Adaptive Architecture

Empathy and Ecology

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The imagination, by means of which alone I can anticipate future objects, or be interested in them, must carry me out of myself into the feelings of others by one and the same process by which I am thrown forward as it were into my future being.¹

William Hazlitt argues in An Essay on the Principles of Human Action, 1805, that we share our futures, and this is a key feature of humanity, that the imagined future of others is as valid as one’s own imagined future. This is a vital skill of all designers, and particularly architects, transporting architectural discourse and practice beyond any notion of egocentric space.

Architecture has always been inventive and adaptable. Our current era however, is unique in its technological potential combined with societal and environmental challenges. The need to generate sustainability, developments

in design techniques, and technological advances are leading to the emergence of a new Adaptive Architecture. The built environment is becoming truly responsive in terms of physical, real-time changes acting under intelligent controls. Adaptive Architecture can be characterized by four key attributes: Dynamic, Transformable, Bio-inspired and Intelligence, to which the key issue of inhabitation must be added.²

Adaptive Architecture has deep cultural roots. The Schröder House designed by Gerrit Rietveld in close collaboration with Mrs Schröder and completed in 1925, is an early demonstration of a transformable architecture. Paul Overy observes ‘the space-dividing elements – the first floor itself, the roof and four walls – shape the spatial structure of the house. Within the structure there are five areas of transition form outside to inside and vice versa.’³ Above all the Schröder House is considered as a whole – a holistic work of architecture.

Arguably what characterises late twentieth century and early twenty first century technology is the development of systems. However, there needs to be an equal emphasis on how well architecture performs and how performative qualities can be enhanced by informed design. It is revealing to reflect on Rietveld’s definition of architecture: ‘art is the clearest form of reality. The painter teaches us to experience reality by defining colours, the sculptor by defining materials, and the architect by defining space. Although in the architect’s case the material and construction are essential, the space, between and around the solid form is of primary importance.’⁴

In 1981 Mike Davies of Richard Rogers & Partners, whilst researching the façades of Lloyds of London, wrote this lyrical vision of a dynamic façade:

Look up at a spectrum washed envelope whose surface is a map of its instantaneous performance, stealing energy from the air with an iridescent shrug, rippling its photogrids as a cloud runs across the sun; a wall which, as the night chill falls, fluffs up its feathers and turning white on the north face and blue on the south, closes its eyes but not without remembering to pump a little glow down to the night porter, clear a view-patch for the lovers on the south side of level 22 and to turn to 12 per cent silver just after dawn.⁵

It is pertinent to note that during the design and construction of Lloyds of London, 1976 – 1984, the client used fountain pens and almost no

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computers at the start of the project and by the moving-in day, computers were ubiquitous amongst the Re-insurers. Mark Goulthorpe’s Aegis HypoSurface can be seen as a physical embodiment of at least part of Mike Davies’ vision. Mark Goulthorpe argues as ‘architecture inevitably shifts from representative to calculated tropes. This offers extraordinary potential to fundamentally rethink our manner of designing, building and dwelling, and to fold in the temporal logics that computation offers.’

Humankind now has the techniques and technology to create responsive façades that reduce energy demands, enhance comfort and integrate energy generation into contemporary architecture. Building envelopes no longer simply resist energy flows. They are dynamically variable and can harvest energy. Tim Macfarlane suggested that ‘with the range of glass types and coatings are combined in a double or triple glazed unit, there are 10 to power of 9 options and that no two buildings will carry the same specification.’ This is unlike the era of single float glass being in accordance with the Building Regulations of England and Wales when I studied architecture.

The work of Archigram and Peter Cook started in an era known for the ‘white heat of technology,’ to quote the future British Prime Minister Harold Wilson in the autumn of 1963. This visionary work remains a timely provocation to contemporary architecture. Although we are still to experience Archigram’s Walking Cities, these pen on ink drawings present a future, the future of the 1960s, with such veracity that looking at them in a magazine or gallery one could not but help dreaming of a more flexible adaptive future for architecture and humankind.

In 2019 humankind benefits from millennia of cultural continuity yet faces new challenges and opportunities. In organising the ARCADIA 2013 Conference, co-chairs Beesley, Khan and Stacey perceive the opening up
of new intellectual territories, be this arising from technology or our native inventiveness. The discipline of architecture is ripe, fuelled by research. There are new modes of practice where the realms of research design and development are seen as one. Where knowledge passes osmotically from practice to academia, from teacher to pupil and from the future architect to the architect-academic. A co-working of the future.

Stewart Brands’ seven shearing layers of change, in *How Buildings Learn*, published in 1994, are: Site, Structure, Skin, Services, Space, Plan and Stuff. This was based on research by DEGW. This proactive but arguably backwards looking hierarchy was challenged by many case studies in the Adaptive Architecture conferences of 2011 and 2013, in particular within Dynamic Façades and Transformable Structures. Change can now be integrated into the architecture and the structure need not be static. Brands’ book now appears strangely dated as he conceives change as something that happens to buildings after they are designed and not part of the design process. It also seems dated in the stated rate of destructive change, anticipating that a façade in North American construction will be totally replaced ‘every 20 years.’ Research undertaken by Michael Stacey Architects with KieranTimberlake revealed that the typical timescale for the replacement and renewal of the curtain walling of a skyscraper in Manhattan is over 50 years. Furthermore it is now possible to specify finishes that receive a guarantee for over 40 years, for example, super durable polyester powder coating on aluminium, or over 80 years for 25µm of anodising on aluminium.

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Transformable Structures and Transformable Architecture in the inventive hands of an engineer such as Chuck Hoberman is a means of creating a sustainable built environment that offers both comfort and joy. The Thames Water Tower, London, England: Architect Brookes Stacey Randall Fursdon, 1995, was designed as a striking contribution to the urban landscape of London. This inventive tower of glass, stainless steel and aluminium is a prototype for an environmentally responsible and responsive building. It was built to house a surge pipe on Thames Water’s drinking water ring main, an
unseen marvel of hydro engineering serving all of London. The tower was designed by Brookes Stacey Randall Fursdon, in collaboration with students of the Royal College of Art, Damian O’Sullivan and Tania Doufa. The tower celebrates an otherwise invisible engineering achievement, with an amplified electronic barometer in the centre of Holland Park Roundabout, London.\(^{17}\)

The 15m-high tower has a base housing the services, a smooth column of glass, and a capital formed by the solar array. Blue water appears to rise up the tower, layer by layer, in response to climatic conditions and then fall again in times of low air pressure. ‘The approach to the design of the structure and enclosure is one of increasing sophistication as it rises up to the tower to the solar vane,’ observed the Editors of ViA Arquitectura.\(^{18}\) They continue: ‘The Thames Tower is a working model of a responsive building. In the design of the tower the architects sought to detail the complete assembly in such a way that the play of light is encouraged as it strikes and penetrates not only the glass and water but also the polished surfaces and components within the tower to create a visually poetic effect.’\(^{19}\) The project was realised through the research and application of new technologies.\(^{20}\)

The Thames Water Tower was tendered with a solar vane that automatically opened for daylight hours and closed at night when it was not functioning.

**Image 9** Sketch of the original dynamic solar vane of the Thames Water Tower which would have opened and closed in response to daylight, designed by Brookes Stacey Randall Fursdon

**Image 10** Thames Water Tower, 1995, architect Brookes Stacey Randall Fursdon

17 Michael Stacey was a founding partner at Brookes Stacey Randall Fursdon, 1987 and set up Michael Stacey Architects in 2004.

18 M. Plannelles Herrero and A Mengui Muñoz, (December 2001), Agua – Water Via Arquitectura, 10.5-2, p. 49.

19 Ibid.

This design option had to be dropped due to the tight timescale of the project, in line with the completion of the Thames Water Drinking Water Ring Main, and not due to cost constraints. Thus, although a specialist subcontractor responded to the architect’s inquiry eventually, Brookes Stacey Randall Furdson had to design the fixed solar vane that tops the tower in order to meet the completion date set by Thames Water.

Professor Robert Kronenburg observes: ‘flexible architecture consists of buildings that are intended to respond to changing situations in their use, operation, or location. This is architecture that adapts rather than stagnates; transforms rather than restricts; is motive rather than static; interacts with its users rather than inhibits. It is a design form that is by its essence cross-disciplinary and multi-functional and consequently, is frequently innovative and expressive of contemporary design issues.’

Peter and Alison Smithson advocate adaptive architecture in *The Charged Void*, proposing the characteristics of spaces to be ‘such that they can be tuned by the occupant to the changing values of their time without denaturing the architecture.’

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22 Alison and Peter Smithson, *The Charged Void: Architecture*, The Monacelli Press, New York, 2001. Additional research on the Smithson was provided for this paper by Ben Yuval Ben-Gait, an MEng EAD student at the Bartlett, University College London.
The London based architect Cedric Price thought that ‘labelling a room on plan has a paralysing effect on the way it’s used.’ New types of reconfigurable architecture, which will show how adaptive strategies can extend the cultural potential of architecture, extend a building’s life cycle, enhance energy efficiency and optimize resource utilization. Deyan Sudjic heralded the birth of intelligent buildings in 1981 citing the Generator project by Cedric Price. ‘Despite all the breathless promise, the only architectural fruit of the microelectronic boom to have made it off the drawing board and into the home on a large scale is no more imaginative than the humble programmable doorbell,’ Sudjic observed in 1981. He thought that this was about to be transformed by Cedric Price’s Generator project for the Gilman Paper Corporation in Florida, a company retreat where Price proposed an ever-changing assembly of components that could be reconfigured at will – the basic data base was the architect’s CAD drawings and all components would have linked logic circuits. The additional software was developed by John and Julia Frazer. Price conceived the software as a perpetual architect. The computer would not only make proposals for improving the layout – it would prepare unsolicited plans if no reconfiguration had occurred.

It is pertinent to pause to consider how profoundly humankind has changed planet Earth since the Industrial Revolution of the eighteenth and nineteenth century. To many geologists the present period of time should in geological terms be defined as the Anthropocene, an epoch where humankind has altered the environment and ecology of Earth to the extent that it is being recorded in the Earth’s crust, in the very rocks of planet Earth. Robert Macfarlane suggests: ‘The idea of the Anthropocene asks hard questions of us. Temporally, it requires that we image ourselves inhabitants not just of a human lifetime or generation, also of ‘deep time’ – the dizzyingly profound eras of Earth history that extend behind and ahead if the present.’

The roots of the Anthropocene have their origin in the industrial and urban revolution of the Eighteenth and Nineteenth Century when humankind harnessed the means of production so successfully it made work at vast scales possible, without the enormous workforce seen in ancient Egypt or Rome. The term Anthropocene was coined in 1999 by Paul J. Cruzten, a Noble Prize-winning atmospheric chemist, who believed the term Holocene was no longer accurate. The Holocene epoch began about 11,700 years before 2000AD, and simply means entirely recent, in ancient Greek. Based on the record of greenhouse gases such as CO2, Paul J. Cruzten and his
colleagues propose that the Anthropocene started in 1782, the year James Watt patented, in the United Kingdom, his efficient steam engine, a key invention of the Industrial Revolution.

Writing in *The Anthropocene Review* (March 2014) Jan Zalasiewicz, Mark Williams and Colin Waters of the University of Leicester with Anthony D. Barnosky and Peter Haff, suggest the weight of the planet Earth’s technosphere has reached 30 trillion tonnes.\(^7\) Jan Zalasiewicz and colleagues note: “The technosphere comprises the interconnecting technological systems that underpin modern civilization,” citing Haff (2012).\(^8\) They continue, it ‘is a phenomenon that has now reached a scale sufficient to perturb the natural physical chemical and biological cycles of the Earth,’ citing Rockstron et al., (2009). Based on Crutzon (2002) this provokes ‘the suggestion of an Anthropocene Epoch.’\(^9\)

Desipte Jan Zalasiewicz et al.’s carefully argued paper “Making the case for a formal Anthropocene Epoch: an analysis of ongoing critiques,” (2017), which concludes that a strong case can be ‘made that the character and scale of its extant stratigraphy already warrants recognition of the Anthropocene as a formal unit of the Geological Time Scale.’\(^{10}\) To date the
Anthropocene is not yet an officially recognised epoch of geological time, by either the International Commission on Stratigraphy or the International Union of Geological Sciences.31

Early in his career Renzo Piano (b.1937, Pegli, Genoa) identified the essence of architecture as *technica* and *humanismo*. Combing technology and humanism in the making of buildings, the making of architecture, requires the skill, knowledge and processes demonstrated by Piano in his long and sustained body of work. Piano has developed a ‘command of the construction process, designing … “piece by piece”’.32 He brings the sensibility of a poet to the practice of architecture. Kate Goodwin considers this sensibility to be evident in his early experiments with tensile structures, observing Piano developed a poetic sensibility conjured ‘in the imagination and human spirit.’ ‘Indeed, for Piano, practical thinking is always balanced by an inclination to poetic dreaming.’33 In Piano’s hands architecture is mutable. Unusually he seeks to keep all components of a new project live to the last possible time in the gestation of a project, to achieve the greatest possible level of integration, to enable the whole to be greater than the sum of the parts. Renzo Piano Building Workshop eschews the conventional layering of discrete packages of elements and systems, which is evident even on an innovative project such as the parametrically designed 30 St Mary’s Axe by Foster & Partners, 2003.


Adaptive Architecture can be considered a direct precursor of Living Architecture Systems. In 1951 the Festival of Britain was staged to celebrate the peace following World War Two (1939-1945) and to herald the end of austerity in Britain. War time food rationing was finally fully withdrawn in Britain in 1954. The festival included a Living Architecture Exhibition, which featured the Lansbury Estate in Poplar, London, 1951. This estate was intended as model district of London, it was designed by architect Sir Frederick Gibberd, with YRM Architects and Geoffrey Jellicoe and included affordable housing, schools and churches. Living Architecture celebrated and promoted the role of good design as a means of informing the lives of the people of Britain. The act of rebuilding and renewal is core of being an architect, Renzo Piano sagaciously observes: 'Making buildings is the opposite of destroying. Making buildings is a decent gesture of peace.'

In this discourse the term Bio-inspired has been preferred to Bio-mimetic, since mimicry is a human talent; however, the problem with the mimetic is that it leaves out the dilemmas and opportunities of design. Frank Lloyd Wright, when designing the structure of The Great Workroom of the Johnson Wax Administration Building, completed in 1939, was inspired by the natural form of forests and trees. Wright designed a bespoke structural system for the building in Racine, Wisconsin. The building’s main space, the Great Workroom, is dominated by an ordered forest of ‘dendriform’ or tree-like concrete columns. The slender tapered columns are just 230 mm wide at
their base and sit on steel footings, which are practically unable to withstand bending. Wright borrowed expressions from botany to describe the three parts of the columns: the stem, the calyx and the petal.\textsuperscript{35} He was specifically inspired by the structure of staghorn cholla cactus.

Adaptation of architecture can be as simple as the windows, blinds and sliding screens of Gerrit Rietveld’s Schroder House, 1924, where the first floor transforms from spaciousness to intimacy in the hands of its occupants, or it can be the sophisticated bio-inspired gill like adaptive shading of Ocean One by soma [Austria] with Knippers Helbig Advanced Engineering.\textsuperscript{36} This 3 to 13-meter high Glass Fibre Reinforce Polymer (GFRP) shading system was inspired by the movement of the South African Bird of Paradise (Strelitzia)
flowers. The system was prototyped at one to one to test this automated adaptive façade.

Adaptive Architecture is as much about process as about product or outcome. Adaptability lies at the very core of every architectural project, since a concept or design idea is constantly adapted to fit its medium of expression: thoughts, words, sometimes sketches, models, computer drawings, prototypes and finally built space,” clearly articulate Kristina Schinegger and Stefan Rutzinger. Who continue, ‘for soma the concept leads through this process and every design decision can either be deduced from or has to be negotiated with it. Thus we do not understand the initial idea as the irreducible essence; instead it is constantly improved and altered.’

Some will argue that new methods of parametric design challenge the cognition of architects. It is clear that we are in the midst of a digital revolution. Andrew Feenberg observed how a precursor to the Internet was conceived by scientists as a serious medium for data transmission, yet it was immediately appropriated by social networks - noting ‘the “cold” computer became the “hot” new medium.” The Internet has altered the way in which architects and engineers work and even has a revolutionary political potential. We need to be protective and proactive in generating the space within which to design, using our collective and individually knowledge wisely as we make the value judgements inherent in the design process. We need to
be reflective practitioners and to practice design intelligence in order to generate appropriate architecture of quality.

People, strangely described as the ‘end-users’ of architecture, respond to the clarity of thought that informs an architectural proposition. Alison and Peter Smithson consider that:

If a building or an element of city is to give intellectual access to its occupants, access to their affections and their skills, access to their sensibilities, the fabric must have special formal characteristics. Layering has such characteristics, for between the layers there is room for illusion as well as activity. Layering is an idea unfolded from within the formal usage of the existing language of modern architecture.\(^{40}\)

13-meter GFRP Prototype of gill-like adaptive shading of Ocean One
Alvar Aalto, during a lecture in Stockholm in 1944, vividly explained ‘flexible standardisation’ via an analogy, recorded by Jørn Utzon. He described a group of houses ‘as being like a branch of flowering cherry ... All the flowers are essentially the same, yet each is unique, looking this way or that, expanding or retreating, according to its relationship to its neighbours, to the sun and to the wind. The full potential of flexible standardisation has yet to be realised, especially in the design and provision of housing.

Adaptive Architecture can provide delight, firmness and commodity, immutable qualities of architecture, yet it can be a means to realise the opportunities within contemporary architecture and it can be used to address key challenges facing humankind, including global warming. An approach to this challenge is demonstrated in the Nottingham House, the UK’s entry to Solar Decathlon, Europe, 2010. Ford and Stacey observe ‘the Nottingham House is a prototype for a housing system that is adaptable both culturally and technically, enabling it to be used throughout Europe. In essence this means that the Nottingham House is pre-adapted to the risk of elevated temperature ranges in the summers of Northern Europe, as predicted by some climate models, later in the twenty-first century.’ The Nottingham House is a situated domestic ecology that fulfils Feenberg’s recommendation to design and create appropriable technology. Almost nothing is more important in peoples’ lives than their home and home life. In the twenty first century we have the technology and knowledge to construct a much higher standard of housing, which delights and serves humanity well. Adaptive Architecture has the potential to inform the future of architecture and human ecology.
Image 21. Sketch of the atrium at the heart of the Nottingham House.

Image 22. The atrium at the heart of the Nottingham House.

Image 23. Ground floor plan of the Nottingham House.
Michael Stacey’s professional life combines practice, teaching, research and writing. His portfolio of projects and products has been recognised by national and international awards, including twice winning the Shapemakers Award for the Innovative Use of Aluminium, a Bureau International du Beton Award, RIBA Awards and an Award from the Campaign for the Preservation of Rural England. In 2013 The Renault Centre, 1982, which he worked on at Foster Associates, was listed Grade II*. He has taught architecture at Liverpool University, Penn Design, London Metropolitan University, the Architectural Association, The University of Nottingham and currently on MEng Engineering & Architectural Design at the Bartlett, University College London.