Intelligence

RIBA President's Award for Research

Building without bolts

Kostas Grigoriadis wins the President's Award for Research, Design & Technical, with his paper on Computational Blends

Interior view of the multi-material mullion interface showing the aluminium (silver), alumina (red), and glass (translucent blue) sub-material distribution. Credit: Kostas Grigoriadis

Kostas Grigoriadis

Computational Blends: The Epistemology of Designing with Functionally Graded Materials

Architectural Association School of Architecture

'There is a sea change in the world of construction: the shift from assemblage to fusion. In material terms this translates into a move from mechanical to chemical attachments; more simply, things are built without bolts, screws, nails, and pegs' – Greg Lynn

Fused materiality has existed since time immemorial in the form of alloys, but was introduced in the form of gradients only in the late 20th century in aerospace. Its significance for architecture relates to the ever-rising scale of 3D-printing and its expanding material palette. Research by Foster+Partners, Skanska, and Loughborough University for instance, are exploring large-scale component fabrication for 3D-printing entire buildings, while investigations in the fusion of materials into multi-material, or functionally graded material (FGM) building parts (varied gradually in composition within a single volume) indicate considerable material, cost, and energy savings among other advantages.

Convergence of building-scale printing and multi-materiality is only a matter of time. This research initially outlines the impacts that this new material technology heralds.
First, tectonic construction, based on the assemblage of materially uniform, discrete building components, will be replaced by the continuous fusion of

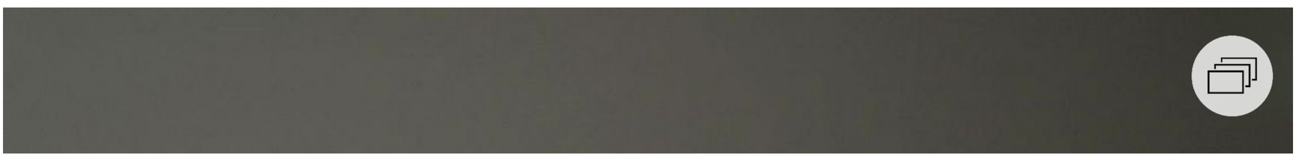
materials. Discrete boundaries will be replaced by gradients which, being more 'forgiving' than discrete components, will see the acceptable margin for error rise. Finally, procedures of translation from 3D CAD information to 2D (drawn) instructions that are then converted into built space, will be superseded by seamlessness between designing and building.

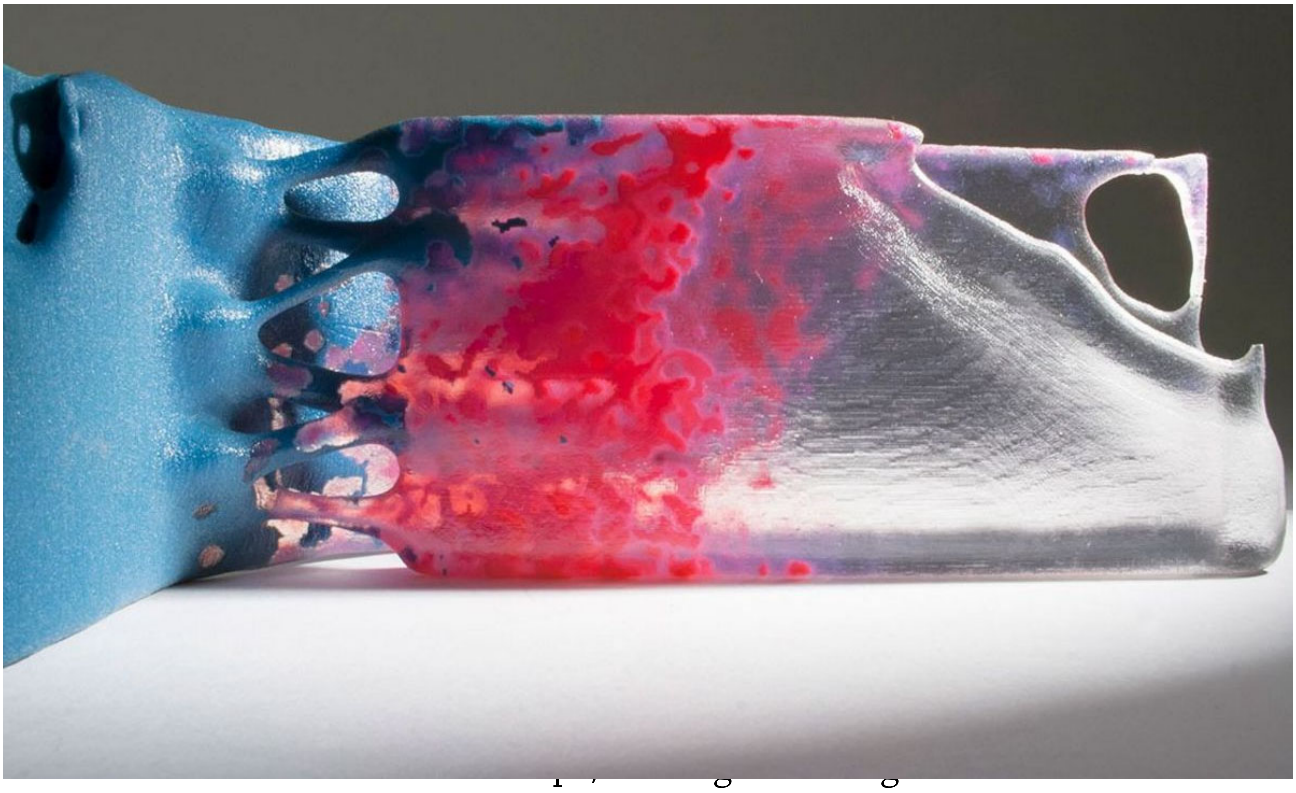
The research moves on to the impact of multi-material use on design practice, criticising and rethinking voxel-based design (the FGM CAD method most used by architectural researchers), due to its inability to incorporate material properties in the design process.

So in the new landscape of part-less FGM constructs, materially-oriented design and the generative emergence of material gradients are expected to take precedence over current, form-biased approaches. The resulting research question is: what design methodology can correspond to the use of functionally graded materials in architecture?
The designer's objective should be to create a framework within which sub-materials can mix into a graded topology, finding their own fitness and arrangement in space over time. As blending typically occurs when matter is in its liquid state, computational fluid dynamics (CFD) simulations offer an alternative for designing with FGM.

The aim is a step-by-step methodology of this novel design process, targeted to the glass to aluminium frame connection in a unitised curtain wall panel – typically associated with low environmental sustainability, supply chain inefficiencies and installation failures that could all be eliminated by a component-less FGM connection. The workflow concerns the whole process of material research, design, and fabrication of the part in a physical multi-material.

The resulting findings mainly concern the issues arising from the use of material simulations in architectural design, and discrepancies between computational and physical phenomena.





of continuousness.

Close up view of the interior of the fabricated multi-material mullion interface
Credit: Kostas Grigoriadis

1 of 2

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