat.

This thesis attempts to contribute to the growing body of work on understanding and modelling processes relevant to river corridor dynamics. A modelling system that incorporates the surface and subsurface hydrodynamics is developed, which allows the modelling of the spatial-temporal heterogeneity of the river at a higher level than is currently possible.

The framework and its development tackles the question of the representation of each domain and their connection, computational effort and efficiency, generating boundary conditions via nesting in hydrological models; and depicting the physical-biological process of evapotranspiration.

After two benchmarks and sensitivity analyses, the coupled modelling framework is applied on two real-world projects with very diverse settings. The first is the Ciliwung River in Indonesia - a meso-scale tropical river with extensive unplanned urbanisation, which pollutes and shapes the river system. In contrast is the Alpine River system of the Maggia valley in Switzerland, which water is in pristine condition. However, its diversion due to the operation by a power plant has regulated its flow - driving changes in the ecology of the river corridor.

Application on both projects and analysis shows a coupled modelling framework could provide value to the study and management of rivers that are increasingly being shaped through anthropogenic forcings directly or indirectly; and demonstrate its potential to contribute to river restoration, rehabilitation and river corridor management.

KASHIF SHAAD

Figure 3. Kashif Shaad collecting soil samples at the upstream research site of Ciawi (Michaela Prescott 2012)

Recent Publications

Stephen Cairns and Jane M. Jacobs (2014), 'Buildings Must Die: A Perverse View of Architecture', MIT Press.

Saber, Esmail M., Matthias Mast, Kwok Wai Tham, and Hansjurg Leibundgut. (2015). "Ventilation Effectiveness and Contaminant Distribution in an Occupied Space Conditioned with Low Exergy Ventilation Technologies in the Tropics." paper presented at Healthy Buildings 2015 Europe, Eindhoven, Netherlands, 18-20 May.

PhD Abstract

Tradeoffs and institutional arrangements for enhancing the societal value of ecosystem services within an urbanised river catchment

Derek Vollmer

Examiners
Prof. Dr Adrienne Grêt-Regamey
Prof. Dr Peter H. Verburg
Dr Barbara Becker

Thesis Abstract
River catchments provide a range of benefits to humans, but maximising these benefits entails trade-offs—particularly between ecosystem services and between beneficiary groups. The institutions responsible for managing these resources require specific knowledge of ecosystem service supply, demand, and their trade-offs, but this information must be framed within a social context if it is to be useful.

In this thesis, a case study of the Ciliwung river catchment running through metropolitan Jakarta demonstrates an approach to generate such information. Drawing on methods from diverse fields including political science, geomantics, landscape planning, and environmental economics, the region is framed as a socio-ecological system and focus is placed on problems that stakeholders are confronted with. A household survey was deployed in one informal settlement (kampung) along the Ciliwung river, which revealed spatial patterns of human-environment interactions, including typically unobserved uses of the river such as solid waste and sewage disposal.

In the same kampung, a monetary valuation of river rehabilitation scenarios was carried out, supplemented with qualitative information derived from interviews. This survey methodology is then expanded to the entire downstream (Jakarta) catchment area to further examine the spatial and socio-economic determinants of residents' preferences for rehabilitation. Based on a social-ecological system framework, the analysis of the stakeholders engaged in rehabilitating the Ciliwung provides an understanding of how social and biophysical variables within the catchment interact, leading to its current degraded state and the potentially constraining rehabilitation efforts.

Finally, for the extended metropolitan region, an approach is developed to prioritise ecosystem services through spatial planning.

This consists of a four-step process involving land cover scenario development, ecosystem service assessment, stakeholder weighting, and optimisation to help stakeholders understand and analyse the consequences of future (up to 2030) land cover change. It is clear that complex social-ecological systems like metropolitan Jakarta are a fertile ground for research, and more efforts are needed to explore the wicked problems that rapidly urbanising cities face.

DEREK VOLLMER

Figure 4 (top). Derek Vollmer (second from left) with colleagues at the 'Waste Bank' in Nagrak Sub-District, West Java
Figure 5 (bottom). Field researchers with Derek Vollmer inspecting water tanks, Nagrak Sub-District, West Java

Singapore-ETH Centre Initiates Alumni Chapter

SINGAPORE -- The Association of Scientific Staff ETH Singapore (AsETH) recently launched an Alumni chapter. We invite current and past researchers with the SEC, both under the Future Cities Laboratory (FCL) and the Future Resilient Systems (FRS) to join us. As a first step, a LinkedIn group for the 'Singapore-ETH Centre Alumni' has been created to provide a platform to connect, network and share news and opportunities.

We look forward to connecting with you on LinkedIn and welcome ideas on ways to engage with past and present SEC researchers.

FEDERICA REMONDI and NAOMI HANAKATA

Recent Events

'Drones: Changing the Way We See The World'

Future Cities Laboratory contributed to the recent URA Exhibition titled 'Drones: Changing the Way We See the World'. Featured FCL projects included:
-- 3D modelling of the NUS campus using UAV photogrammetry in a multi-data approach by the Simulation Platform
-- Detection of mosquito breeding grounds in roof gutters using UAV technology by the Simulation Platform
-- 3D modelling of the Ciliwung River as part of the Landscape Ecology module's research in Jakarta, in collaboration with the Simulation Platform.

Figure 6. Peter Ho, Chairman of the Urban Redevelopment Authority (URA) launching the exhibition 'Drones: Changing the Way We See the World'

Jean-Pierre Pranlas-Descours: 'Density, Architecture and Territory'

Jean-Pierre Pranlas-Descours gave a lecture on urban density at FCL in April. His lecture, drew on his forthcoming book *Density as Model of Sustainable Development*, and proposed density as an integral aspect of design at household, neighbourhood and territorial scales. The lecture was illustrated by studies on five distinctive European cities. Pranlas-Descours is an architect, urban-planner, and professor at the Paris-Malaquais School of Architecture with a Masters in Architecture and History.

Figure 7. Jean-Pierre Pranlas-Descours opens his lecture with a discussion of Giotto's 'Expulsion of Demons from Arezzo'