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Architectural Technology

Architectural Technology

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Stephen Emmitt
Professor of Architectural Technology
Loughborough University

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Editorial Offices
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The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
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Chartered Institute of Architectural Technologists

The Chartered Institute of Architectural Technologists (CIAT) is the only qualifying body for professionals working and studying in the field of Architectural Technology and is internationally recognised. The Institute has its own Royal Charter and under this Charter the objectives are:

- to promote, for the benefit of society, the science and practice of Architectural Technology;
- to facilitate the development and integration of technology into architecture and the wider construction industry to continually improve standards of service for the benefit of industry and of society;
- to uphold and advance the standards of education, competence, practice and conduct of members of the Institute thereby promoting the interests, standing and recognition of Chartered Members within the industry and the wider society.

Chartered Architectural Technologist is a protected title and can only be awarded by CIAT. Chartered Members of the Institute may use the designation MCIAT and the title of Chartered Architectural Technologist. The Chartered qualification demonstrates equality with fellow professionals in the built environment such as architects and surveyors and is recognised by organisations ranging from banks through to government offices and other major clients. The Chartered status allows Members to set up their own practice and provide a full architectural design and contract administration service to the public, as the lead consultant. As such CIAT has a Code of Conduct which all members must comply with. In particular Chartered Members who set up their own practice must register with CIAT and in addition it is a mandatory requirement to hold professional indemnity insurance if providing a service directly to clients. In support of practising Members, CIAT produces a range of documents and information notes and works with sister Institutes in providing additional services.

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Foreword

As President for the Chartered Institute of Architectural Technologists (CIAT) it gives me pleasure to support, on behalf of CIAT, this second edition of *Architectural Technology*. CIAT represents professionals working and studying in the field of Architectural Technology, and is internationally recognised as the qualifying body for Chartered Architectural Technologists, MCIAT and professionally qualified Architectural Technicians, TCIAT. This book recognises the distinct professional identities within the discipline of Architectural Technology.

The design and construction process is now more complex than ever before. This is evidenced by the growth of computer based design tools and the development of building information modelling relating to the planning, design, construction and use of buildings. The knowledge of physical and engineering science required by Architectural Technology students and professionals is also increasing in significance as the need to assess the environmental aspects of materials, components and services of buildings is in demand to help innovate and create a low carbon world.

In my time as an Accredited Course Leader, and while in office as CIAT Vice President Education, I have witnessed the continued evolution of the undergraduate programmes in Architectural Technology shaped by the progressive editions of the Quality Assurance Agency (QAA) Subject Benchmark Statement for Architectural Technology. The book identifies the changes in technologies linked to materials and components (design production and performance) and also technology as a design and management tool (process and management), policies and attitudes (greater attention to sustainability) and application in practice (changing methods of procurement and responsibilities). It remains an excellent publication for those engaged in the study of Architectural Technology and providing the necessary underpinning knowledge for students and practitioners.

CIAT, in supporting this publication, is aware of the continued need for books such as this as an aid for both students and those practising within the discipline of Architectural Technology. On behalf of CIAT, I would like to thank Stephen Emmitt and the publishers. It is CIAT's belief that this book will continue to be a valuable tool for students on Architectural Technology degrees and associated programmes.

Colin Orr PCIAT
President

Introduction

Human beings have a natural tendency to make things. Every time we turn the hot water tap on, every time we go in and out of our front door, we are interacting with products that have been designed, detailed and manufactured to precise standards, products which have then been selected by designers, purchased by a contractor and assembled on a particular site by people (fitters and fixers) using a variety of machinery and tools. Normally we are relatively unaware of such detail until something goes wrong – the tap starts to drip or the door starts to stick – necessitating some form of repair or replacement. Sometimes our attention to detail is focused through the process of re-designing and refitting our kitchens or bathrooms; the choice of units, equipment, finishes, etc., seems endless, limited only by one's imagination and financial budget.

Inventing, making, using, refining, redefining, abandoning and reinventing require constant effort and organisational skills. We make and remake buildings to house our enterprises, shelter us from the elements and to provide a safe, secure, healthy and stimulating environment. Our buildings and associated engineering works are the result of careful consideration, analysis, compromise, determination, collaboration and coordination: the result of human beings using and applying available technologies, both to realise design intent and to maintain the artefact in a serviceable condition throughout its life. Once a building becomes unsuitable as a result of change of use or obsolescence it will be upgraded, remodelled or disassembled, with materials recycled and reused; and the making and remaking process starts again, albeit in a different context.

With the exception of the do-it-yourself (DIY) market the majority of design decisions are made by professional designers and engineers and implemented by skilled contractors and sub-contractors. Many individuals earn their living by design, manufacture, assembly, maintenance, alteration, demolition and recycling of buildings, or parts of buildings, working in an industrial sector known as 'building' or 'construction'. Construction is a major economic activity throughout the world, employing significant numbers of people, consuming significant quantities of (often finite) resources and adding to the pollution of our natural habitat; partly through the process of building, but mainly through the energy consumption of the building over its lifetime. The balance between improving our built environment, encouraging sustainable economic activity and limiting the environmental impact of our building stock is challenging, requiring considerable effort to see ideas translated into reality.

Architecture involves measurable (tangible) and immeasurable (intangible) elements, which makes the pursuit of good architecture a constant challenge for all project contributors. Indeed, it is often the immeasurable aspects, the intuition and feel for a project, that help to bring about exciting, creative and functional buildings that reflect the best of humanity, time and place. Designing and realising buildings that respond to, rather than compete with, ecological systems, that are humane, timely and of course simple and safe to assemble and use, is the goal. Balancing the holistic with the physical and manipulating abstract ideas towards solid artefact through the use of robust technologies to realise buildings that are beautiful, comfortable and enjoyable, can become addictive. This requires a thorough understanding of building technologies, design and management; the components of architectural technology.

If architecture is concerned with making society, it is the materials, components and fixings – the architectural technologies applied to abstract ideas and concepts – that helps to realise the built fabric in and around which society functions. Architectural technology is the constructive link between the abstract and the artefact (SAAT, 1984). Without the technologies to realise the built form architectural design would only exist in the abstract. The term 'architectural technology' is used quite widely in the construction sector, ranging from a rather general use to cover construction technology from an architectural perspective through to the specific use of the term to describe and define a profession; in the UK this is the Chartered Institute of Architectural Technologists (CIAT). Architectural engineering is a closely related discipline; both are hybrid disciplines, representing the fusion of architecture and technology and architecture and engineering respectively.

Architecture has its root in the Greek words *archos* (chief) and *tekton*, (builder). Technology comes from the Greek word *techne* referring to art and skill; the art and science of making practical, functional and aesthetically pleasing buildings.

(a) Sustainable housing, Culemborg, The Netherlands. (b) London Eye detail.
(c) Canopy detail. (d) Handrail detail.

Architectural technology is the realisation of architecture through the application of building science. It is a discipline that aims to bring together artistic, practical and procedural skills; the fusion of three separate worlds (Figure I.1). The artistic component is the domain of

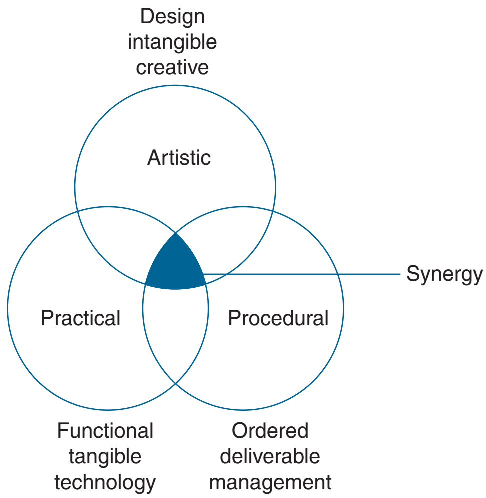

Figure I.1 Architectural technology.

the designer – creative, difficult to quantify objectively and always subjective. The practical component is the domain of the builder – assembling physical materials, technical, physical and quantifiable. The procedural component is the domain of the manager – pulling together artistic and practical skills in an ordered and effective manner. It is rare for all of these skills to be held by one person, making it necessary for disciplines to have an appreciation of the skills and limitations of the individuals they interact with and collaborate with during the life of the project.

When we start to question how buildings are created, assembled and used, we begin a lifelong process of collecting, assimilating, adjusting and reinventing our practical knowledge base; perpetual students of our subject. Design knowledge is grounded in an understanding of how buildings are put together, used, abused, maintained, repaired and eventually taken apart with the majority of materials reused in a new artefact. This knowledge evolves with every new building project. It is a process of problem identification and analysis; idea generation; gathering, analysing producing and coordinating information; turning it into knowledge and using it to make the process of building more effective, with the ultimate aim of pleasing clients and providing exciting, vibrant, sustainable and healthy environments for all those who use them.

Architectural Technology is a primer for students of building design: architectural engineering, architectural technology, architecture, building, construction, building surveying and interior design. The book brings together artistic, philosophical, social and technical issues with an underlying philosophy of environmental sustainability. Often taught as separate subjects, collectively these issues help to articulate the constructive links in building design and also emphasise the importance of architectural detailing. Chapters are presented in a logical and progressive sequence. The first five chapters address fundamental contextual issues and common design generators. This sets the scene for exploring the heart of architectural technology – architectural detailing and the realisation of design intent – in chapters 6–10. The final two chapters explore the building in use and its eventual disassembly and reuse, emphasising the need for an integrated, whole-life, approach to our built environment.

The book is not designed to provide answers but to highlight some of the challenges and opportunities that make architectural technology such an interesting and engaging subject. In adopting an holistic approach it seemed appropriate to include photographs from a wide range of building types and styles, rather than to concentrate on well known designers or buildings, to help emphasise the creative aspects of architectural technology. It is important that readers take the generic issues raised in this book and apply them to their own particular circumstances, whatever their individual preferences.

Chapter 1 Fundamentals

Building design and construction is largely a collaborative effort in which a range of inputs are assimilated and interrelated tasks are undertaken by a wide range of specialists. Everyone contributing to a construction project is, to lesser or greater extents, concerned with issues concerning the integration of design, technology and management. Building professionals need to understand the relationships between manufacturing, detail design, assembly and disassembly; in short the ability to apply available technologies and manage the process to ensure a quality product. One of the biggest challenges facing practitioners is the enormous range of materials, products, structural solutions and architectural styles from which to choose. The challenge lies in selecting the most appropriate to suit a wide range of (often competing) project parameters. These decisions lie at the heart of the design process during which designers, working individually and/or as part of a team, make decisions which affect architectural expression and which rely on technical knowledge and knowhow for their realisation.

Before the Industrial Revolution the designer's choice of materials was largely limited to locally sourced materials. The principal structural materials were stone, brick and timber, with organic materials such as reeds used for finishes. These materials had been used for centuries and the knowledge required for working and applying the materials had been handed down from master to apprentice. Legislation and the enforcement of rules were minimal compared with those in place today and shoddy building was commonplace. Buildings could, and did, collapse, and accidents on the building site

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were only too common in an age when human life was cheap. Although the choice of materials was limited there was a clear understanding of materials' properties, strengths and limitations by the designers and the craftspeople that used them. Vernacular architecture resulted in harmonious developments which relied for the most part on what could be described as sustainable materials. Necessity, rather than choice, and ease of use resulted in the reuse of materials from redundant buildings, such as timber and stone, to create new artefacts.

With the Industrial Revolution came change. Transportation allowed materials to be moved greater distances relatively cheaply and also created a market for new building types, such as railway stations. Advances in materials and services, combined with increased performance requirements, led to the development of highly serviced buildings, which also had the effect of isolating humans from the natural environment. Writing in 1954 the architect Richard Neutra noted that mankind was becoming too detached from the natural world. In doing so he raised similar concerns expressed some time earlier by Ruskin and his contemporaries; arguments which are still relevant today. Along with preoccupations of style over substance, appearance over functionality, and economy over design quality, it is not unusual to find disconnect between our buildings and their context; with little in the way of sensory engagement between building and user or building and site. With increased awareness of our environment and greater attention to how users interact with technologies and buildings there appears to be a growing move towards greater engagement. Some of this has been driven by increased awareness of environmental issues and greater attention to our health and wellbeing. Some has been driven by advances in technologies and material science.

The digital revolution has brought about rapid advances in manufacturing possibilities and narrowed the gulf between the design and the realisation of buildings. It has also brought about digital tools that provide the means for collaborative working in real time and modelling of design solutions prior to construction. This has stimulated new ways of detailing buildings; sometimes in a high tech manner employing the latest materials, sometimes employing more familiar (low tech) materials in a new way. Either way, the possibilities for designers are many. Increasingly these innovations are being promoted as being sustainable or environmentally friendly. The challenge for designers is to look past the marketing and assess the positive contribution the growing number of technologies and manufactured products make to our built environment.

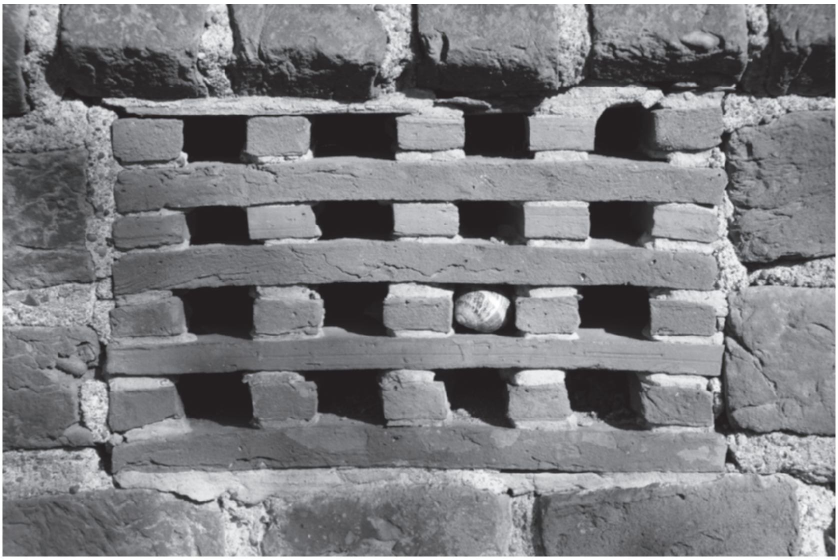
Sensory engagement

Rachel Carson's *Silent Spring* (1962) is widely acknowledged as the catalyst to the world-wide environmental movement and increased public awareness of environmental issues. In 1965 James Lovelock put forward the Gaia hypothesis (Lovelock, 1990), that organisms interact with their environment to produce a self-sustaining equilibrium. The argument is that if humans disturb the environment (e.g. pollute it) they will disturb the equilibrium (e.g. changing weather patterns), something that is only too evident now as we experience more unpredictable and extreme weather conditions around the globe.

During the 1970s government concerns over oil supply resulted in attempts to conserve fuel resources through increased standards for thermal insulation. In the late 1970s and the early 1980s governmental policy shifted towards energy economy. By 1992 concern was focused on the reduction of CO_2 emissions. The term 'sustainable development' came into common usage following publication of the *Brundlandt Report* (World Commission on Environment and Development, 1987) and further attention was generated by the Rio Earth Summit conference of 1992 and the widespread adoption of *Agenda 21*. In 1997 the Kyoto conference resulted in agreement to reduce greenhouse gas emissions by 20% (based on 1990 levels) because of concerns over global warming.

Since Kyoto many governments around the world have undertaken a wide range of measures to try and improve the environmental performance of their building stock, mainly through legislation. Focus is primarily on reducing energy consumption by forcing designers and contractors to reduce the embodied energy of the building and lower its carbon emissions through ever more stringent building regulations and associated guidance. In the UK all new build housing must be zero carbon by 2016 (DCLG, 2007) and other new buildings by 2019. Concerns over climate change have led to a reassessment of how buildings are detailed so that our built environment is more resilient to future shifts in weather patterns. Collectively this has brought about innovations in materials and systems (the architectural technologies) and a re-assessment of how we build. Conventional construction methods rely on a plentiful supply of resources, some of which have started to become scarce and hence expensive. Alternative approaches and attitudes to construction, in the philosophy and use of materials and energy, seek to minimise environmental impact through sensitive design, detailing and specification, construction and maintenance. The mantra is to reduce, reuse, recycle and revitalise.

Reuse of available resources, Avebury.



A home within a home (terracotta air brick and snail sheltering within).

Toward a sustainable vernacular

Architectural design is practiced as a way of thinking and designing by following some fundamental rules (principles); not by conforming to a fixed style or a set of forms (typologies). By working to ethical principles it is possible to realise buildings that are sustainable and add value to society. The aim should be to achieve a sense of economy, enriching daily activities with the least use of materials and energy. Primary design principles are to:

- **Minimise:** waste, energy consumption, materials use, damage to the environment, unhealthy indoor environments, unethical practice.
- **Maximise:** value, renewable energy sources, sustainable (natural) materials, quality of life for users, sensory engagement, ethical practice.

With the drive to reduce the carbon footprint of our building stock it would be easy to take a rather narrow view of sustainability (energy reduction only) and overlook the wider picture. Cultural, economic, environmental and social aspects of sustainability need to be considered concurrently and in line with the principles of minimising and maximising:

- Cultural sustainability requires sensitivity to the characteristics of the local community. By recognising cultural and religious diversity it should be possible to make a positive contribution to society. This may be as subtle as engaging with the local community and incorporating local detailing traditions into new building styles.
- Economic initiatives may relate to affordability and whole life costs; the use of local materials, products and suppliers to sustain the local economy; creation of new markets and products in response to environmental legislation, etc.
- Environmental aspects include, for example; efforts to reduce waste; energy efficiency and carbon neutral buildings; improve the quality of the internal environment by eliminating toxins and improving air quality. Other initiatives relate to the use of renewable and natural materials, adaptability and the reuse of materials.
- Social aspects relate to ethical sourcing of materials and considerate treatment of the environment and employees; the health, safety, wellbeing and comfort of workers and building users; community involvement and empowerment; and responding to the local cultural context.

Primary drivers behind a more sustainable tradition may simply be to comply with current legislation and guidance. It is, however, possible to push the boundaries and design buildings that go beyond the minimal requirements by being creative and thinking about the fundamental performance requirements of the building and its impact on the environment over its long life. Invariably this may create tensions between cultural, economic, environmental and social factors. But it also stimulates markets for innovations in both process and product. The response to climate change has been to use new materials and products with recycled content, new techniques and new architectural details. It has also resulted in a return to natural and renewable materials and traditional building methods, some of which are being used in conjunction with highly sophisticated off-site manufacturing techniques to create innovative and sustainable buildings. Changes in attitudes to how we build and to how we apply architectural technologies are also related to our better understanding of healthy buildings and our sensory (re)engagement with our immediate environment.

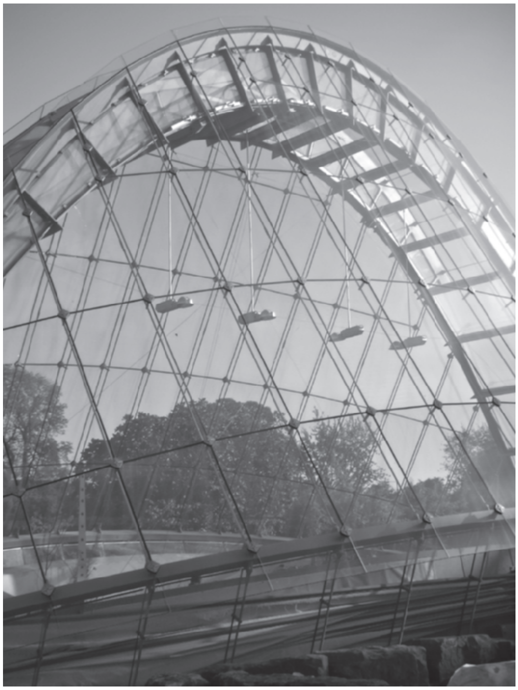
Building innovation

Building has relied heavily on manufacturing processes and mass production for a long time. Clay bricks are perhaps the best example of a mass produced product, although they tended to be manufactured

Paxtonian glasshouse detail.

for local use until the development of effective transportation systems allowed their widespread distribution throughout the country and export abroad. Pre-fabricated buildings have also been an essential part of building for a long time. As early as the 1780s portable cottages were being transported to the colonies, first exploiting timber frame technology, then corrugated iron and later cast iron (see Herbert, 1978). Developments in patent glazing and glazed framed buildings can be traced back to the genius of Decimus Burton and Joseph Paxton. Burton worked with the builder Richard Burton to create the Palm House at the Royal Botanic Gardens, Kew. The technology was borrowed from shipbuilding, the design is essentially that of an upturned hull of a ship, maximising the properties of wrought iron to create large clear spans to house the plants. Paxton was the chief gardener at Chatsworth House where he built the Great Conservatory between 1832 and 1848, which provided the experience to supervise and organise the erection of the Crystal Palace. Built as a temporary structure for the Great Exhibition of 1851, Paxton's design is regarded as the first major pre-fabricated building (Bowley, 1960). Paxton was well versed in the potential of mass production, marketing his Paxtonian glass houses via mail order to the wealthier members of society.

Palm House, Kew Gardens.



New structures, Kew Gardens.

Seaside pleasure piers also relied very heavily on mass produced components. The doyen of pier building, Eugenius Birch, an engineer, worked closely with manufacturers to realise his designs as elegant structures, building 16 pleasure piers between 1853 and 1884, the majority of which relied heavily on mass produced components in cast and wrought iron. These were largely selected from standard components listed in the manufacturers' catalogues. Birch was an individual who understood the potential and limitations of the materials he selected (timber, cast and wrought iron) and exploited them to produce some elegant structures, most famously Brighton's West Pier and Blackpool's North Pier, a trait common among the world's best designers.

During the 20th century there were many attempts to harness industrial processes for the benefit of building and the building user. The Bauhaus movement is one of the best known, a movement which advocated mass production and repetition at the heart of its design philosophy. In the UK the use of mass production of pre-fabricated homes ('prefabs') to house families after the Second World War was a triumph of manufacturing and assembly. Factories dedicated to the

New structures, Wisley.

war effort soon switched their attention to the domestic housing market and materials not previously associated with house building, such as aluminium, were used because they were readily available. This was followed by the trend for system building in the 1960s when 'efficiency' was the main priority, a period when many large panel system tower blocks were assembled, very badly, on site. Poor detailing, inappropriate use of materials, inadequate supervision of construction, combined with the social problems associated with the majority of high-rise blocks in the UK, accelerated the demise of the tower block. The partial collapse of Ronan Point in East London in 1968, following a gas explosion which killed five people, gave system building a bad name.

More recently attention has turned once again to pre-fabrication techniques in response to the Egan Report's core message of faster, cheaper and better through the integration of design and production (Egan, 1998, 2002). Developments in information technologies, especially ICT, 3D design packages and building information modelling