AD ARCHITECTURAL DESIGN

HYPERSURFACE ARCHITECTURE II

HARESH LALVANI

META ARCHITECTURE

Architect-morphologist Haresh Lalvani has developed a technique to modulate sheet metal into a wide range of new configurations that can be easily manufactured using a patent fabrication process he developed with M lgo-Bufkin. Here he discusses the development of his theory of Meta Architecture, his application of the term Hypersurface, and his work with Milgo-Bufkin which is currently launching his new design series.

Meta Architecture is based on manipulating morphologically structured information via algorithms and genetic codes that encipher the formal possibilities of architecture. These possibilities are determined by mapping them in a unified morphological universe,[1] a higher dimensional meta space which (theoretically) encodes all past, present and future morphologies. It also maps all their transformations. The coding of structures within this universe leads to an artificial genetic code [2] This is a universal morphological code[3] and acts as a driver for organising shaping building and transforming architecture over short-term and long-term time scales. Coupling the code with manufacturing processes, both at the macro level of current computer-aided manufacturing and the micro level of nanotechnologies and genetic engineering enables the direct translation of the code into the physical process of building Coupled with biological (DNA-based) or other chemical physical) building processes, the artificial genetic code enables growth, adaptation evolution and replication of buildings, permitting architecture to design itself and eventually liberating it from the architect. Architecture as we now know it will end when self-architecture begins.[4]

Within this overall premise, several examples from my ongoing work in Meta Architecture, and the related visual product, Hyper Space Architecture or Hyper Architecture), are presented The work offers an alternative paradigm to 'digital architecture' which has emerged in the last decade. Increasingly sophisticated computer graphics tools have enabled architects to visualise relatively complex spatial environments in virtual space without recourse to physical models or in some instances as in Frank Gehry's museum at Bilbao), to digitise complex built models directly These digital visualisations, all conceived in virtual space, are admittedly visually spectacular and are conceived 'top down' both visually and spatially However they are neither informed by construction methods or the properties of physical materials, nor by any morphological principles of space and structure, which impose strong constraints on architecture. Architecture, shaped by these constraints and modelled by morphological principles – including Meta Architecture – is architecture that proceeds from the 'bottom up

The works presented here exemplify the bottom-up approach in two different ways: one driven primarily by higher-dimensional geometry and the other by combining geometry with manufacturing process in making physical form out of real material. Both examples show the unprecedented possibilities for shaping architecture opened up by recourse to basic morphological principles (geometric, topologic, structural etc). The images demonstrating the first approach are excerpted from my folio 'Hyperspace Architecture' which shows the various applications of higher dimensions for architecture,[5] and the second approach is from an ongoing experiment currently being carried out with Milgo/Bufkin, a leading metal fabricator in New York.

Highly ordered geometry is used in the first approach (figs 1 and 2) as a basis for generating irregular hyperstructures, in this case, hypersurfaces. The term 'hypersurface' here is used according to its original meaning defined in the strict geometrical (mathematical) sense: ie having spatial dimensions greater than three. This definition contrasts with the usage in this and the previous special issue of *AD*, edited by Stephen Perrella, entitled Hypersurface Architecture' where the term 'hyper' is used as a meta-dimension of the surface and not its spatial dimension. Interestingly in the first example shown here (figs 1a, b), the term has a double meaning The two tiling designs are identical in their base geometry which comprises an assembly of identical crescent-shaped tiles[6] based on two-dimensional projections from five-dimensional Euclidean space. The crescents are thus hyper-tiles. n addition they have a superimposed pattern of dark lines, echoing the other meaning of 'hypersurface' as used by Perrella). While the designs appear random each tile is identically marked in both cases. The image captures the paradigm that irregular and random-looking designs can be constructed from identical modules, an idea of great significance for architecture as it visually blends order with chaos.

Another example (figs 2a–c further exemplifies this juxtaposition between order and disorder in a three-dimensional structure. The rregular surface, a true hypersurface projected from higher-dimensional space hovers like a cloud over a space that, when extended is non-periodic. The structure can be constructed from a single-node design,[7] a single-strut element and flat panels. Additional stabilising features would most likely be needed for its structural stability This is just one example of the unlimited and varied architectural compositions that can be constructed from this new morphological invention

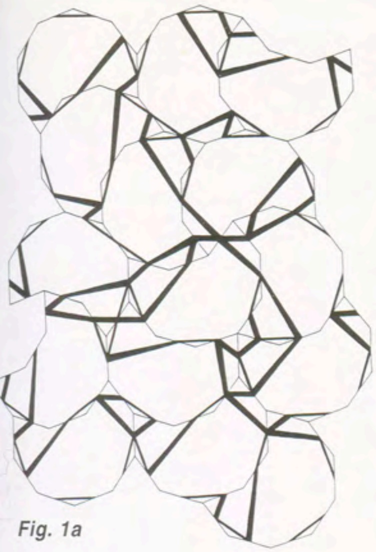

Fig. 1a

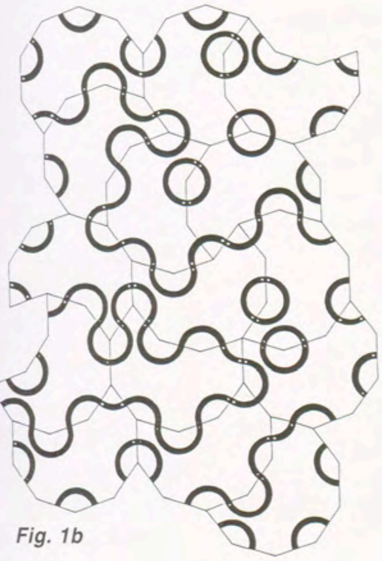

Fig. 1b

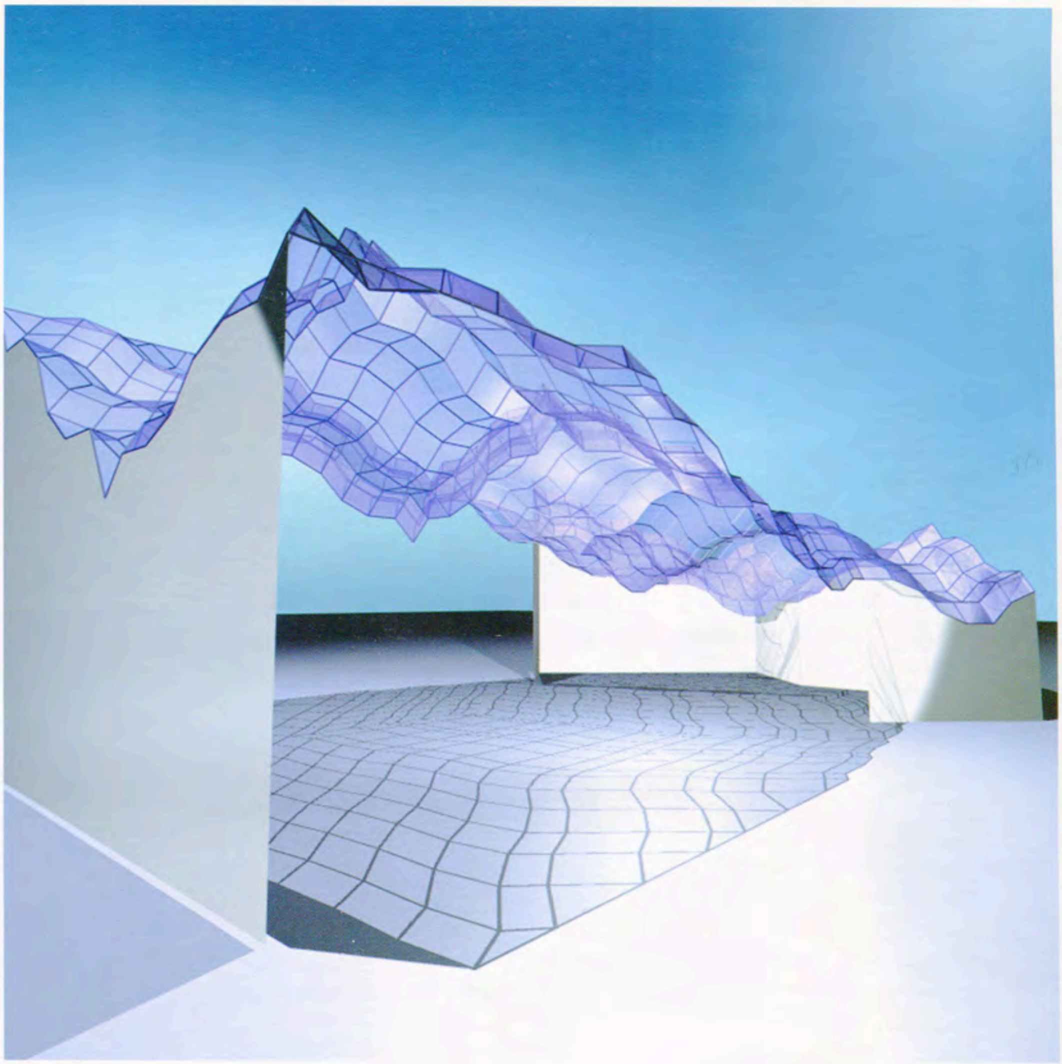

Fig. 2a

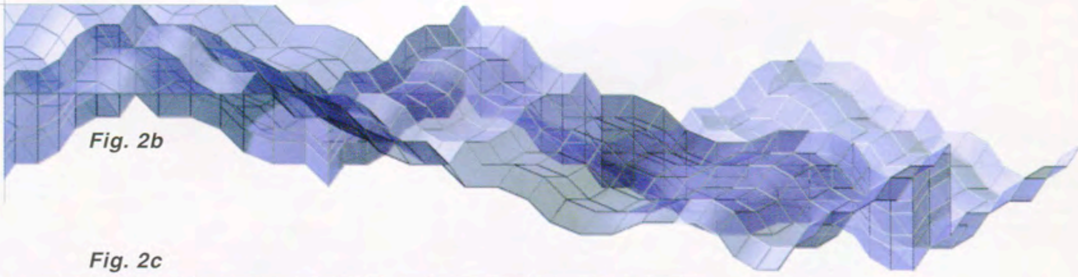

Fig. 2b

Fig. 2c

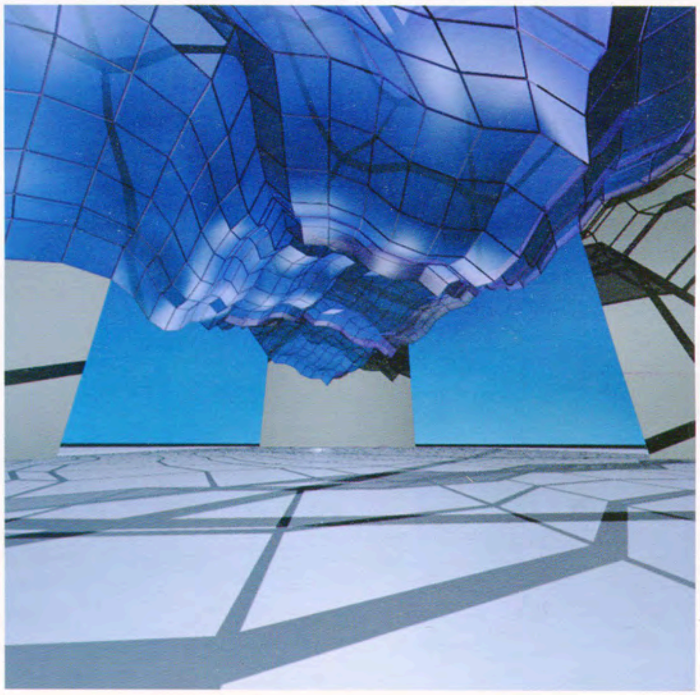

Fig. 3

The next group of images (figs 3a–o exemplifies the second approach. The project deals with software-driven fabrication of sheet metal for architectural surface structures[8] and is being carried out at Milgo/Bufkin's manufacturing facility Though columns, capitals, wall and ceiling panels are immediate architectural applications of concern for Milgo's business interests, the project provides a unique opportunity to experiment with broader Meta Architectural concepts, especially the relationship between an artificial 'genetic code' and the manufacturing process. All sheet-metal structures shown here were generated using a morphologically encoded algorithm, which provides the possibility to generate endless 'variations on a theme' by manipulating the code. As a result, no two structures need be alike, so each individual in the world if desired could have their own unique structure. A procedure was developed whereby single continuous metal sheets could be marked by computer-driven equipment and then folded (manually for now). The resulting structures not only have a new look, but appear to be structurally advantageous at the same time. Architectural and industrial design products as well as complete environments based on these structures are currently being developed (figs 4-8). The algorithmic approach permits the structures to be modelled transformed and fabricated with ease. We expect that the morphologic elegance in the shaping of these structures would also translate into an economy in building

Fig. 4

Fig. 5

Column Museum (fig4 shows a sampling of the morphologically encoded columnar structures being prototyped and fabricated at Milgo. *Fractal High-Rise* (fig 5) shows a branched fractal column concept applied to a glass skyscraper *Umbrellas* (fig 6) utilises the twisted fold for a freestanding structure in an open-air environment. *Transitions* (fig 7) shows flat, wavy and irregularly curved walls within the same spatial layout, using the same material and fabrication technology *WaveKnot* (fig 8) employs a continuous rippled surface for a ceiling or roof defined by a simple topological knot space.

The undulating look of these structures resulted from an interest in the fundamental behaviour of sheet material under forces. Material 'flows' under its own weight and other forces according to predetermined morphologic laws, which pertain more to fluid motion than to static objects. Constructing architectural elements from rigid rectilinear units (such as bricks and beams has 'frozen' this inherent flowing nature of architectural envelopes. The wrinkles on our skin, the surfaces of plants and skins of animals, waves and cloud forms, display this fluid-like quality in nature. Curvilinear architectural forms constructed using standard building methods have usually raised concerns of economy

However our experiments at Milgo suggest that advanced software-driven manufacturing processes, coupled with powerful morphological underpinnings, can easily and possibly economically generate a wide repertory of new curvilinear vocabulary unavailable to architects in the past. Paradoxically high technology representing the opposite pole in the man–nature dichotomy permits fluid shapes not possible earlier in a simple and elegant manner and in doing so, brings us closer to forms in nature. This is true not only in visible forms, but also in the concept of the genetic code, which permits each one of us to be unique yet encoded by the same basic genetic alphabets (DNA bases). These sheet metal structures are morphologically coded in a similar way

Fig. 6

Fig. 7

Notes

I am indebted to the following for their contribution to the project: computer modelling and rendering, Neil Katz and Mohamad Al-Khayer photography, Robert Warren; product development, prototyping and fabrication, Milgo-Bufkin with Bruce Gitlin and Alex Kveton. More information on these projects with Milgo-Bufkin, Brooklyn, New York, can be found on their website <www.milgo-bufkin.com> from January 2000.

1 Haresh Lalvani, 'Morphological Universe, Expanding the Possibilities of Design and Nature' unpublished, 1998, based on a lecture presented at ACSA conference, Dalhousie University, Nova Scotia, October 1998, on the theme 'Works of Nature: The Rhetoric of Structural Invention'

2 My interest in the genetic code of architecture dates back to 1975; my first published work on morphological coding was in the context of Islamic patterns (1982). In 1993, I proposed 'architectural genetics' as an emerging science.

3 I have been developing such a code for over two decades. Early interim results appeared in 'Multi-dimensional Periodic Arrangments of Transforming Space Structures' PhD Thesis, University of Pennsylvania (1981), self-published as *Structures on Hyper-Structures* (1982). Subsequent extensions of this work have been published in various papers, and applications to various structural morphologies have been in progress since the early 1990s.

4 For the origins of 'growing' architecture, see William Katavolos, *Organics*, Steendrukkirj de Jong & Co (Hilversum), 1961 Vittorio Giorgini, 'Early Experiments in Architecture using Nature's Building Technology' in H Lavani (ed), *The International Journal of Space Structures*, vol 11 nos 1 2, special issue, 1997

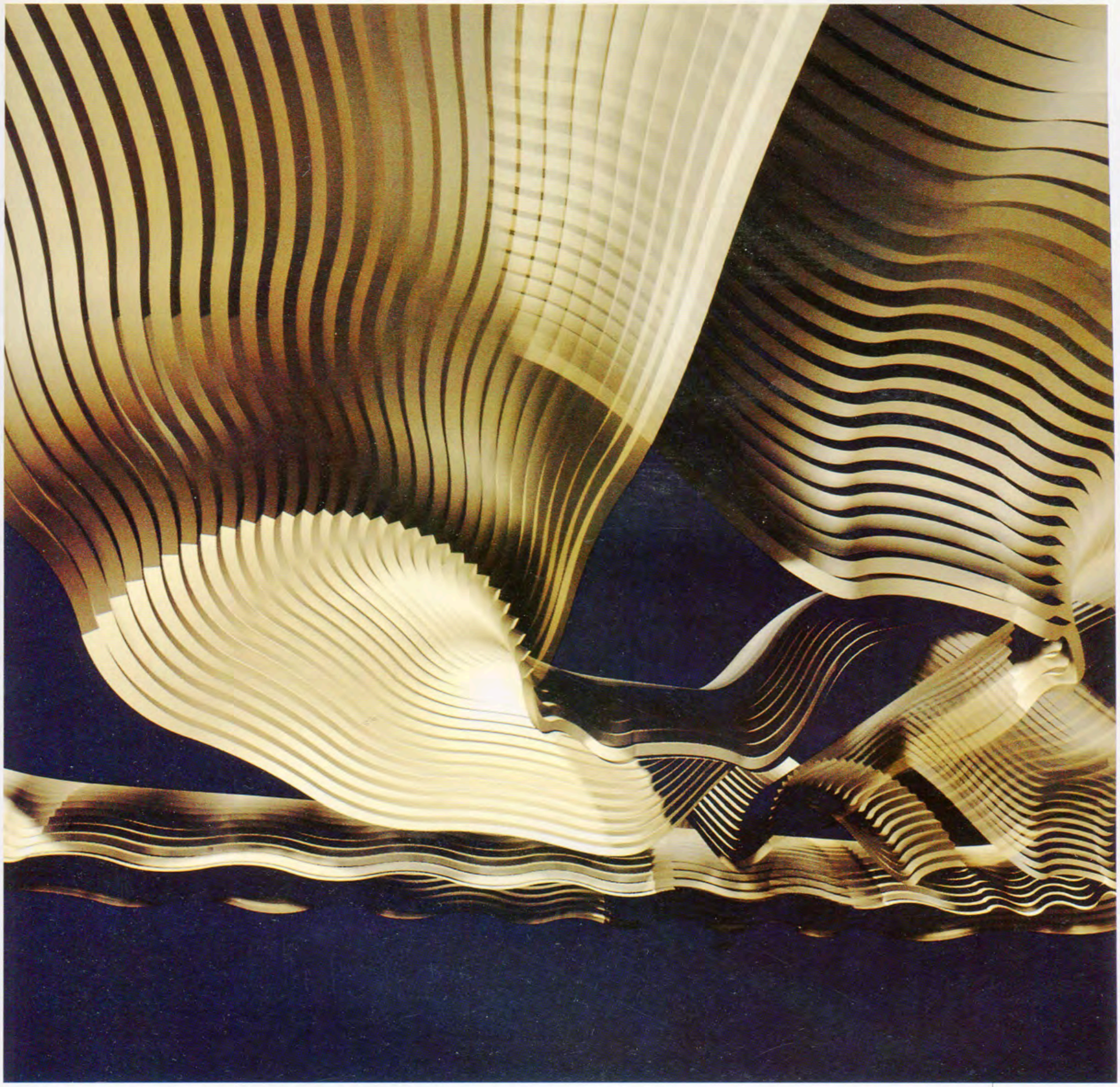

Fig. 8

My work in this concept came via genetic engineering and was proposed in 'Towards Automorphogenesis, Building with Bacteria' unpublished, 1974, the source of which goes back to the question asked by my thesis of 1967· 'Why don't we build with bone and spider silk?' In recent years, John Johansen has been proposing growing architecture using 'molecular engineering'

5 Lalvani, 'The Architectural Promise of Curved Hyperspaces' 2nd International Seminar· 'Application of Structural Morphology to Architecture' University of Stuttgart, 1994; 'Hyperstructures' in P Dombernowsky and T Wester (eds), *Engineering a New Architecture, Conference Proceedings,* Aarhus School of Architecture (Denmark), 1999.

6 Lalvani, US Patent 4,620,998, 1986.

7 Lalvani, US Patent 5,505,035, 1996.

8 Patent pending.

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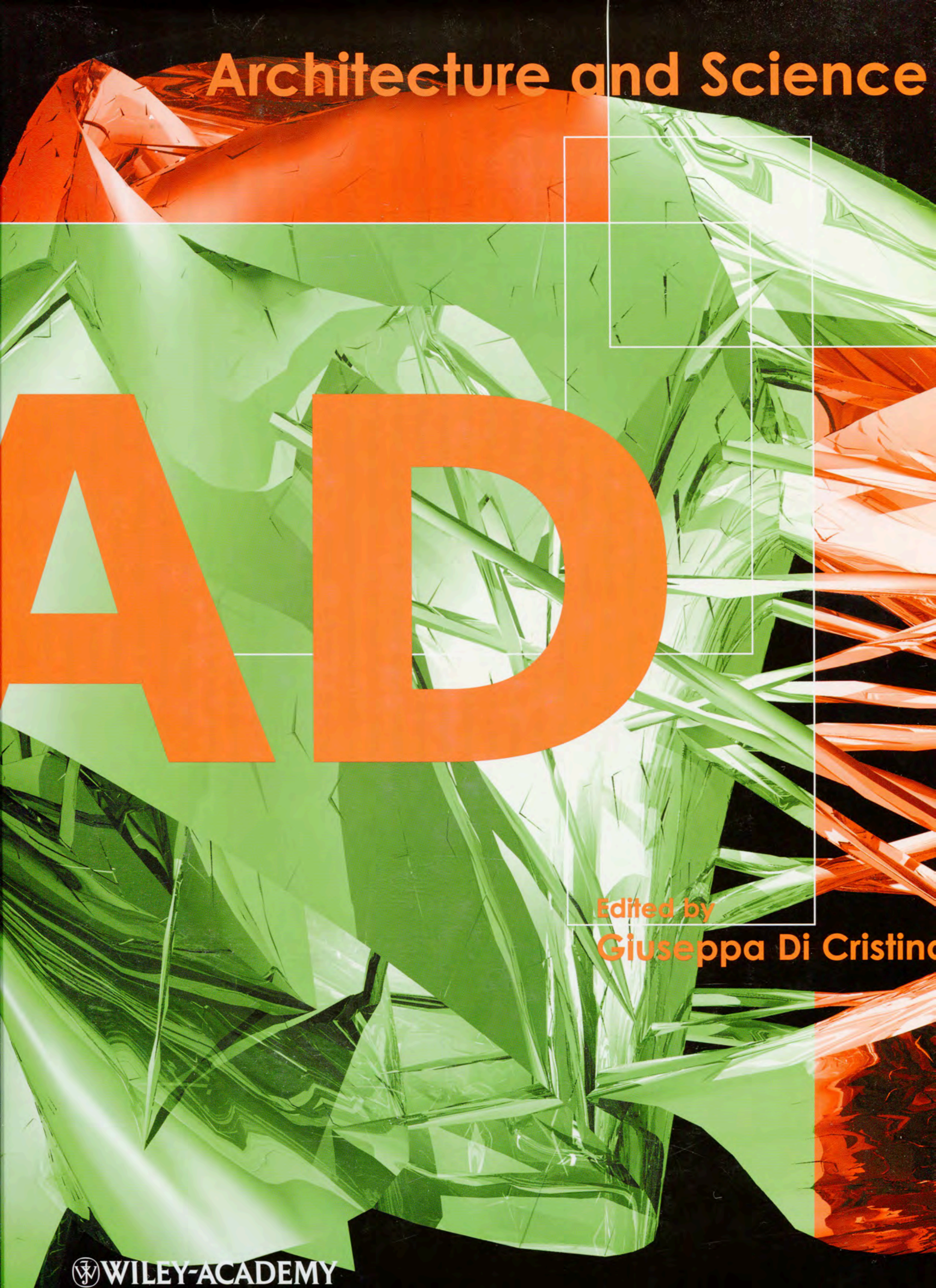

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