PATTERNS

ESSAYS ON THE ART AND SCIENCE OF ENGINEERING FOR SUSTAINABILITY

Sustainability issues infiltrate every level of decision-making and impact right through the triple bottom line of social, economic and environmental well-being. Make no mistake - this affects everybody.

Editorial

Sustainability is one of the Government's current buzzwords. I recently attended an hour-long brainstorming session of some of the leading figures in the building services sector, and the word was used no less than thirteen times by the various parties around the table. But perhaps sustainability is more than just a buzzword, perhaps it is symptomatic of a real desire to make a change. As Michael Dickson, Chairman of Buro Happold, says in his introduction:

'Construction without depletion is not just a convenient style for altruistic developers. Rather it is a movement that is gathering pace, driven by compelling economic reasons...'

And those compelling economic reasons are impacting on every aspect of design for construction. The issues are diverse and widespread, affecting the way that suppliers fabricate their products, the way that designers plan their buildings, the way that clients think about funding. Sustainability issues infiltrate every level of decision-making and impact right through the triple bottom line of social, economic and environmental well-being. Make no mistake - this affects everybody.

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Contents

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The paper stock used in this journal was manufactured using pulps originating from a mixture of soft and hardwood fibres. All the woods used such as birch, oak, chestnut and pine are sourced from sustainable forests and processed using an elemental chlorine free process (ECF).

98% of effluent from the process is held in suspension at the mill's treatment station, and a selective waste separation procedure ensures that 90% of waste is available for recycling.

Net energy consumption during paper manufacture is [illegible] Gigajoules per tonne sourced from National Grid electricity, and natural gas.

The re-launch of Patterns had been considered for some time: the Journal's popularity as an erudite yet accessible source of cutting-edge information, and its usefulness in disseminating techniques and knowledge is widely respected, but, since the last issue, Patterns 12, celebrating the life of Ted Happold, its niche has been ill-defined. However, the growing prominence of sustainability issues, and the increasing political commitment to environmental responsibility, such as that embodied in the Kyoto agreement to reduce greenhouse gas emissions, was perhaps the motivator for the re-launch as much as the arrival of a new millennium. Tony McLaughlin has coined the term 'Form, Function and Environment', identifying that there is now a third key driver to design - no architect can afford to ignore the impact of environmental considerations in shaping the built form.

The series of articles contained here convey the breadth of issues to be tackled, and the innovative vision that some engineers are using to address these issues. They are attempting to arrive at solutions that strive to meet the client brief with elegance and economy, but also do so in a globally responsible yet pragmatically achievable way. Not all the initiatives are currently implementable, and certainly not all are glamorous - let's face it, carefully designed layers of beige cellulose insulation are far less visually stimulating than stands of slender windmills - but all represent serious potential for reducing the construction industry's environmental burden.

Of course, there are other design aspects being examined, and there are a whole host of wider impacts that we have not even considered here - management techniques, manufacturing and component production improvements and legislative controls to name but a few - but this collection is perhaps a glimpse through some of the technological doors into the future. And the future is where we must all hope that these ideas come to fruition - as our young engineers point out in the concluding piece:

'We... are prepared to tackle these difficult issues, to spend our energy and time wisely in pursuing truly sustainable building solutions, but we need the support and experience of our colleagues... in order to make the change'.

It is up to all of us in the industry to help them to do so.

Tanya Ross is an Associate of Buro Happold

Tanya Ross

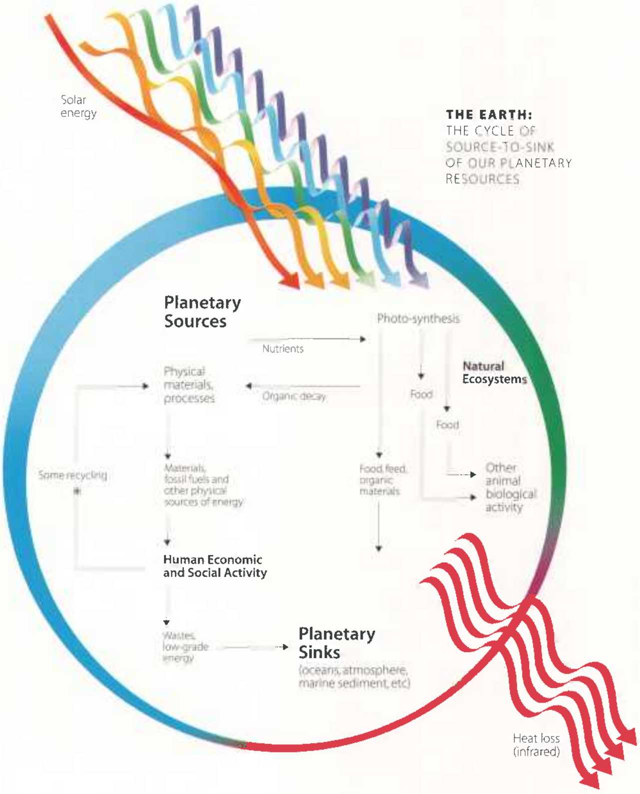
EDITOR

MARCH 2001

Michael Dickson sets the context for sustainability issues, suggesting that we are approaching a new industrial revolution.

Touching the Earth lightly

In the urban context, Herbert Girardet, the noted American environmentalist, film-maker, author and advisor to the UN, has argued cogently for a move away from the first Industrial Revolution's linear process of inefficient conversion of energy and materials into limited product and much waste; toward a more biological cyclical process where much is recycled for reuse. It is a move away from supply of a discrete 'product' to the flow of continued flexible 'services' - the car is not purchased, instead transportation passenger miles are provided with the car remaining the property of the lessor for upgrading, improvement and recycling. The aim is more profitable business.



Similar processes are at work in the formation and supply of our built environment - so that there is a real incentive to produce a more efficient, better product for use - more rent for less cost of operation and a greater profit for the lessor coupled to more productivity by the user/lessee.

Construction without depletion

Construction without depletion is not just a convenient style for altruistic developers. Rather it is a movement that is gathering pace, driven by compelling economic reasons: the current, relatively low cost of primary energy and the unrestricted use of irreplaceable materials can no longer be sustained indefinitely.

Because the issues are complex, and different for each building type, the language of 'green' architecture with high comfort and low environmental impact needs to be expanded immediately - otherwise through our activities as a species we may overload the planet.

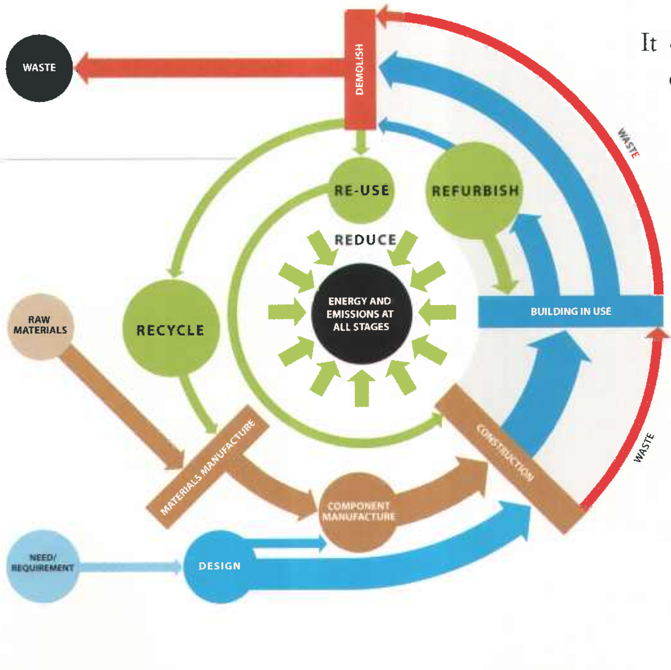
A diverse range of current building types - from hospitals, high-rise towers and offices, to universities, theatres and rural communities - suggest that architectural design is moving towards lowering the burden on the planet without loss of pleasure, value or comfort. Indeed in the work-place there is evidence emerging from authors such as Amory Lovins (author of 'Natural Capitalism, The Next Industrial Revolution') that occupants actually prefer naturally responsive environments, resulting in a decrease in absenteeism and increased productivity.

Cradle to Grave

This gradual move away from 'controlled' internal environments is being driven by the value placed on economic performance over the lifetime of the built product. Tools such as Life Cycle Costing give a reasonable definition of the economic effectiveness of different designs, whilst Life Cycle Assessment evaluates the environmental burden of a development primarily in terms of non-renewable energy and materials, pollution, ultimate waste and so on. But this is not enough. A grammar of 'sustainable' development from cradle to grave is gradually emerging, which identifies that our architecture needs to be efficiently engineered to embody minimum energy, and to allow for the consequences of adaptability of use and flexibility of arrangement during the complete cycle of use, refurbishment, re-use and recycling. To this end, building services installations need to be conceived to consume minimum high-grade, non-replaceable energy consistent with maintaining comfort, by working in harmony with building construction and the ambient climate.

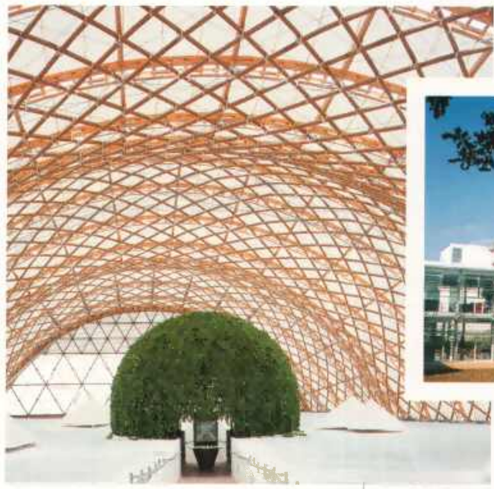
THE THREE R's:

REFURBISH
RE-USE
RECYCLE



It can be argued that - to save both costs and the environment - we need to study solutions from the past as well as use modern computing power and technology to evolve a new architectural language that will benefit the occupier and reduce the environmental burden for following generations. A reduced requirement for building services installations, means reduced capital costs and lower running costs.

Architect: Feilden Clegg Bradley Architects



Architect: Shigeru Ban Architect

Architect: Feilden Clegg Bradley Archi

BERRILL BUILDING
THE OPEN UNIVERSITY:

AN ELEGANT BUT
FLEXIBLE SOLUTION:

THE JAPAN PAVILLION
AT HANOVER EXPO 2000:

'TOUCHING THE GROUND LIGHTLY'

THE OFFICE OF THE FUTURE FOR
THE BUILDING RESEARCH ESTABLISHMENT:

INTEGRATION OF CONSTRUCTION
AND ENVIRONMENTAL RESPONSE

> Sustainability needs to be applied in all cultures, climates and geographical locations; it calls for an ethical stance and, very often, the confidence to depart from the norm.

Greening Architecture

There are many strands to 'greening' our architecture - each approach deserves credit for the innovative way that both architects and engineers have attempted to think beyond conventional limits and engage with their clients in a genuine dialogue of 'more' for 'less' while still achieving value and delight.

One building that demonstrates how a successful team collaboration can result in an energy-conscious yet elegant solution is the Berrill Building at the Open University in Milton Keynes. Photovoltaic cells integrated into the cladding, building orientation and massing arranged to maximise natural light and natural ventilation, a heavy-weight structural solution that utilises its mass to store thermal energy - and the whole combined together in an architectural expression that is neither a clumsy medley of 'bolts-ons' nor ostentatiously advertising its green credentials. Above all, its construction was carefully considered to minimise waste and environmental disturbance and improve speed of construction.

Architect: Edward Cullinan Architects

THE CONSERVATION WORKSHOP FOR THE WEALD AND DOWNLAND MUSEUM:

USING A NEW PALETTE OF RENEWABLE MATERIALS

Architect: Richard Rogers Partnership

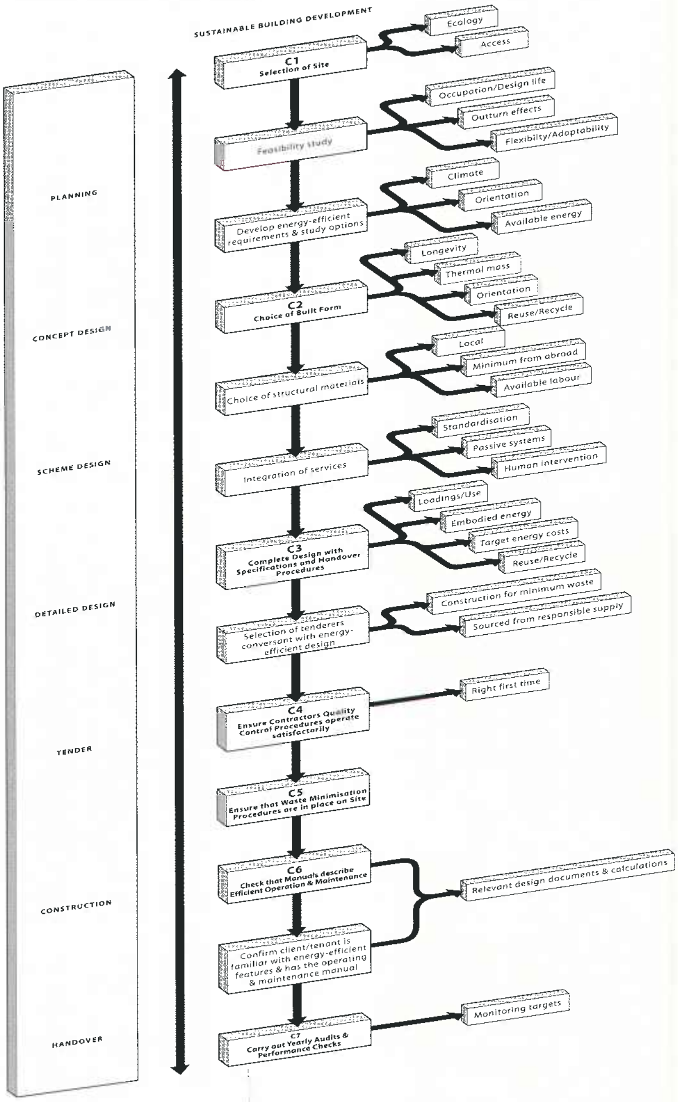
PAUL HAMLYN LEARNING RESOURCES CENTRE, THAMES VALLEY UNIVERSITY:

A FLEXIBLE APPROACH WITHOUT LOSS OF AESTHETIC ORIGINALITY

Architect: Foster and Partners

QUEEN ELIZABETH II GREAT COURT AT THE BRITISH MUSEUM:

RE-USING OUR HERITAGE SUCCESSFULLY



OPTIONS FOR SUSTAINABILITY IN A TRADITIONAL PROCUREMENT ROUTE

Architect: Michael Hopkins & Partners

SOLID STATE LOGIC:

MODERN ARCHITECTURE WITH MINIMUM ENERGY

There are wider issues too: outside the boundaries of individual building projects, construction professionals need to exercise 'joined-up thinking', by assessing the whole milieu of any new construction project. Does the land use pattern work? What are the planning issues? Will the transport infrastructure support the project?

Can a public transport policy be successfully integrated towards new development? On this front, the Buro Happold office at 17 Newman Street, London - naturally ventilated and illuminated during the day, with single glazing to the windows - scores 'very good' on the BREEAM scale because it is located adjacent to a public transport node, at Oxford Circus. So we are able to travel to work without adding to the car-generated carbon dioxide and nitrous oxide fumes.

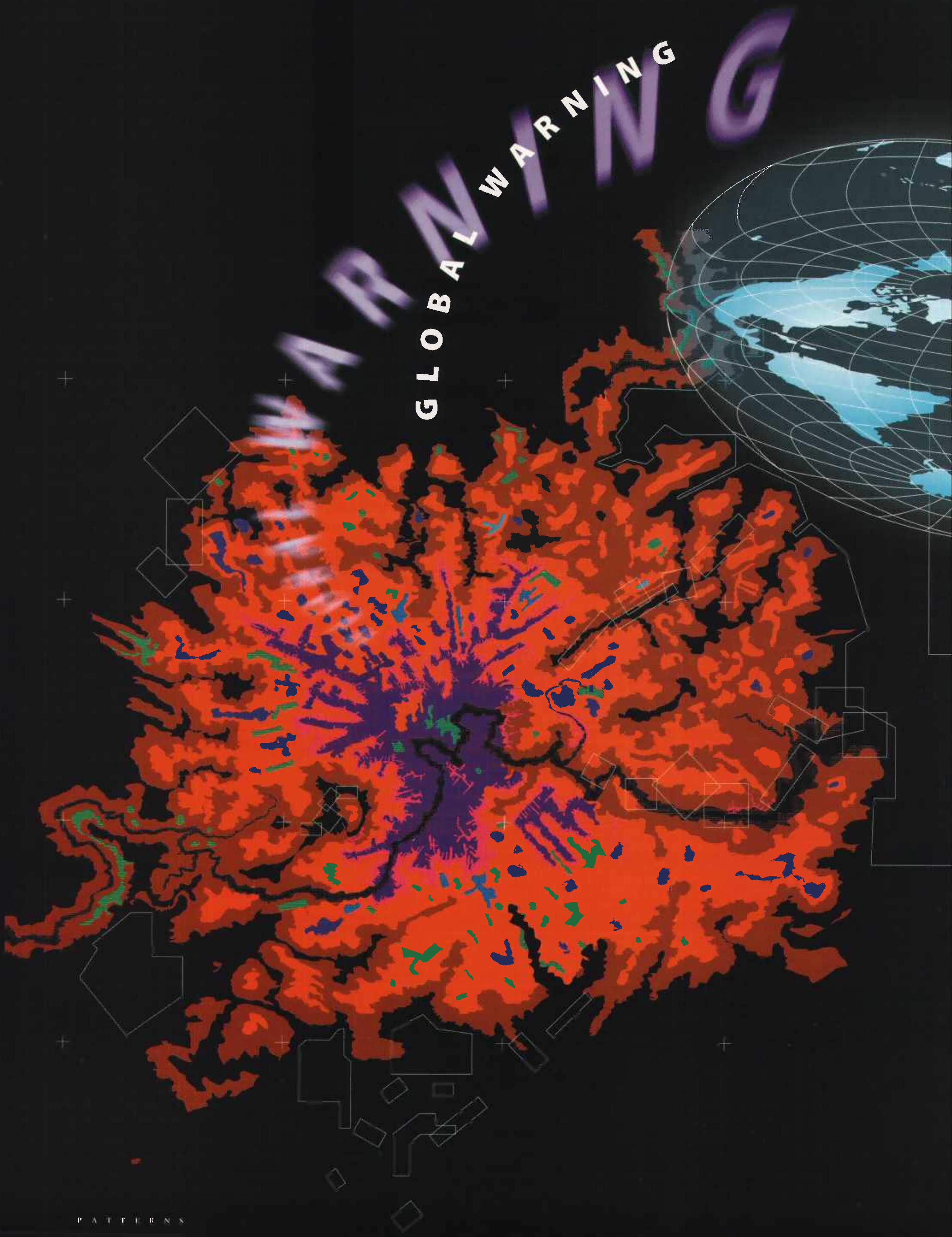
Efficient Procurement

The goals for the built environment are inextricably linked to the construction process - 'more' is required from 'less' in less total time. Design has to be recognised as having two overlapping stages - briefing and concept stage, requiring time for gelling a finite proposal from the clients' brief, followed by design for procurement.

Concept designers have to embrace the specialist expertise of suppliers to achieve standardisation without boredom. The concept itself has to link clearly to the business case for the effective occupation and operation of the finished building. The 'third' office at KLM, Stanstead, was delivered in 80% of the total time and 70% of the cost of earlier models by a process of continuous improvement by all.

Sustainability in the built environment requires multi-disciplinary and inter-disciplinary work; it needs to be applied in all cultures, climates and geographical locations; it calls for an ethical stance and, very often, the confidence to depart from the norm. This is perhaps our greatest challenge as responsible engineers - to test our limits, to question our solutions, to risk our reputations in order to save our planet. At the same time a better process will also create a better asset for the client, for the user and for subsequent generations.

Michael Dickson is Chairman of Buro Happold and Chairman of the Construction Industry Council


WARNING
GLOBAL WARNING

What is Sustainability? Former Chairman of the Government Panel on Sustainable Development, and member of the Urban Task Force, **Sir Crispin Tickell** is better equipped than most to explain...

Almost half the members of our species live in cities, and the others are increasingly drawn towards them. How we should make them, how we should make the individual buildings in them, how we should make the country support them, in short how we should make them work, is one of the major problems of our time. Cities have become both our glory and our bane.

Lord Rogers recently published 'Cities for a Small Planet' - here is a quote:

> 'Cities remain the great demographic magnets of our time because they facilitate work and are the seedbeds of our cultural development. Cities are centres of communication, learning and complex commercial enterprises; they house huge concentrations of families; they focus and condense physical, intellectual and creative energy. They are places of hugely diversified activities and functions: exhibitions and demonstrations, bars and cathedrals, shops and opera houses. I love their combinations of ages, races, cultures and activities, the mix of community and anonymity, familiarity and surprise, even their sense of dangerous excitement.'

Thus cities have come to represent the best we can aspire to. Yet the larger and more complex that cities become, the greater their vulnerability to change around them. Somehow, we have come to believe that with one or two blips, progress has always been upwards and onwards. Instead we should remember that all previous urban societies - over thirty of them - have collapsed, nearly all because of the destruction of, or damage to, their resource base. They may represent a value added to human life through a specialisation of human functions. Yet they bring together all the hazards in an acute form within our cities.

A generation ago, some people, including architects, referred to cities as mechanisms, and the houses in them as living machines. The image of the super-organism seems much more appropriate.

Every city, every house, every individual, absorbs resources and emits wastes. The resources include food and water, fuels and energy, building materials, timber and pulp and of course processed goods; and the wastes include sewage, exhaust gases, household and factory discards, both solid and liquid, and such other materials as concrete, metals and plastics. Cities and their support systems thereby create an environment of their own. Depletion of the resource base outside with deforestation, soil erosion, and import of water and energy materials from ever further afield, can create spreading brown cities from the centre, rather like the Australian grass 'spinifex' which grows outwards leaving a devastated middle. It has been calculated that the land area required to supply London's environmental needs is 120 times that covered by the city itself.

> ‘Treating the world as if we intended to stay’

Now where in all this is sustainable development? Labels are nearly always misleading. Indeed, some people see sustainable development as an oxymoron. For them, development and sustainability are a contradiction in terms. The phrase can also serve as an umbrella over very little. For nearly everyone it is more of a convoy of ideas rather than a single idea, and fog sometimes comes down to hide the ships in the convoy from each other.

There have been many attempts at definition. The usual approach is based on that used by the Brundtland Commission on Sustainable Development (1987):

'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' Or expressed as a sound bite: 'Treating the world as if we intended to stay'.

What are we trying

It is as well to be clear about what it is that we are trying to sustain. All ideas of sustainability must surely begin with planetary health. That health is now endangered for five main reasons. Cities are involved in all of them.

- **The giddy-making increase in human numbers**
- **The deterioration in land quality and soil fertility**
- **The increasing pollution of water, both salt and fresh**
- **The changes to the chemistry of the atmosphere**
- **The extinction of species - caused by humans - at up to over a hundred times the normal rate.**

Together, these changes amount to an acceleration of environmental change unprecedented since humans became an identifiable animal species. As hunters and gatherers, our effect on the earth was confined to relatively small areas. Only recently has the scale of human expansion reached the point where it affects the planet as a whole. Looking at the impacts of such expansion, it can be seen that they are all connected with, and drive each other.

1 Population increase:

- **Viability of cities**

The current rate of growth of urban populations is roughly equivalent to a new Mexico every month. Nearly all the current increase is in poor countries, by definition those with less resources and lowest capacity to dispose of waste. It should go without saying, that the more people there are, the worse these problems will become. A prime problem today is that pressure of consumption can easily render renewable resources unrenewable, or renewable only after long stretches of time.

- **Refugees and population movement**

More people, in or out of cities, means more pressure on the environment. It also means more refugees. According to the United Nations High Commission for Refugees, in 1968 there were fewer than 6 million refugees on a restricted definition of those fleeing from political, ethnic or religious persecution, but in 1994 the number had risen to over 27 million. These figures do not include environmental refugees, some moving across frontiers, others displaced within them, but depending on their definition the number could be more than 27 million. Much of the impact of this flow of human beings will be in and around cities.

- **Disease**

We must reckon with the medical consequences of greater pressure of numbers. The frequency of contact, the density of the population and the concentration of infective and susceptible people promote the transmission of disease. Changes in the environment, whether natural or human made, produce new variants in viruses, bacteria, parasites and insects. The re-emergence of such diseases as cholera, dengue and other viral fevers can be traced to changes in land use and the growth of cities. Many disease vectors live, breed or feed in urban areas where there is poor drainage and inadequate provision for garbage collection, sanitation and piped water.

There are also more direct effects of human activity on human pathology. We are producing a rich variety of changes in the air we breathe, the food we eat and the water we drink. New pollutants, especially those arising from cars in urban conditions contribute to respiratory disease. There is also evidence of different kinds of pollutants interacting with each other and multiplying their effects.

to Sustain?

2 Degradation of land and water:

Deterioration of the resource base

Increase in food supplies has not kept pace with the increase in population. Today, many of the problems are with distribution. But even countries generating food surpluses can see limits ahead. Application of biotechnology, itself with many problems attached to it, could never hope to meet likely shortfalls. Water shortages are increasing everywhere, and with them, increasing pollution of supply.

3 Atmospheric balance:

Climate change

This is much in the news and rightly so. Climate changes could alter the fundamentals on which human society is based. With more or less rainfall, more or less drought, more extreme events, and rises in sea level, the geography of human life would change, as it has so often changed in the past. 120,000 years ago, Trafalgar Square was the swampy home of hippopotamuses; 18,000 years ago it was tundra with mammoths, reindeer and sabre-toothed tigers; and 900 years ago it was on the edge of islands in the Thames estuary. The recent 'El Niño' phenomenon has well illustrated what vast changes can be caused by small perturbations in the climate system.

Cities are especially vulnerable to climatic change because they already have a somewhat artificial climate. Less greenery means less rainfall and transpiration of plants, and more absorption of radiation and higher temperatures. Buildings absorb heat and do not retain moisture so there is less evaporation. All this leads to what have been called urban heat islands: higher temperatures, less wind, lower humidity, more cloudiness, fogs and smogs.

4 Damage to other species:

Impact on biodiversity

Reduction of diversity affects food supplies (already heavily dependent on a few genetic strains) and medicine (heavily dependent on plant and animal sources). But more important are the ecological benefits: we rely on forests and vegetation to produce soil, to hold it together and regulate water supplies by preserving catchment basins, recharging ground water and buffering extreme conditions; we rely on soils to be fertile and to break down pollutants; and we rely on nutrients for recycling and disposal of waste. There is no conceivable substitute for the natural services, and all of them constitute parts of the urban support system.

As human actions affect the environment in which we live, so human society is evolving. Each of us can make our own list of what is most important, and where the relationships between environment and society, now and in the future, interact most strongly. Not surprisingly in our increasingly urban society, they are most evident in the character of our cities.

- Working patterns altered due to information technology: more work at home, less need to join the daily tides in and out of cities.

- The increasing dereliction of city centres. Clusters of huge concrete stalagmites are deeply oppressive to the spirit - perhaps the good mental health of citizens suggests that we should revert to the notion of city walls to preserve the coherence of urban life within, and to prevent the destruction of it from without.

- With urban decay has come the emptying of village life and the loss of local identity. Cities and villages alike are suffering from the intensive splitting effects of roads to carry our favourite and most convenient toy - the motor car.

- The greater polarisation of rich and poor both within countries and between them. With this has come the growth of less social and more commercial communities in which human activities have prices rather than values attached to them.

- The sometimes perverse effects of a complicated system of welfare benefits designed to assist the poor - or relatively poor - which creates distortions and inequities of its own.

Obviously these problems differ worldwide, and the emphasis varies. But the combination of change from without and from within creates a unique challenge, which sustainable development is, however crudely, designed to meet.

How can the construction

In February 1998, the British Government Panel on Sustainable Development took as one of its major themes 'the contribution of good architectural design and the use of materials to sustainable development.' The issues raised were:

- **Architectural Design**

Good architectural design pre-supposed fitness for the intended purpose; efficiency (sensible maintenance costs, long-lasting materials, affordable, environmentally-friendly heating and ventilation); and a positive contribution to existing landscape and quality of life. The work of architects and engineers has a massive impact on resource use: in particular energy. The construction industry is a vital element in policies to promote effective use of energy, materials and resources.

'The construction industry is a vital element in policies to promote effective use of energy, materials and resources'

- **New Technologies**

The Government should do more to encourage innovative technologies to raise standards throughout the industry, using such levers as the Best Practice and Energy Design Advice Scheme.

- **Energy Efficiency**

Greater energy efficiency in construction could make a significant contribution to the Government target of reducing carbon dioxide emission to 20% below 1990 levels by 2010. At present the Building Regulations on thermal efficiency lag behind those of many other countries.

industry contribute?

- **Use of Materials and Reduction of Waste**

The Government should include guidance on the use of recycled materials, and reduction and disposal of waste in construction.

- **Use of Economic Instruments**

The Panel recommended greater use of financial incentives and disincentives generally.

- **Revision of Building Regulations**

The Government should do more to bring all concerned into close and continuous working relationships, perhaps through the creation of consultative bodies whose terms of reference would be laid down in the Building Regulations.

The Government response to these recommendations was generally positive, and resulted in changes and progress, through the Building Regulations, the Construction Best Practice Programme, the imminent introduction of the Climate Change levy, the so-called 'carbon tax', and a number of other Government sponsored initiatives.

The Way Forward

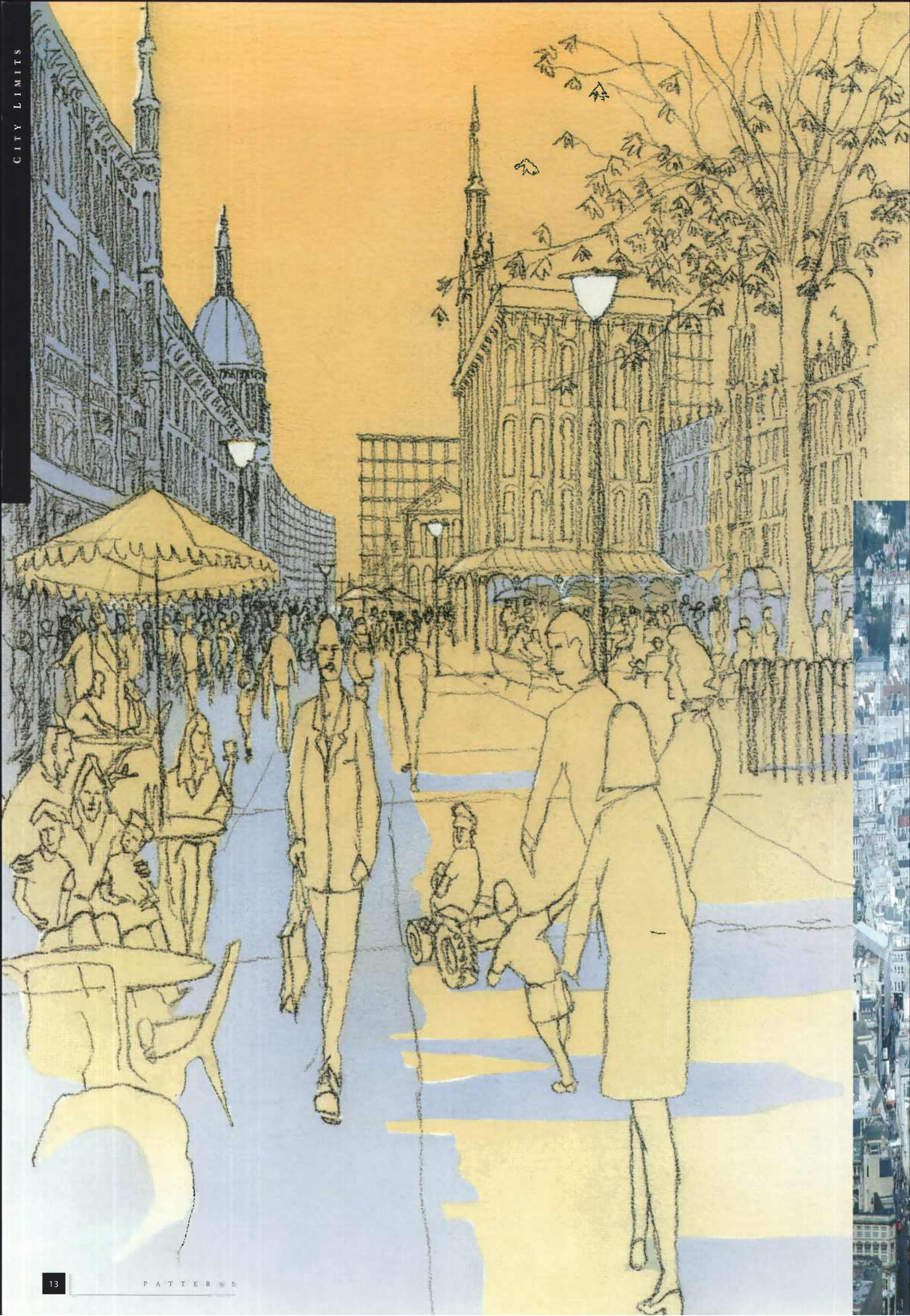
In conclusion, we can say that the building industry is as affected as any by the changes which are taking place around us, and the even greater changes that are to come. Under the pressures of population increase, degradation of soils, pollution of freshwater and salt, climate change, and destruction of the underpinning diversity of human life, the world may go a number of ways far beyond our capacity to predict. We have to recognise that human society has now reached a point where cities have grown out of control. Yet they continue to be enormously popular places to live.

All of us know that there is something wrong which could become more wrong if we did not look towards a different kind of city in the future. If the ants can work out the right size, character and function for their cities, we should be able to do the same for ours. The result, as Lord Rogers sees it, should be a pluralist city, a city of overlapping activity, an ecological city, a city of easy contact, an equitable city, an open city and not least a beautiful city in which art, architecture and landscape can move and satisfy the human spirit.

More generally, we also have to recognise the environmental constraints upon us. We need to move away from crude and unrealisable aims of limitless economic growth towards notions of a more friendly, more humane, more stable but still dynamic society in which human population, underlying resources and available sinks, and environment in the broad sense (including the good health of species and ecosystems other than our own) can come into the long-term balance. Success would be dependent on good will and effort at the local as well as the national level. It would require innovation from below as well as measures and well-meant guidance from above. For many it would mean a paradigm shift; away from the disposable towards the durable.

Another and more sinister way would be to await a series of natural catastrophes to force change upon us. Such catastrophes might not happen all at once but they would certainly be messy and contagious. There are signs of them here and there already. Surely we have to recognise that sooner or later Nature will win. The question is when and how? After more damage to our society, to life in general, and to the good health of the planet? Or in conformity with a redirection of human thought and endeavour? In my view it would be as well to be on the winning side from the start.

Edited by **Tanya Ross** from the First Happold Medal Lecture published by the Construction Industry Council, written and presented by **Sir Crispin Tickell GCMG KCVO** on 4th November 1998. Reproduced with permission.



Sustainability issues have seen a shift in our approach to designing the city, particularly with respect to how we view our existing cities. **Jeremy Caulton** looks at some current issues in urban planning.

City Limits

Regeneration

Following revitalisation in the sixties, renewal in the seventies and redevelopment in the eighties, we are currently experiencing a regeneration phase. The nineties focused on regeneration as a more holistic - and hence sustainable - process of reversing economic, social and physical decay in our towns and cities.

The emphasis, focusing regeneration on the centre of our towns and cities, has two drivers: to promote a 'ripple effect' across surrounding areas, and to counter the attention paid to fringe and edge of town locations over the 1980s. According to Bill Hillier (urban planner and author of 'Space is the Machine', Cambridge University Press, 1996), growing urban systems must respond to the paradox of centrality, simply because if you try to maximise internal integration, then you lose external integration, and vice versa. Urban forms need both internal and external integration to function successfully.

Traditionally our town and city centres were social foci, achieved through an organic mix of functions: offering shopping, the market place, an arts, cultural and entertainment venue, a business centre, a transport hub and a place to live and visit. They are where traditionally a wide range of needs are met in a single visit. However, with changing technologies and development pressure, the trend for British towns over the last century has been one of shifting emphasis, from centre to edge. The result, based on Hilliers' preposition, was the loss of internal integration, so resulting in the decline of our centres. This is not unique to Britain. It is a phenomenon now being experienced across the western world.

The decline of the city centre has been further reinforced as property owners adjusted to new market conditions by lowering rents and changing uses. Falling land values made sites ripe for conversion or redevelopment, gradually altering centre functions. Improved access to edge-of-town and out-of-town locations saw the shift of city-centre functions outwards as a result. For some developers it was easier to 'start afresh' than face the battle against site assembly or planning issues. Reversing this trend has not been easy, raising many questions in the process: what function should our centres now be performing? How can they maintain their health to attract shoppers, users, visitors and investors? The urban renaissance may be suggesting that they are re-marketed as places to live, but in order to fulfil the complete functions of a centre they need to succeed in wider social, economic and physical terms. As a result, town centre regeneration has focussed on three principles; attraction, access and amenity.

Government Initiatives

Following the Earth Summit in Rio in 1992, the UK Government was bound to take a lead in reviving our town and city centres. The sustainability agenda saw the re-promotion of centres as 'places where people want to live, work, play and invest' according to the Richard Rogers led Urban Task Force in 1998. This has been interpreted by many as the restoration and recreation of traditional 'classical' urban values and fabric following on from the American urbanist movement imported into the UK in the early 1990s.

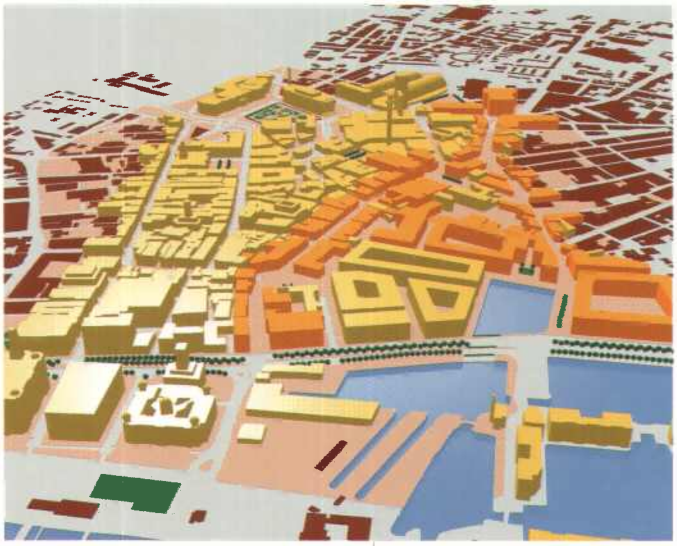
The Government took the lead with policies that were to start the revival of our centres. Planning Policy Guidance Note 1 (PPG1) in 1992 (revised in 1996) placed emphasis on sustainable development through the mixed-use agenda and the importance of high quality design. PPG6 followed, aimed at halting the decline of centres and reducing the reliance upon the car. Its basis was a series of sequential tests to assess edge and out-of-town developments to stop the decanting of uses from the town centre. The policy actively sought development of strategies to encourage investment into upgrading existing buildings

LIVERPOOL CITY CENTRE CONCEPT:

THE CATALYTIC EFFECT OF FOCUSING ON THE CITY CENTRE

THE **'LIVERPOOL VISION'** IMAGES ON THIS SPREAD WERE GENERATED BY BURO HAPPOLD'S URBAN PROJECTS GROUP AS PART OF A SHORT-LIST SUBMISSION

and provide quality new development. The emphasis was on town centre vitality and viability. PPG13 (first issued in 1994) sought to reduce travel by fostering development in locations already well served by public transport (usually the town centre) and by revitalising traditional urban centres by improving their attractiveness to the user and investor. It pushed the button on access and the integration of land use and transport planning, reducing both the number and length of journeys in the interest of sustainable development. Current trends have been to encourage modal shift with emphasis given to access to development by public transport, cycling and walking. The town centre fits neatly into this category.



LIVERPOOL CITY CENTRE:

REPAIRING THE ORIGINAL CITY STRUCTURE

Too many city centre schemes have failed in recent years, particularly those that have embraced the shopping mall as 'internalised' high streets. Current approaches, following traditionalist urban values, assume that successful places are equally attractive to those who live and work in them, as they are to visitors and investors. Development which creates lively places and makes spaces that are safe, accessible and pleasant to use, naturally tend to create the conditions for a flourishing economic life.

Measures of Success

Of course, the success of this approach cannot be measured immediately. It is the nature of urban planning that the benefits are not perceived for years, perhaps even decades. But certainly the initial feedback from the Liverpool Vision scheme (see Case Study opposite) and others, has been positive, and the principles applied are to be used as a model for future urban regeneration projects.

What we have learnt from the process, is that, with an enlightened client and a positive vision,

> 'a more sustainable approach to urban regeneration is achievable'

and implementable - now we have to wait and see if the practice matches the theory.

Jeremy Caulton is Group Manager, Buro Happold Urban Projects Group

City Limits
Case Study

Liverpool Vision

Liverpool Vision (a first round Urban Regeneration Company) was mandated to regenerate Liverpool's city centre. Its objectives included.

- Drawing investment into the commercial office sector.
- Re-establishing Liverpool as a regional shopping location.
- Increasing tourism and visitor profiles by extending the range of leisure activities.
- Creating a high quality, well-managed and safe public realm.
- Improving appearance of city gateways and connections.
- Repopulating the city core and surrounding neighbourhood as places to live, work and shop.
- Preparing a long term, financially prudent development plan that can be co-ordinated and managed by a dedicated team.

These all had the single goal of sustainable regeneration of the city centre. Liverpool Vision sought early success within a long-term strategy focusing on:

- revitalising the city centre with focused initiatives;
- redefining the city centre through quality environments linked by a series of spaces;
- different scales of intervention in different parts of the city;
- brokering urban change management through Liverpool Vision.

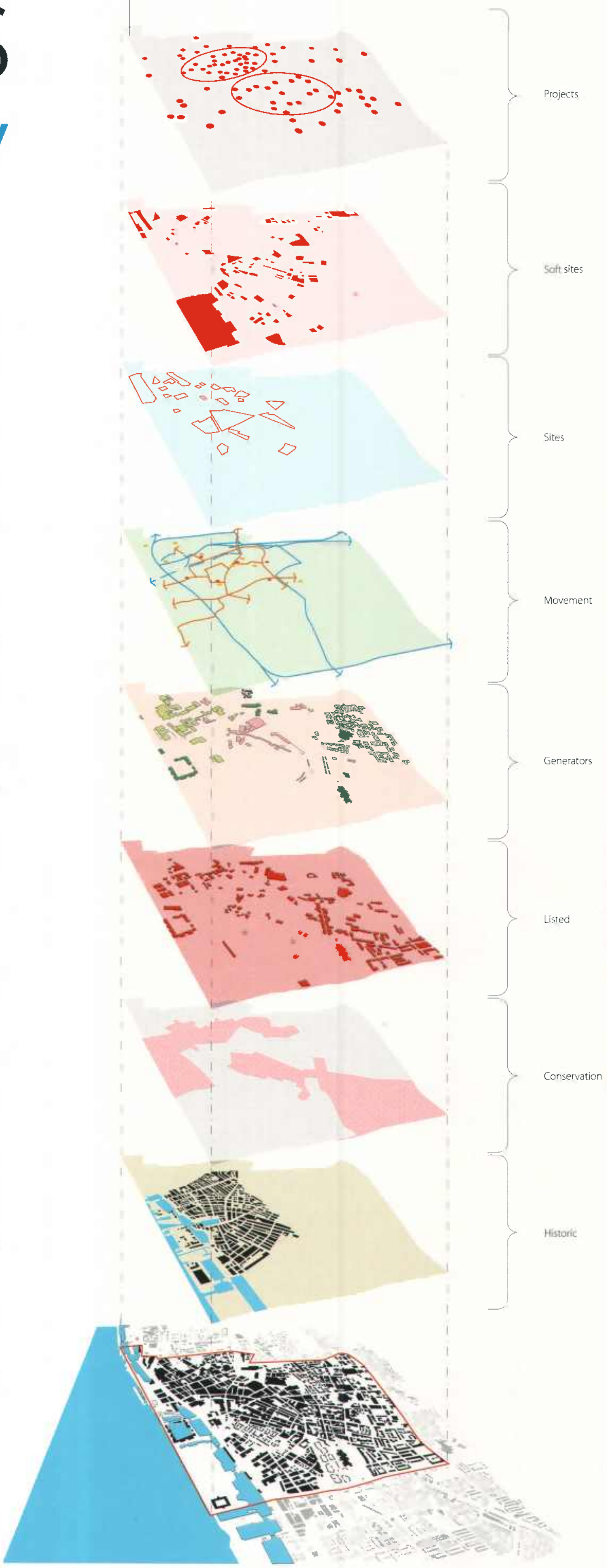
Antoine Grumbach, master-planner from Paris, coined the well-known phrase 'building the city upon the city'. This is how the development of Buro Happold's masterplan proposal was approached, ensuring the city was reworked to accommodate change rather than be rebuilt:

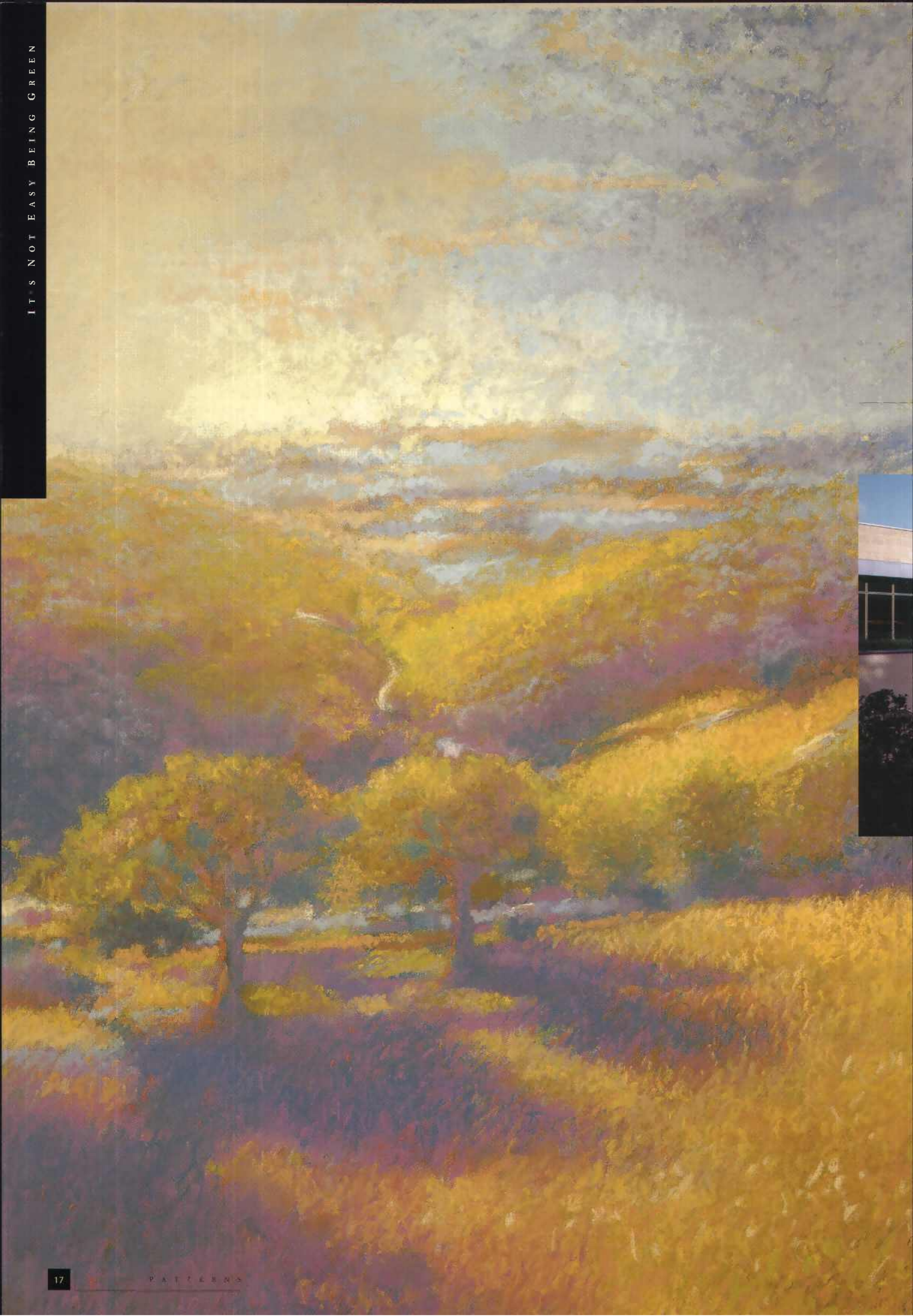
- to demolish as little as possible, restoring and refurbishing sensitively;
- to commission exemplary modern buildings on gap sites;
- to improve cross-connections using historic models;
- to encourage modal shift away from the car;
- to revisit city gateways and the environment of the public realm.

The intention was to prioritise certain centre sectors ensuring incremental renewal with the endorsement of end users, developers and city managers.

LIVERPOOL CITY CENTRE:

LIVERPOOL CITY CENTRE
OVERLAYING AREAS OF 'OPPORTUNITY'





Tony McLaughlin explains some of the difficulties in greening the blue chips: implementing sustainable strategies in a commercial marketplace.

It's not easy being **Green**

Architect: Bennetts Associates Construction Managers: MACE

WESSEX WATER OPERATIONS CENTRE, BATH

Nelson Riddle wrote a song entitled 'It's not easy being green'. Now the song has nothing whatsoever to do with environmental issues, but for those of us trying to promote the environmental agenda in design, the title has a ring of truth. So-called 'green issues' have arrived in construction and they are not going to go away. They include real global problems yet present great design and commercial opportunities.

More than ever, we need to understand issues such as:

- **where do our building materials come from?**
- **how deep is the resource that supplies it?**
- **is there a replacement programme?**
- **how much energy does it take to transform it from its raw state to the building product used in the construction process?**

Knowledge of materials, of energy use and of the construction process have become the cornerstones of 'sustainable building science'. Energy resources need to be considered right through the building cycle - from construction to operations and decommissioning. These are real social issues, which have far-reaching impact, and yet have to be balanced with aesthetics and corporate image.

It may be easier for designers to take on board the sustainability issues than for the eventual end-users. We deal with the blue-print, they live with the reality for the building's lifetime. Clients have to live with the consequences of the 'greening' process, which can have a direct impact on their daily operation.

Air-conditioning, like the motor vehicle, is a wonderful invention; it's a pity about the side-effects.

WESSEX WATER HEADQUARTERS:

NORTH FACING ENTRANCE ELEVATION

Photography by Mandy Reynolds/Fotoforum

Air Conditioning - a necessary evil?

In a building designed passively to avoid the need for air conditioning, a percentage of the workforce may perceive the difference and react quite dramatically - this may not be acceptable to some organisations. Perhaps if air conditioning did not consume energy and pollute our fragile ecosystems, we would be putting it into all our buildings as a matter of course. Just imagine, opening the windows and leaving the air conditioning on! Like the motor vehicle, air conditioning is 'a wonderful invention - it's a pity about the side effects.' The inescapable truth is that it consumes energy - and great amounts of it too - from a continually declining resource. In the past some of our large blue chip companies have equated prestige to air conditioning, egged on by letting agents. (We've seen the advertising hoardings: 'Prestigious building, top quality, full air conditioning...'). But the rules are changing, albeit slowly, and these organisations are realising that 'green' credentials can also make good business sense. In some cases shareholders are actively demanding it.

Wessex Water's New Operations Centre in Bath is a case in point. Here we have a client whose brief was environmentally inspirational - the company wanted its building to be at the forefront of sustainable design, contemporary in style and provide a good working environment. As a successful water utility company whose customers demand environmental responsibility in the product it delivers (i.e. clean water), Wessex Water promised that it would support the whole team in their sustainable objectives. Wessex Water reinforced its commitment in its annual report 'Striking the Balance' and employed the services of Jonathon Porritt of Friends of the Earth and 'Forum For the Future' to act as an adviser - here we had a company prepared to practice what it preached.

WEST FACING MEETING ROOMS:

INTERNAL SHADING IS EMPLOYED TO REDUCE IMPACT OF LOW LEVEL AFTERNOON SUN

LANDSCAPED COURTYARDS:

COURTYARDS AND GROUNDS, DESIGNED BY LANDSCAPE ARCHITECTS GRANT ASSOCIATES AND BERNARD EDE, PROVIDE PLEASANT 'BREAK-OUT' SPACES

It was heartening to find that Wessex Water's beliefs and ambitions were truly reflected in the working brief to the architects and engineers for the new building. Free from commercial jargon, Chief Executive Colin Skellett stated in clear, simple terms the aspirations for the new Operations Centre, under five headings:

- **Image and aspirations**
- **Management culture**
- **Construction**
- **Context**
- **Energy**

' Our pursuit of sustainability is also guided by holistic principles. The environment is not something out there, green and lush or dirty and damaged, but indivisible from ourselves and everything we do '

Colin Skellett

CHIEF EXECUTIVE WESSEX WATER

FROM THE BREIF TO THE DESIGN TEAM

SOLAR HEATING:

SOME OF THE ARRAYS OF SOLAR HEATING ELEMENTS ON THE ROOF

VIEW ALONG SOUTH-FACING ELEVATION:

A COMBINATION OF HORIZONTAL AND VERTICAL SHADING ELEMENTS LIMIT SOLAR GAIN WITHOUT DETRACTING FROM THE VIEW

MAIN CIRCULATION SPACE:

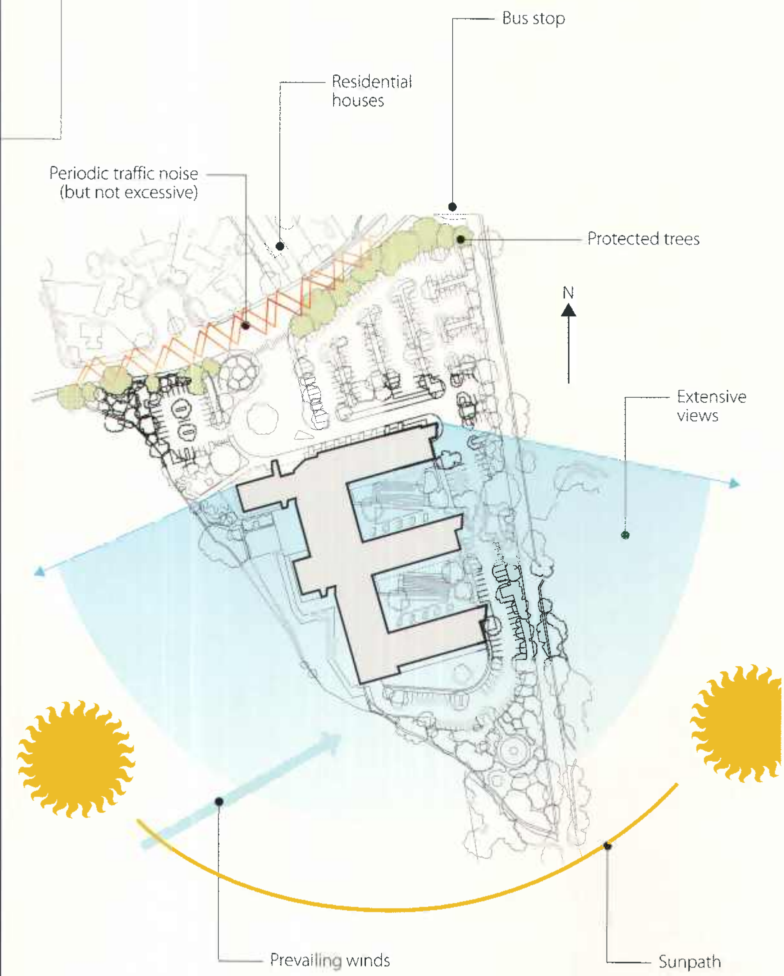
CENTRAL 'STREET' STEPS DOWN THROUGH THE BUILDING

TYPICAL OPEN PLAN OFFICE SPACE:

INTEGRATED STRUCTURE AND SERVICES

It's not easy being

Design Realisation

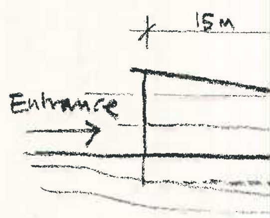


WESSEX WATER OPERATIONS CENTRE:

SITE ANALYSIS

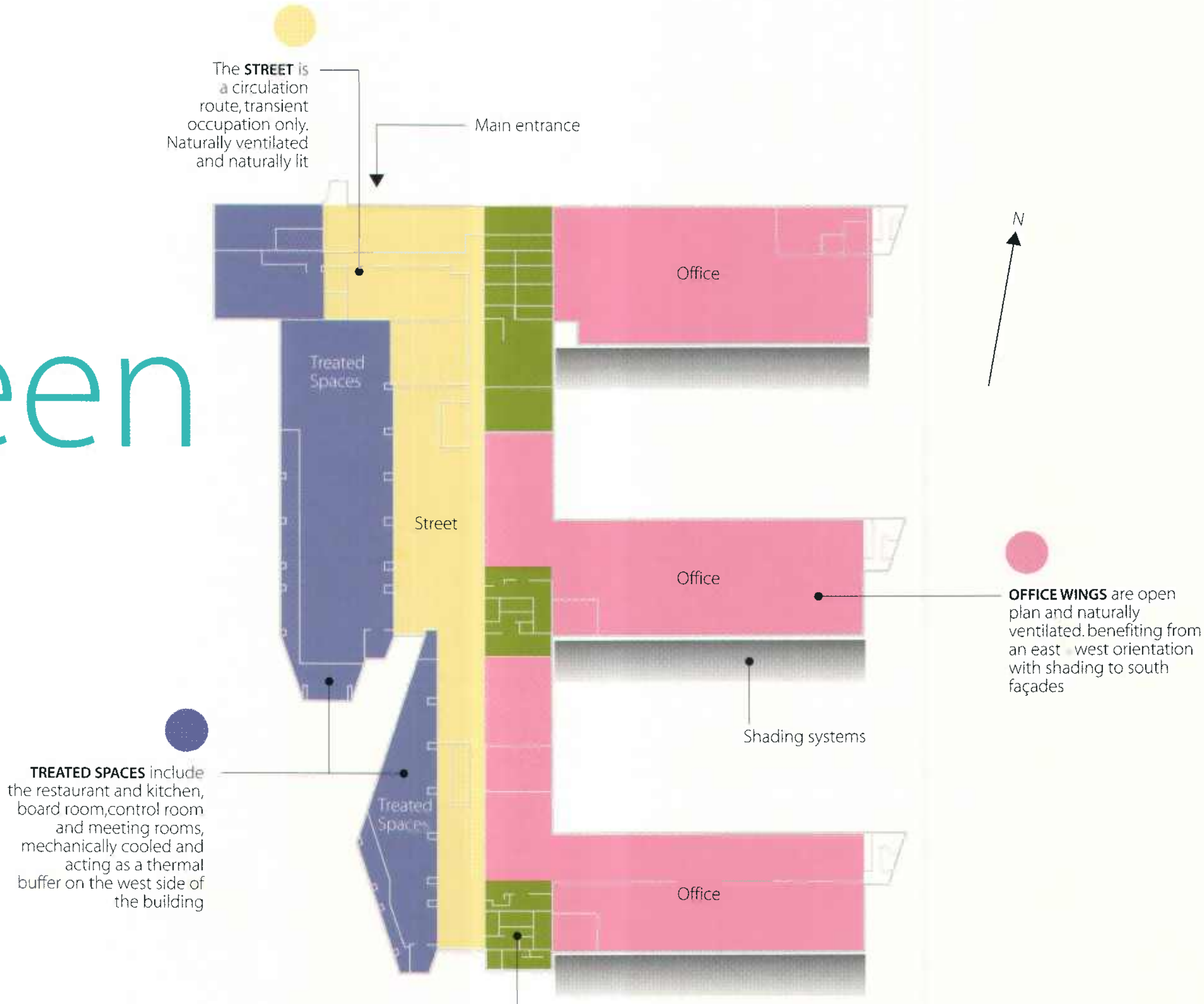
Bennetts Associates as architects, Buro Happold as engineers and MACE acting as Construction Manager were collectively no strangers to a 'green' brief. The team quickly set to work, examining the selected brown field site (formerly a hospital), on the south-eastern edge of the City of Bath. Surrounded by farmland, with a southerly slope overlooking an attractive valley, edged with minor roads, this was the perfect setting for an environmentally responsible building. Traffic noise was not a serious issue, and the southerly slope could be utilised to encourage wind movement through the development. The resulting design is a predominately naturally ventilated building with exposed thermal mass, a night cooling regime, solar water heating, condensing boilers, rainwater / grey water recycling systems, external shading, artificial lighting linked to occupancy and natural lighting levels and high levels of thermal insulation.

Even with this site and the strong brief from Wessex Water, it was impossible to totally remove the need for mechanical cooling: control rooms and computer rooms with high heat loads were essential for daily operations. As a result, the building plan is organised so that the mechanically cooled and intermittently occupied rooms are placed on the western side, shielding the more sensitive naturally ventilated open-plan office space. The office wings are planned on an east / west axis, so that solar gain on the façade is minimised, i.e. the glazed elevations face north and south. Coincidentally, this allows the building users to take advantage of southerly views and the prevailing south-westerly winds to drive the natural cross-ventilation.



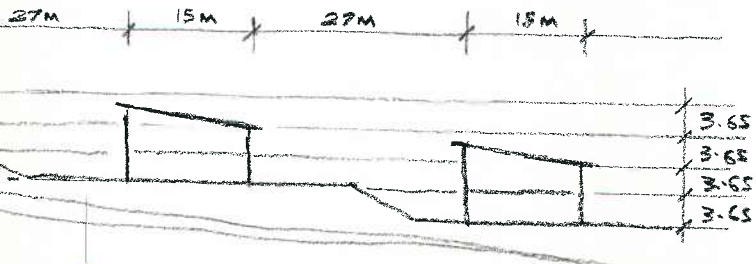
The building represents the first use of Recycled Aggregate Concrete (RAC) in a major UK commercial structure. Including other recycled components such as pulverised fuel ash (PFA), the concrete contained approximately 25% recycled materials by weight, a significant reduction of virgin material in the structural frame.

green



WESSEX WATER OPERATIONS CENTRE:

GROUND FLOOR PLAN SHOWING ZONING



WESSEX WATER OPERATIONS CENTRE:

SCHEMATIC SECTION THROUGH SITE LOOKING EAST

A desire to limit the amount of excavation needed to be balanced with the ideal building orientation, with orientation acknowledged as a more significant factor in the final analysis. In addition, on-site initiatives operated by MACE, included a minimum building waste control system.

WEST ELEVATION:

FAÇADE SHADED BY DEEP OVERHANG

RECEPTION AREA:

SPACE AND TRANSPARENCY ENCOURAGES PUBLIC ACCESS

WESSEX WATER OPERATIONS CENTRE:

COMPUTER GENERATED IMAGE OF THE COFFERED CONCRETE CEILING STRUCTURE

Selling the Design

The greatest area of concern regarding naturally ventilated spaces is their performance on hot summer days. To address this concern it is first necessary to understand the principle of thermal comfort. There is a definition of comfort:

> 'that condition of mind in which satisfaction is expressed with the thermal environment'

but this fails to recognise the highly subjective element: no single environment will be judged satisfactory by all its users, even if they are doing the same activity and wearing the same clothes. Various learned professionals have sought to derive a formula for use in building design, the most successful being those of Professor Fanger, of Oslo University, who developed the widely used comfort criteria described in ISO 7330. However his work is only relevant to highly controlled buildings, and is not sufficiently adaptable to manage openable windows. So the task of 'selling' the concept of comfort can become a complex one in itself.

The client asks if it is going to be warm in the building during the hot summer days. The answer of course is not a simple 'yes' or 'no' and needs to be qualified with weather data, statistical frequencies, assumptions on working patterns, maintenance regimes... If not handled carefully, this can be the downfall of a low energy, naturally ventilated scheme at the early stages. Which brings me back to the title of a certain Nelson Riddle song!

At the Wessex Water Operations Centre we chose 'resultant temperature' as our measurement of comfort, evaluating the frequency of high temperature events so that the client could understand the risk involved. Resultant temperature takes into consideration the radiation element as well as the more obvious air temperature. To illustrate, the air temperature within an old church in Florence may be the same as outside, but the massive stone walls (cooled over the previous night) will be acting like a cold radiator, drawing heat from the occupants by radiant exchange. It is therefore feasible to have resultant temperatures that are lower than external air temperatures. For this reason, our design is concerned with exposing the thermal mass of the concrete structure, and with using night ventilation of the building to cool this concrete ready for the next working day. The concrete mass acts as a sponge, absorbing the heat gain during the day and then being drained of this heat by cooler air at night.

Perhaps the real test was when Wessex Water staff moved from air conditioned offices in Bristol and Bath to their new hilltop abode. The environmental tools were in place, so the facilities management team played an important role in the staff perception of the building's performance. They needed to educate the staff in the use of the systems, patiently explaining the issues and overcoming any commissioning niggles, doing so in a structured and transparent way.

WESSEX WATER OPERATIONS CENTRE:

THE 'STREET' PROVIDES GENEROUS CIRCULATION SPACE AS WELL AS A POPULAR PLACE TO MEET WITH COLLEAGUES

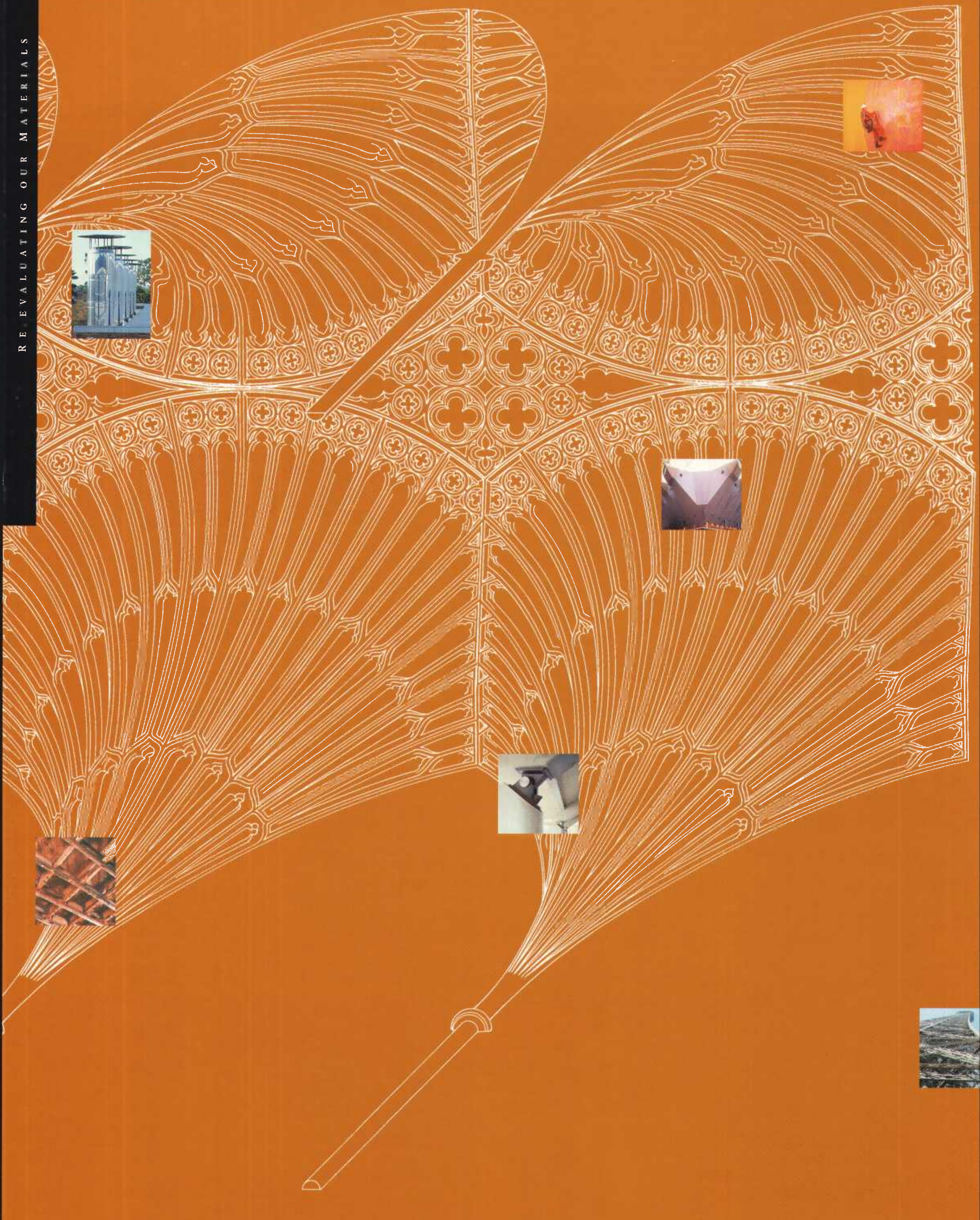
Missed Opportunities?

There are of course many other aspects that have contributed to the success of the Wessex Water project. There are also, perhaps, some missed opportunities. Studies into the use of photovoltaic arrays revealed a 'pay-back' of 30 years, deemed uneconomic (although space provision has been allowed for retro-fitting should this situation change) and the possibility of utilising bore hole water for cooling was rejected because of cost and risk. The results of these two studies are not surprising, but it is disappointing that such technologies are still beyond the practical reach of even an enlightened large company. There is a point beyond which it is unreasonable to expect larger companies to act as 'environmental angels', although it is only through the application of these 'high-risk' schemes, that the industry receives feedback on their effectiveness, and can explore ways to improve their performance. Progress in the building industry requires knowledge of the past.

Excellent!

As a client Wessex Water has been rewarded for its environmental stance. The design has been given an 'Excellent' BREEAM rating (Building Research Establishment Environmental Assessment Method) using the revised methodology, published in 1999. The project is also one of the M4I (Movement for Innovation) study projects examining the way we procure our buildings, team relationships, working practices and sustainable issues. It has been a learning process for all the designers involved, and occasionally a struggle to maintain the sustainable agenda, but it has been rewarding to see the positive coverage the building has received, and it is to be hoped that it becomes a benchmark for future developments. Being green may not be easy - but it's immensely satisfying.

Tony McLaughlin is a Partner of Buro Happold



Materials

From the days when man first laid stone upon stone to create a shelter,  construction materials have been wrested from the earth and transmogrified with varying degrees of effort to  form building components. The way we use these precious natural resources is changing as the construction industry strives to **reduce** waste and utilise more efficient means to translate raw material into finished product.  Many worthwhile initiatives are being pursued: **rediscovery** of stone as an 'unprocessed' building material; the use of crushed concrete  and industrial by-products as aggregates; **revival** of lime mortar as a jointing medium and the **recycling** of steel members to name but a few. The two following articles describe perhaps opposite ends of the materials spectrum: new ways of using timber - a traditional material,  and the possibilities for introducing new 'artificial' materials into buildings.

A Timber Renaissance

Three good reasons to use timber as a sustainable construction material.

James Rowe puts the case for wood

A RENEWABLE RESOURCE:

TIMBER BEARING THE FSC STAMP IS GUARANTEED TO HAVE BEEN SOURCED FROM FORESTS THAT ARE MANAGED SUSTAINABLY

1 A renewable resource

Timber is a genuinely renewable material - so long as the rates of felling and planting are kept in balance it is possible to keep a supply of timber in perpetuity. Whilst there are many concerns about the rate of depletion of natural rainforests, particularly in South America and Asia, there are global initiatives underway in the forestry industry to limit stock erosion by controlling trade higher up the supply chain. One of these is the certification scheme by the Forestry Stewardship Council (FSC). A measure of the success of the system is that it is now possible to buy tropical hardwoods such as iroko and greenheart that bear the FSC stamp. The more that specifiers demand this certification, the harder it will become to find profitable outlets for timber produced by the clear-felling of large areas of forest.

2 Low Embodied Energy

The energy embodied in timber is low in comparison to other common structural materials. In particular, the conversion from standing tree to structural element involves no high temperature processes such as smelting or firing. The energy is consumed in felling and transportation to the saw mills which are increasingly mechanised production lines. Most plants in Europe use waste wood as the fuel to produce significant quantities of the energy required for their operation.

3 Fully Biodegradable

Putting aside for the moment the question of how timber is treated to inhibit rot, wood is a natural and fully biodegradable material. It is possible to dispose of timber at the end of its useful service life in any number of environmentally sound ways. It can be buried, in which case it forms a compost, or it can be burned. Although burning will produce carbon dioxide, it can only ever produce the same amount as the parent tree absorbed during its life.

There are important caveats to all of these points. Clearly, if the rate of felling exceeds the rate of regeneration, none of these benefits can be genuinely realised and the supply is not sustainable. It is vital that end users demand information about the management of the forestry at its source, and actively support certification schemes.

Energy costs associated with transport and distribution can double the embodied energy figure. 85% of the timber used in the UK is imported: sawn softwood from Canada or Scandinavia is no more expensive and also often of higher quality than the home produced equivalent. The global market place effectively fixes the global price, and it is therefore hard to justify buying British, despite the obvious energy benefits.

Perhaps the most important caveat concerns the issue of timber treatment. The most effective preservative method, from the point of view of minimising the risk of rot and infestation during service, is CCA treatment, often described as tannalising. CCA stands for Copper Chrome Arsenic. The copper and arsenic act as agents that make the timber poisonous to the organisms that attack wood, and the chrome acts as a fixative to prevent them from leaching out. However, in terms of the toxicity that is thereby locked into the

> ‘It is very satisfying that a material that has shown itself to be so well suited to the buildings of the last millennium should be revealed to be, for very different reasons, perfect for one of the first buildings of the next.’

Mandy Reynolds/Fotoforum

Architect: Pentagram Design Limited

Mandy Reynolds/Fotoforum

Architect: Pentagram Design Limited

INTERNATIONAL SHAKESPEARE GLOBE CENTRE:

ROOF DETAIL

material, they completely alter the life-cycle benefits of using timber. Timber thus treated can only be buried in engineered waste tips, it cannot be burned as it will give off poisonous fumes and leave toxic residue. There are also concerns that if the cocktail of the three chemicals is not exactly right there is the possibility of toxins leaching out in service, and there are health risks both to the users and to the carpenters working with the timber. In many instances, the use of such treatment is simply not necessary; protection can be achieved by good detailing rather than chemical treatment. However, we need to have a thorough understanding of the issues involved and the alternative forms of specification available in order to have the confidence to eliminate such treatment.

Putting the case

Three recent projects

International Shakespeare Globe Centre (1988 - 1995)

The Globe Theatre is a reconstruction of Shakespeare's original theatre on London's South Bank, between Southwark and Blackfriars Bridges. It was constructed using 16th Century building techniques and materials, working within local supply chains and traditional non-mechanised production processes. In that period, the only timber used in any quantity in construction was oak. Oak was, and remains, in plentiful supply in England and the North of France. By using oak, it was inevitable that the timber would come from forests within a few hundred miles of the building.

The traditional carpentry techniques required careful hand-working by carpenters rather than large scale machining: this reduced the energy embodied in the processing whilst providing employment to skilled craftsmen. The main reason for using oak, both then and now, is that it is naturally resistant to rot and wood beetle. As an oak tree grows, it deposits tannin in the main body of the trunk; this acts as a natural protection against the fungi and insects that attack timber. And, of course, all the constructional details were in the highly evolved language of mediaeval timber framing, with the craftman's inherent appreciation of how to make joints that shed (rather than trap) the water that the organisms that cause rot require to thrive.

INTERNATIONAL SHAKESPEARE GLOBE CENTRE:

16TH CENTURY BUILDING MATERIALS AND TECHNIQUES

Mandy Reynolds/Fotoforum

Architect: Pentagram Design Limited

Hooke Park (1985 - 2001)

At the School for Woodland Enterprise at Hooke Park, Dorset, the brief is to find innovative ways to use low grade spruce thinnings. Thinnings are the smaller trees that must be removed from a stand of trees in order to maximise the yield of the final crop. Because they are small (less than 200mm in diameter at breast height), they are of little use to saw mills, and have virtually no commercial value. They are structurally adequate, the challenge being to find new ways to use them as a building

HOOKE PARK WORKSHOP:

USING THE FLEXIBILITY OF YOUNG TREES TO FORM A STRUCTURAL FRAME IN TENSION

Architect: Ahrends Burton and Koralek with Frei Otto

INTERNATIONAL SHAKESPEARE GLOBE CENTRE:

THE DESIGN OF THE THEATRE WAS BASED ON ARCHAELOGICAL EVIDENCE AND PRECEDENT

HOOKE PARK, WESTMINSTER LODGE:

USING ROUNDWOOD AS A STRUCTURAL FRAME

Architect: Edward Cullinan Architects

for wood

Architect: Ahrends Burton and Koralek

HOOKE PARK, THE PROTOTYPE HOUSE:

STRENGTH IN TENSION

block, with the minimum amount of processing possible - namely by using them in their natural round state. Each building has sought to investigate a different aspect of the mechanical properties of the thinnings.

Being young softwood trees (about 25 years old), they are particularly vulnerable to rot and require treatment, immersion in boron salt, while still green. Boron salt is much less toxic than CCA, but is soluble in water and can be washed out by rain. The timbers therefore have been detailed to be internal or well sheltered to avoid rain penetration. Because the buildings are constructed from trees taken from the forest surrounding them, and because they are almost entirely unprocessed, the energy embodied in the structure is negligible.

Weald and Downland Museum (1999-2001)

The Conservation Workshop at the Weald and Downland Museum, is dedicated to rescuing the vernacular timber framed buildings of the Sussex Downs, which are dismantled, repaired and reassembled in the grounds. Because of the nature of the Museum, great importance has been attached to making the best use of traditional carpentry skills, and carpenters have been consulted throughout the evolution of the design. However, the museum wanted to produce a building that did not show these skills to be mere historical curiosities: the understanding of the material that is demonstrated by all the buildings that the museum owns is just as relevant to modern buildings, as it is to very old ones.

Architect: Edward Cullinan Architects

WEALD & DOWNLAND MUSEUM CONSERVATION WORKSHOP:

AN ELEGANT BLENDING OF THE CRAFTSMAN'S UNDERSTANDING OF JOINERY AND THE BEHAVIOUR OF TIMBERS WITH THE SOPHISTICATED ENGINEERING OF SHELL STRUCTURES

The building that has evolved is a timber gridshell - a lattice structure of very thin laths of oak. The laths, 50mm wide and 35mm thick, are laid out flat as a regular array to form a grid of timbers spaced a metre apart. The laths are bolted together at the intersections, and the whole mat, 50m long and 20m wide, is lifted into the air and slowly deformed into the shape of three connecting domes. The structure is braced by horizontal members, which also receive the cladding, and then clamped at its boundaries. In this way, it is possible to take the loads on the building in direct compression in the laths, which means that the structure can be very lightweight, thereby using a very small amount of timber when compared to a conventional building. The research and testing carried out during the design has identified a very interesting property of oak in addition to its durability: compared to other species it is not only strong, but also flexible, demonstrating a degree of plasticity that is the central requirement of all good engineering materials, and is ideally suited for the construction of a grid-shell. It is very satisfying that a material that has shown itself to be so well suited to the buildings of the last millennium should be revealed to be, for very different reasons, perfect for one of the first buildings of the next.

James Rowe is a Senior Structural Engineer with Buro Happold

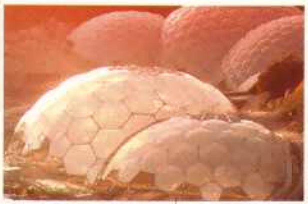
Construction, responsible for a large section of the global 'take' of raw materials, results in huge amounts of waste. Design must be carried out responsibly, using whichever material best meets the brief with minimum impact on the environment. **Dr Andrew Cripps** explains.

A Material Difference

Three materials have recently emerged as alternatives to familiar building components:

1 ETFE Foil Cushions

ETFE foil cushions consist of a cushion of air held between layers of the material ETFE (EthylTetraFlouroEthylene), a polymeric material related to Teflon. It has been used in a growing number of buildings in the last ten years, from tennis centres to hospitals as well as in a large number of recently-completed lottery-funded projects.



ETFE FOIL CUSHIONS: THE EDEN PROJECT, CORNWALL

WESTBOROUGH SCHOOL, ESSEX: THE AIM OF THIS PROJECT IS TO PRODUCE A USEFUL BUILDING WITH THE OPTIMUM USE OF CARDBOARD

In order to develop an understanding of the potential benefits and disadvantages of the use of ETFE foil cushions, basic properties of the material have been analysed, data has been gathered about the production process, and a comparison has been made with its main rival: glass. The work shows that ETFE can be a very useful material for use in the right circumstances, especially overhead sky-light / atria situations, where its low weight, good thermal properties and high solar radiation transmission including light transparency, are of most value.

A swimming pool roof is an ideal application, but glass may offer better characteristics where clear vision is required, or damage is likely from people.

ETFE FOIL CUSHIONS: THE ROOF OF THE SECOND SCHLUMBERGER BUILDING, CAMBRIDGE, UK

2 Cardboard

People think of cardboard as a disposable, short life packaging material with poor properties. In reality it can perform very well over an extended period if it is designed correctly and treated properly. It is also made from a waste product for which there are few alternative uses - paper. There are already several common uses of cardboard in construction: doors are filled with a cardboard honey-comb; tubes are used for column forming and as pile sleeves; panels are widely used in temporary structures.

Two large scale but short lifetime buildings have been successfully completed: the Shared Ground Exhibit at the Millennium Dome (where Blue Peter viewers supplied the cardboard to be recycled into structural elements), and the Japan Pavilion for the Hanover Expo 2000. At Westborough School in Essex, we wanted to develop something more modest, but with a longer useful life. Together with architects and manufacturers, a specification for cardboard panels and tubes has been developed which combine to offer a realistic design for a single classroom, to be used as an after school club and general classroom space. To deal with water and the risk of fire, the coatings method is preferred to additives, as it allows easier future recycling of the materials at the end of the building life. The project is a good example of a highly collaborative team development.

LARGE SCALE CARDBOARD CONSTRUCTION:
THE JAPAN PAVILLION AT HANOVER EXPO 2000

Adam Wilson
Architect: Shigeru Ban Architect

Architect: Cottrell and Vermeulen

3 Polymer Composites

There are a number of negative environmental impacts that result from the manufacture and use of polymer composites, but positive outcomes from using them in the correct situations. Examples include Glass Fibre Reinforced Plastic (GRP) used as cladding at the Rest and Body Zones in the Millennium Dome, strengthening of beams and bridges to allow increased loads to be carried and as protection against hostile environments, particularly in seawater. These materials dominate some other industrial sectors, particularly boats, aerospace and racing cars, where weight and strength matter more than cost. There are appropriate applications in building, and this ongoing research project is setting out to identify these and develop user confidence in them.

Mandy Reynolds/Fotoforum
Architect: Richard Rogers Partnership

GLASS FIBRE REINFORCED PLASTIC:
THE REST ZONE AT THE MILLENNIUM DOME

Mandy Reynolds/Fotoforum
Architect: Branson Coates Architects

GLASS FIBRE REINFORCED PLASTIC:
THE BODY ZONE AT THE MILLENNIUM DOME

Dr Andrew Cripps is in charge of Research, Development and Innovation activities at Buro Happold

The search for alternatives to fossil fuels is not new, but it is perhaps only in the last decade with dire warnings of climate change and once distant dates for supply exhaustion now imminently looming, that the technology is beginning to be taken seriously and come into mainstream use.

On the following pages, we give an outline of the variety of 'renewable' sources on offer, as well as examining in more detail the evolution of one such technology - photovoltaics - from hippy periphery to pragmatic use.

All the sources of energy on Earth are ultimately derived from the Sun's energy, or from gravity. Our current rate of consumption of energy is unsustainable as it far exceeds the rate of regeneration.

Doug King looks at renewable energy sources - those that are self-regenerating in the short term because the sun or gravity will continue to provide their energy for the foreseeable future.

Energy alternatives

The power density of solar and wind energy is not high and availability is very variable - typically the power that can be extracted from a given area of land is one to two orders of magnitude lower for renewable generation than for conventional power generation. The benefits of renewable generation, in terms of less environmental damage, and comfortable co-existence with established land uses, is an enormous motivation to pursue the alternative technologies.

Renewable energy generation in the UK has more than doubled since 1990 and currently produces about 2% of UK energy. Government initiatives to encourage more schemes have contributed to the fall of wind energy prices for example, from 11 p/kWh to 3.1 p/kWh and landfill gas prices from 5.7 p/kWh to 2.9 p/kWh. There has also been a real reduction in both capital and operating costs associated with the projects, and it is to be hoped that these will continue to encourage further development.

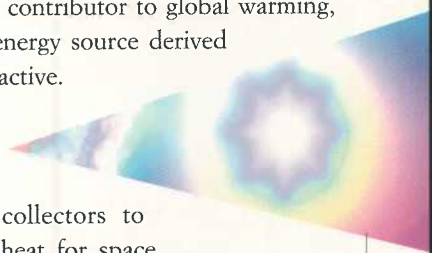
Biomass fuels

TRADITIONAL WOOD-FUEL IS STILL OUR MOST IMPORTANT SOURCE OF NON-FOSSIL FUEL ENERGY, GLOBALLY MEETING ABOUT 10% OF PRIMARY ENERGY DEMAND

Biomass (such as crops, trees or animal dung) can be harvested as biofuel to generate energy directly, or biomass may be converted to liquid or gaseous fuel. Specifically grown bioenergy crops, such as short rotation coppice wood, can produce in excess of 20 tonnes of biomass annually per acre, with an energy content of 65-105MWh. Bioenergy crops must be properly managed to be renewable - the crop being replaced to provide a continuous source of fuel. The carbon dioxide emitted when the fuels are converted to energy is then taken out of the atmosphere by the re-growing biomass, making the system 'carbon neutral'. However, modern biofuel generation requires a high degree of processing and transportation of the resulting product. Accounting for emissions of CO_2 in this process, the typical net reduction in emissions over fossil fuel will be of the order of 90%.

Biomass conversion into liquid or gaseous fuel may be done in one of two ways: biological digestion or chemical decomposition. The biological processes are essentially microbic digestion and fermentation, whilst pyrolysis is a thermochemical process that converts organic materials into usable fuels, at an efficiency of up to 95%. As the process is thermal the best fuels are those with low moisture content, typically wood, dried sewage sludge and organic domestic waste. Anaerobic decomposition produces a mixture of gases, including methane, carbon dioxide and carbon monoxide, which can then be used in conventional gas fired plant. Since methane from sewage and organic refuse is a significant contributor to global warming, utilising it as an alternative energy source derived from waste is particularly attractive.

Solar Energy



SOLAR ENERGY IS AVAILABLE AT THE EARTH'S SURFACE ON A CLEAR DAY AT ABOUT 950W/M², IN THE FORM OF HEAT AND LIGHT. IT CAN BE HARNESSED TO PROVIDE HEAT DIRECTLY, OR TO GENERATE ELECTRICITY

Active solar heating uses collectors to convert solar radiation into heat for space and water heating. A typical installation usually also includes some form of heat storage such as a hot water store, as the peak of solar radiation rarely coincides with the peak heating requirement.

Where low grade heat can be utilised, such as for swimming pools, the collectors can be simple, and therefore relatively cheap, but where the heat is needed at higher temperatures, such as for space heating, or where collectors are required to operate at lower ambient temperatures, the heat losses become greater and the collectors must be more sophisticated. Some 2-3% of the monthly solar radiation incident on a collector can be delivered as useful heat in solar water heating applications in the UK. This amounts to some 670-1000MJ/m² per year; the precise figure depends on factors such as water and ambient air temperatures.

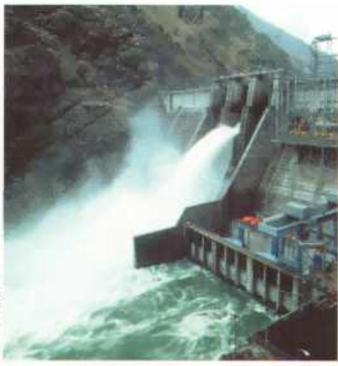
When radiation falls on certain semiconductor materials, the energy of the incident photons liberates some of the electrons in the material, which can be harnessed as electricity. Current applications of this photovoltaic technology are examined in detail on the following pages.

Wind Power

The kinetic energy in wind can be harnessed by sails to turn a windmill to generate mechanical energy or electricity. For a typical wind speed of 5m/s the power a windmill can extract is about 80W/m². This is relatively low, but roughly of the same order of magnitude as solar energy collectors. Wind speed varies constantly in magnitude and direction. Most windmills are designed to operate at wind speeds in the range 5-15m/s. Batteries (or the grid) provide power when speed is low and safety devices protect the installation in high winds. In the UK, onshore wind generation is one of the more promising renewable energy sources, with the potential to provide some 30% of current electrical energy demand. The current Government plan is to generate 10% of the demand by the year 2025, which would require some 4000km² of land.

Hamish Sund/Image Bank

THE POWER THAT A WINDMILL CAN EXTRACT IN A COASTAL AREA IS ABOUT TEN TIMES GREATER THAN IN AN URBAN AREA, DUE TO THE EFFECTS OF TOPOGRAPHY AND NEIGHBOURING BUILDINGS



Hamish Sund/Image Bank

HYDROELECTRIC POWER PLANTS CONVERT THE ENERGY IN FALLING WATER BY CHANNELLING IT THROUGH A TURBINE GENERATOR, WHICH PRODUCES ELECTRICITY

Water Power

Hydroelectricity presently accounts for about 2% of the UK's electrical generation capacity or about 15% of the world's electricity. The majority of this capacity is in pumped storage schemes, which are not renewable. The amount of energy that can be extracted is dependent on the vertical distance through which the water falls, and the flow rate. Large-scale hydro-electricity schemes generally utilise a dam to store water at an increased elevation, which also provides the capability of storing water during rainy periods and releasing it during dry periods. This results in the consistent and reliable production of electricity, able to meet demand.

Small-scale hydroelectric plants generally utilise heads of only a few meters or less. Power plants of this type may utilise a low dam or weir to channel water, or simply use the energy of the flowing water. Small-scale hydroelectricity is generally best suited to isolated sites without access to conventional energy sources, where the variability of the water flow with the seasons can be tolerated, with schemes as small as a few hundred Watts viable.

Large-scale hydro-electricity however, has some significant environmental impacts:

- the flooding of vast areas of land altering the ecology
- possible enforced relocations
- decaying vegetation, submerged by flooding, may give off quantities of greenhouse gases

Damming a river can:

- alter the amount and quality of water in the river downstream of the dam
- prevent fish from migrating upstream to spawn
- trap silt, depriving the river's flood-plain of a natural fertiliser during high water periods.

> Renewable energy generation in the UK has more than doubled since 1990 and currently produces about 2% of UK energy

Wave and Tidal Power

Waves are created as wind blows over the surface of the sea, storing energy until it reaches the coast where it is released, sometimes with destructive effects. There are problems in developing and building wave powered generators which are both cheap and efficient, as they must be strong enough to cope with storms while being light enough to work with small waves.

THE GREATER THE DISTANCE THE WAVES TRAVEL, THE HIGHER AND LONGER THE WAVES WILL BE

The tides are created by the gravity of the sun and the moon acting on the body of water in the oceans and pulling it into a hump. As the earth rotates this hump remains more or less stationary, manifesting itself as the rise and fall of the tides, effectively a single large wave. This wave has consistent and predictable properties and a period of 12.5 hours.

Wave and tidal power generators operate in the same way as conventional hydroelectric generation, by funnelling water through a turbine, with the head to drive the turbine derived from the height of the wave or tide. Such generation is highly intermittent, as the turbine will only generate electricity during a portion of each passing wave. Tidal schemes, where the wave is more consistent, can generate electricity for about 10 hours per day. Barrages across river estuaries amplify the rise and fall of the tide by the funnelling effect of a narrowing channel.

If every reasonable project in the UK were to be exploited for tidal power the yield could provide nearly 20% of the electricity demand for the country. There are other benefits to barrage construction:

- protection of a length of coastline against storm surge tides (as with the Thames barrier)
- provision of estuary crossings
- opportunities for water-based recreation and amenity
- increased land values
- substantial creation of employment

Geothermal Energy

Geothermal energy is heat energy generated deep in the earth by pressure and the rotation of the planet and manifested at the surface by naturally occurring phenomena such as volcanoes, hot springs and geysers. The hot spring that feeds the Roman Bath in the City of Bath produces 1.2million litres of hot mineral water per day at a temperature of 46°C. In Roman times such a phenomenon was beyond understanding and was attributed to the work of the gods.

Hydrothermal resources can be tapped using existing technologies in well-drilling and energy-conversion to generate electricity or to produce hot water for direct use. In some areas, the energy of hot dry rocks can be tapped by circulating water between a series of boreholes through the natural fissures in the rocks. These techniques can produce hot water or steam at the surface for energy conversion.

For electricity generation, hot water is extracted from deep wells at high temperature and pressure, and is flashed to steam in special vessels by lowering the pressure. The steam is fed to a conventional turbine generator, then injected back into the reservoir to help maintain pressure. If the reservoir is to be used for direct-heat application, the geothermal water is usually fed to a heat exchanger before being injected back into the ground.

WHILST VOLCANOES ARE TOO UNPREDICTABLE AND DANGEROUS TO EXPLOIT FOR ENERGY USE, HYDROTHERMAL ENERGY OR HEATED GROUND WATER IS WIDELY AVAILABLE AND CONSISTENT IN OUTPUT

Conclusion

Much work has already been done in the field of energy alternatives, the technical limitations are well-understood and research work continues to improve the efficiency of conversion methods. The next step is to incorporate these fledgling technologies into real applications, by presenting these alternatives to clients, encouraging them to embrace perhaps unfamiliar techniques for generating power by demonstrating the wider benefits. We must also continue to support initiatives that make renewable energy an increasingly competitive, and hence increasingly viable option.

Doug King is an Associate of Buro Happold

> Most people are surprised to learn that the majority of the energy used in the United States goes to heating, cooling, and lighting buildings. Inevitably, architects and engineers will look to the past and to the future in re-addressing to the concept of energy-efficient buildings. Integrated photovoltaics are basic to the principles of site-sensitive architecture. PVs offer light, transparency, and fluidity to the range of solutions just beginning to be explored in projects of every scale. Designers working with both low and high-end technologies and budgets will all contribute to the expanding dimensions of building with energy.

Lucy Fellowes CURATOR, COOPER-HEWITT NATIONAL DESIGN MUSEUM, NEW YORK, NY

Thanks must go to **Nick Goldsmith** of FTL Associates, who organised the ground-breaking exhibition on photovoltaic technologies at the Cooper-Hewitt National Design Museum in New York

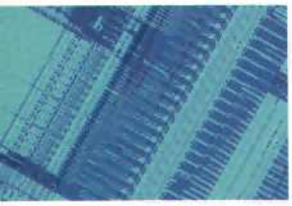
Although photovoltaics have been around for some time, **André Chaszar** explains that their ability to provide renewable, non-polluting electrical energy in locations varying from the densest urban centres to the remotest hinterlands sees them emerging as truly viable in the field of building applications.

Photovoltaic Solutions

A Brief History

At the turn of the millennium, photovoltaics (PVs) have come of age. Developed originally for the space exploration program, they at first relied on thin wafers of single-crystal silicon painstakingly grown, sliced and mounted on a conductive backing (collectively called a 'solar cell') then assembled into arrays wired together and protected by heavyweight glass to produce minute amounts of electricity for satellites outside the earth's atmosphere. Subsequent refinements focussed on increasing efficiency, resulting in a diverse range of cell compositions and production methods but little in the way of commercial viability. As recently as the 1980s, many considered PVs to be a dead-end for providing electricity to buildings.

PVs' current renaissance is due to two main technological factors, as well as a few social and political ones. On the technological side, development of 'amorphous' compositions (i.e. not reliant on single crystals) has enabled PVs to be produced much less expensively. Current production methods have brought PVs firmly into the realm of glazing technology, giving rise to the notion of BIPVs: building-integrated photovoltaics. These are more easily integrated into the architectural concept and vocabulary of a building than PV arrays mounted on ungainly racks on the roof or the lawn, as well as capitalizing on the cost savings of the cladding elements they replace.



Both trends have made it possible for PV producers to reorient their research efforts from improving the efficiency of electrical generation (measured as usable energy per W/m^2 of incident sunlight, for example) to improving the efficiency of PV production methods, so that a given building's demand can be met with more, less-efficient PV units rather than fewer, more efficient ones, at roughly the same or even lower cost. (Good news for glass manufacturers!)

Social and political conditions increasing the demand for PVs include grassroots interest in environmentally responsible home improvements, the continued existence of small but innovative groups of 'off-gridders' striving for self-reliance, and the perception of legislators that 'green technologies' such as PVs make good political sense. The former two conditions result in consumer demand and a degree of activism, whereas the latter is expressed in the form of grants and tax credits for PV manufacturers as well as homeowners and developers who purchase and install PVs. New regulations allowing individuals to sell their excess electricity to utility companies have also helped to create favorable conditions for PVs, so that they are today on the verge of becoming a mainstream building technology.

FAIRFIELD PARK CALIFORNIA

BIPVs USED IN BOTH ROOF AND WALL

Architect: Kiss and Cathcart

PVs in Use

Despite the typically lower efficiency of PVs mounted on vertical rather than horizontal or sloped surfaces, the large areas (and high visibility) of building façades recommend them as prime locations for BIPV systems. Such, for example, is the retrofitted curtainwall designed by Kiss and Cathcart for a mid-rise office building in Hamburg, which is draped outside the existing façade as a semi-barrier to provide a thermal buffer zone as well as solar shading and electrical power. High-rise towers offer vast façade areas as potential PV sites, often with the added advantage of rising clear of surrounding, potentially shading buildings. A modest example is 4 Times Square, an office building in New York City, where PVs were incorporated into some of the spandrel panels.

Reputedly, the world's largest example, with 1000 kW of installed PV capacity, is the Mont-Cenis academy in Sodingen, Germany. Here approximately 10,000 m^2 of PVs are incorporated into an enormous glass 'parasol' which creates a microclimate for the buildings underneath. 90% of the PVs are on the roof, serrated slightly to give a favorable solar orientation, and the remainder are on the southern and western vertical façades. The PVs double as shading devices, with clear areas between the opaque cells, and their density is varied over the façade surface so as to give more shade over the buildings below and more light to the circulation areas in between. This facility is projected to produce 750,000 kWh per year (enough to power some 200 residences), of which only 25% is needed for the Academy itself, and the remainder exported to the public electrical grid.

Coming soon...

Those engaged in research and development in PV technology have no shortage of ideas for more and better ways of producing and applying it. Some of the more exciting of these are:

- Thin-film PVs on flexible backings, for tensile structures and other curved surfaces
- Site-applied PV membranes which could be placed on any sort of new or retrofit building.
- Hybrid PV / Thermal collectors, which can utilize the waste heat produced in the electrical conversion process and improve the performance of the PVs by keeping them cooler.

Recent applications

HEW HEADQUARTERS, HAMBURG:
THE NEW FAÇADE OVERSAILS THE EXISTING BUILDING

HEW HEADQUARTERS, HAMBURG:
OVER-CLADDING USING INTEGRAL PVs

- PV-powered electrochromic windows, allowing controllable transparency of glazing with an integral power supply.

PVs are compact, produce useful energy (electricity is easily distributed and applicable to many uses), and not least are seen as 'sexy': giving buildings which use them an urbane, high-tech aesthetic which still seems to be de rigeur for the majority of mainstream building owners and home gadgeteers. As fossil-fuel costs and environmental consciousness increase, improving PV technologies will become a standard feature of our future buildings.

André Chaszar is a Senior Engineer with Buro Happold

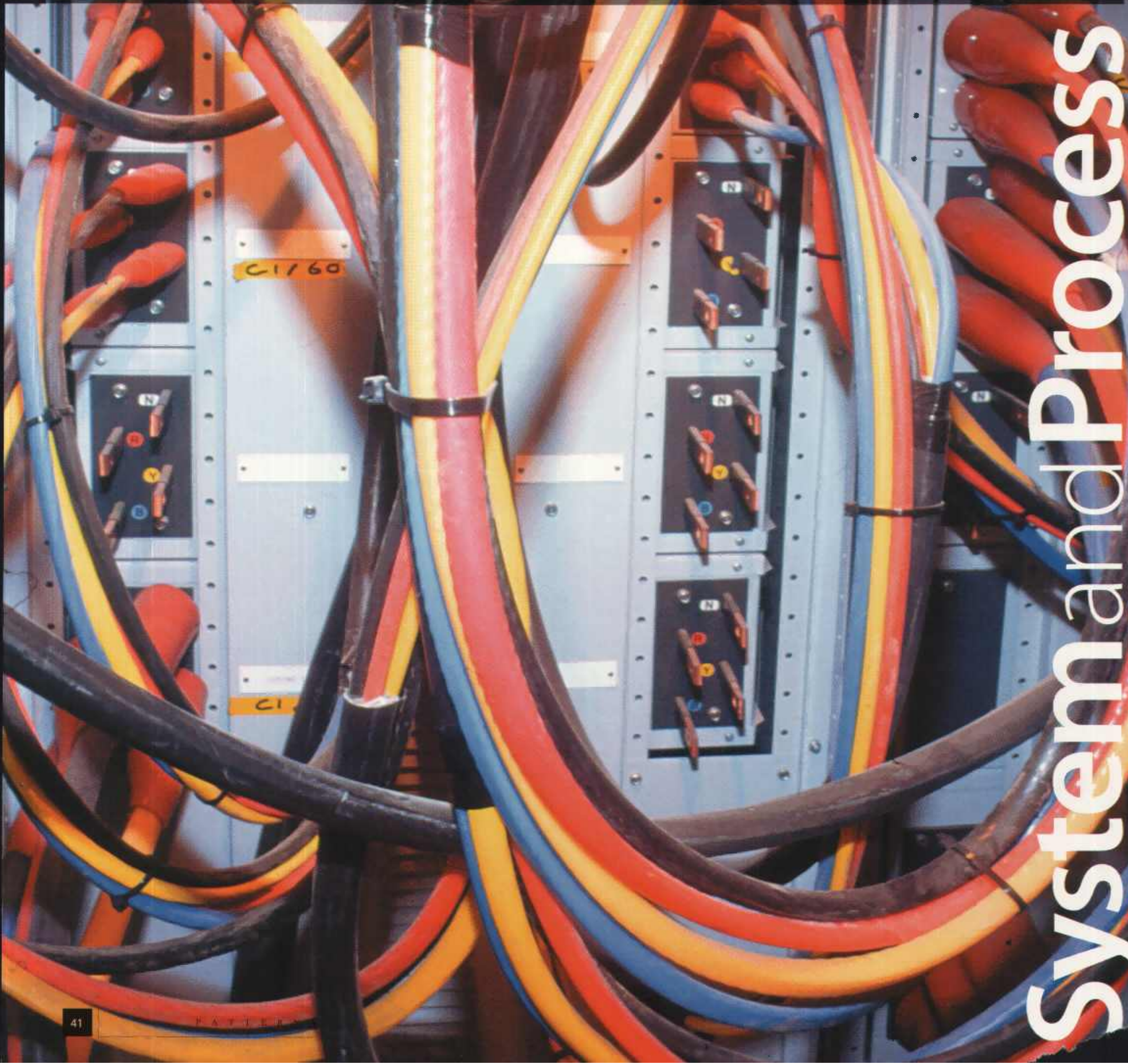
> **'At this time, photovoltaics as energy sources don't make strict economic sense in building applications. On the other hand, they cost no more than, say, polished granite, look just as good, and produce energy in addition. In other words, PVs' visual impact can be significant, and they are potentially powerful elements in a building's or building owner's image.'**
>
> **Steven Strong** PRESIDENT, SOLAR DESIGN ASSOCIATES, CAMBRIDGE, MA

Architect: Kiss and Cathcart

System and Process

Whilst a knowledge of materials and energy may form the cornerstones of sustainable building science, an understanding of the construction process and building systems is no less vital. We need to recognise how materials are put together to form buildings and to appreciate how energy is injected into buildings. Many approaches have been taken in the area of building systems: improved fabrication techniques for individual components or groups of components; enhanced performance for envelopes; ever-more reduced structural frames, and a whole host of opportunitues within the building services sector for continuing minimalisation of resource use, whether energy, water or materials.

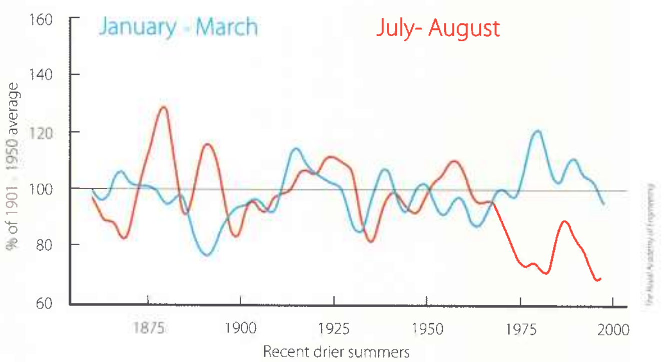
Three very specific aspects are covered in the following pieces: implementation of a water recycling system on a single project scale; adoption of a technique to integrate ventilation with fabric construction and building envelope evolution in an arid climate. These are very much the 'tip of the iceberg' - below the waterline there are numerous areas for further study.



Greywater Success

As water utility companies have been forced to recognise the demands that modern lifestyles are placing on water supplies, more research is being dedicated to investigating alternative sources of cleanwater. **Chew Pieng Ryan** explains how Thames Water used the Millennium Dome as a live experiment.

Thames Water, struggling to balance increasing demand in the densely-populated south-east, an area which receives less annual rainfall than some Mediterranean regions, approached the New Millennium Experience Company (NMEC) suggesting a collaborative effort to develop an innovative approach to water management on the site of the Millennium Dome in Greenwich. The main objectives of the project included demonstrating and researching water recycling technologies, evaluating water efficient appliances and investigating public attitudes to water recycling initiatives.



SEASONAL RAINFALL IN ENGLAND AND WALES 1860 TO 1997:

COMPARING ACTUAL RAINFALL WITH A FIFTY YEAR AVERAGE FIGURE

The Parameters

The New Millennium Experience Company anticipated a maximum attendance of 35,000 people per day, and over ten million during the course of the exhibition year. This yielded a requirement for 500m^3 per day for WC and urinal flushing. Three potential sources of secondary water for recycling were identified on site:

1. Rainwater

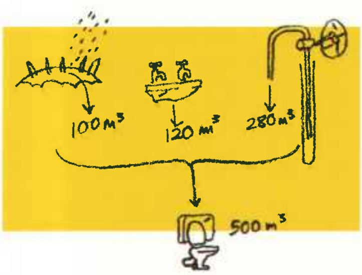
The surface area of the Dome itself is some 90,000m^2. Rainwater run-off from the roof is collected via a gutter and channelled through specially designed hoppers, which feed into the surface water drainage system. A maximum of 100m^3/day can be collected in this way.

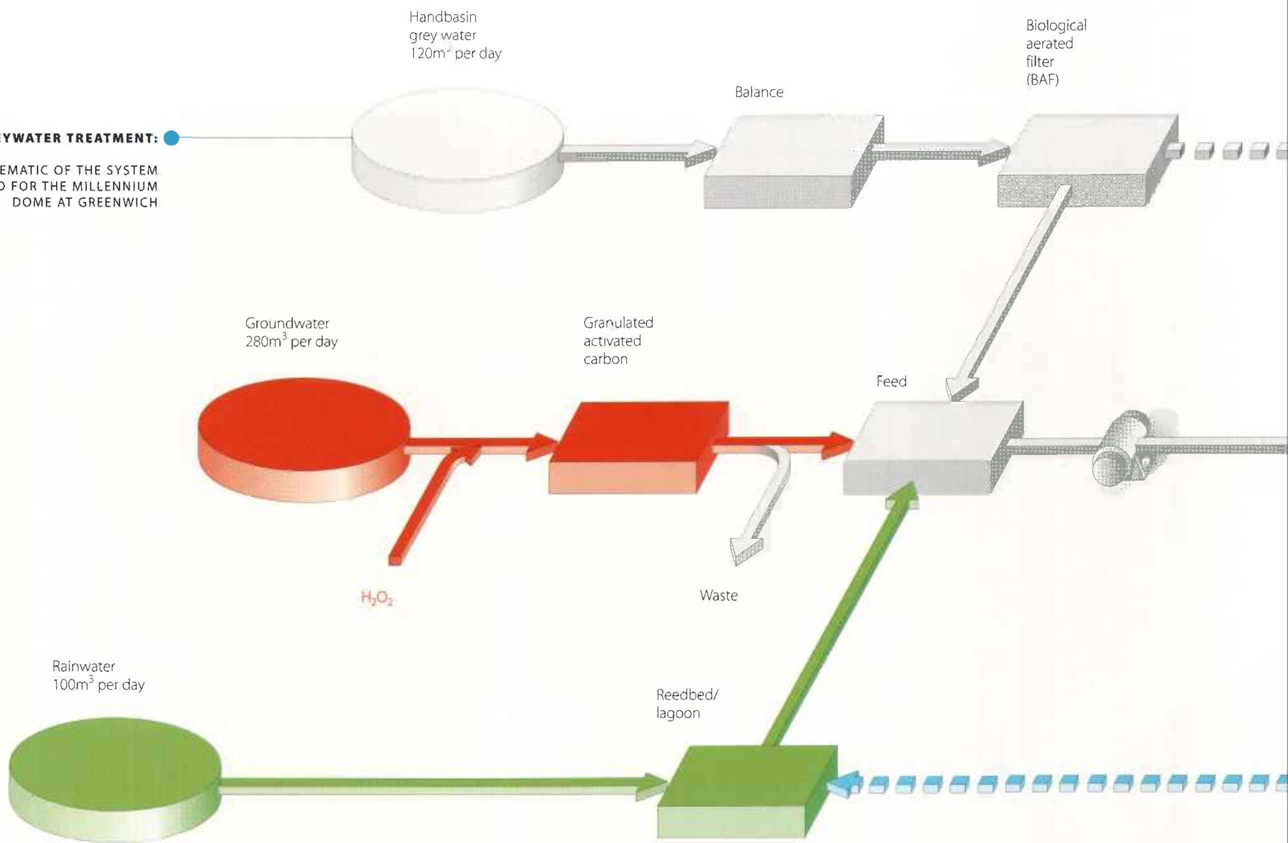
2. Greywater

Greywater is collected from the handbasins and staff showers in the Dome's six core buildings. The expected visitor numbers were predicted to use on average 120m^3/day of hand-basin water.

3. Groundwater

London has had a problem with rising groundwater since 1970 due to a decline in pumping rates, caused by the changing industrial and commercial base. A 110m borehole was drilled on the site and water pumped direct from the aquifers.





GREYWATER TREATMENT:

SCHEMATIC OF THE SYSTEM DEVISED FOR THE MILLENNIUM DOME AT GREENWICH

HOPPERS COLLECT RAINWATER VIA A PERIMETER GUTTER AND DISCHARGES INTO THE UNDERGROUND SYSTEM

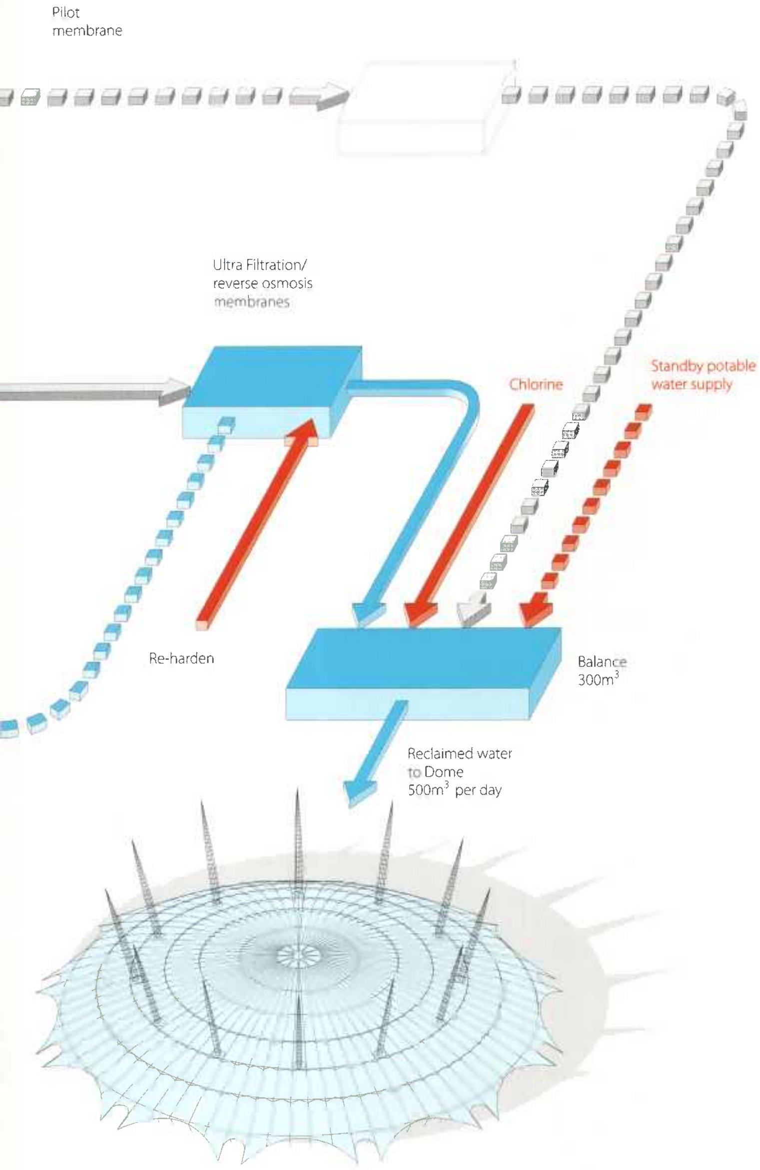
Treatment Methodology

A range of treatment options were available. The Dome provided the opportunity to implement a re-use scheme at full scale and demonstrate the full range of innovative treatment options.

Since the rainwater run-off was collected swiftly and thus uncontaminated, open reedbeds were an appropriate choice. Rainwater was passed through the first reedbed, designed for stormwater treatment, followed by a second reedbed that functioned as a storage lagoon. The latter also performed a tertiary treatment function. The beds, approximately 0.6m deep, had a 0.5% gradient, and were filled with washed river gravel planted with the common reed. An arrangement of educational boards and a walkway running through this landscape allowed the general public to understand the operation of this 'natural' form of water treatment.

The primary concern in treating greywater is to meet the quality criteria for pathogen kill. Another key concern is ensuring minimal potential for biological regrowth in the reclaimed water. Thames Water Research carried out a range of pilot scale trials using biological aerated filters (BAF) followed by a variety of membranes with specific emphasis on soluble bio-chemical oxygen demand (BOD) removal using synthetic greywater. Another consideration was dealing with modern soaps that would be contained in the greywater discharge. The trials indicated that tight ultra-filtration membranes were the most appropriate for handbasin and shower greywater.

Water from the borehole was tested to establish the groundwater quality. A problem with hydrogen sulphide gas was experienced together with a much higher than anticipated salt and iron content. A system was devised to dose the groundwater with hydrogen peroxide to oxidise any metal contaminates, then pass the water through granular activated carbon to remove the organic contaminates. Membrane filtration follows carbon exchange where ultra-filtration removes residual organics and a reverse osmosis (RO) membrane desalinates the groundwater. As RO filtration is needed to remove the salt from the borehole water, it is therefore combined with the BAF treated greywater and rainwater from the reedbeds through the same membrane configuration. The treated water was then re-hardened and disinfected before being pumped back into the Dome for flushing the WC's and urinals.



THAMES WATER PAVILLION:

WATERCYCLE EXHIBITION AT THE MILLENNIUM DOME, GREENWICH

Distribution Networks

The distribution elements of the recycling systems became a significant part of the water services systems for the Dome. A dual-system of drainage was required - conventional 'foul' water from toilets and kitchen disposals, and 'greywater' from showers and wash handbasins, as well as a dual system of water supply pipework - conventional potable water and 'reclaimed' water to serve the WC's. A protocol needed to be developed for the reclaimed water pipework: purple coloured pipe used in the United States was already in use for another service, so black pipe with four longitudinal green stripes was adopted. In total, 692 WC's and 220 urinals were served with reclaimed water, with 277 wash handbasins providing greywater.

A Recycling Demonstration Showcase

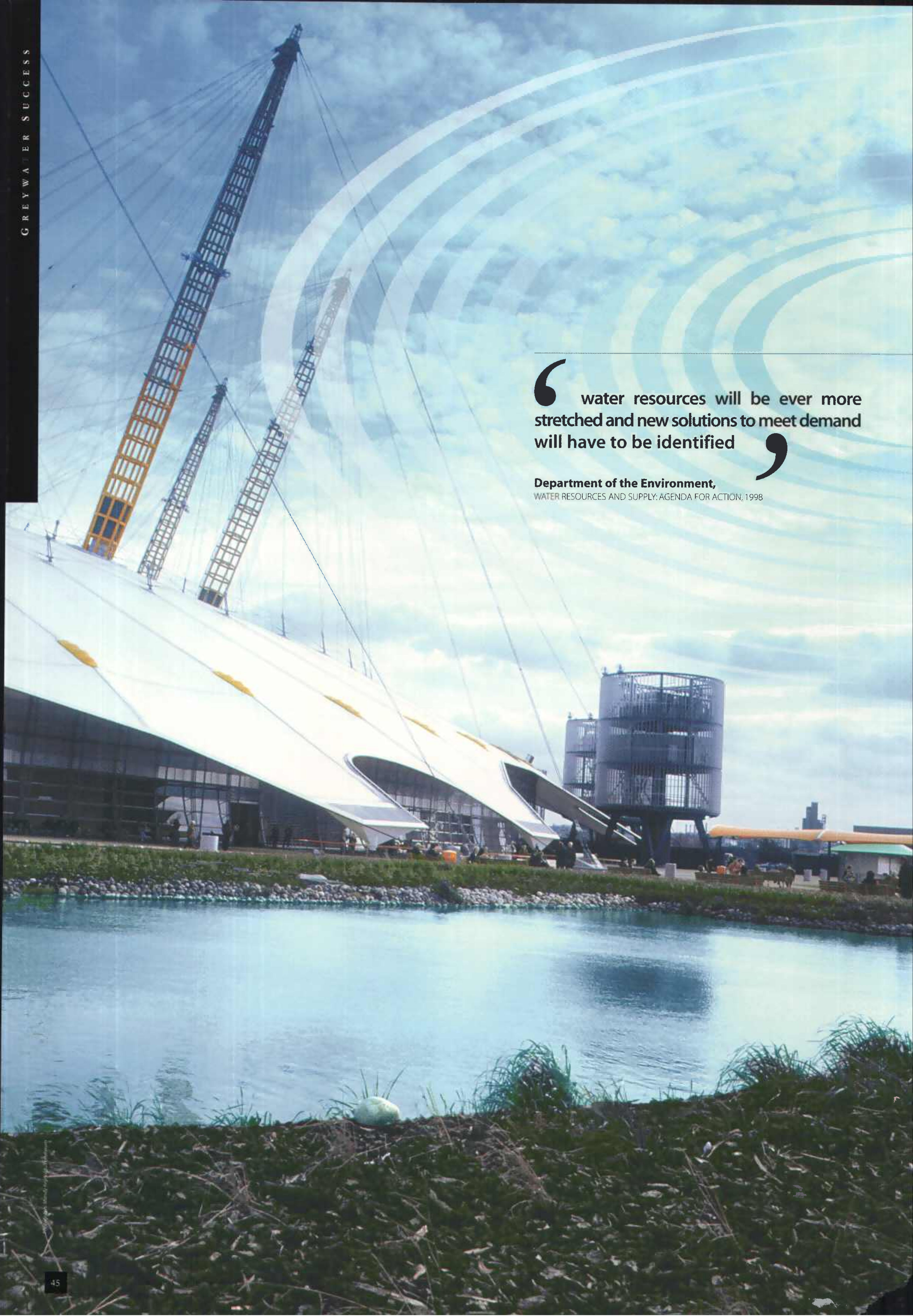
The recycling plant at the Millennium Dome is the hub of Thames Water's research into water use and conservation. It is staffed by full time Thames Water research scientists as well as students with on-going research collaboration. During the lifetime of the 'Millennium Experience', the plant was fully evaluated under operational conditions. One of the key areas was to establish the appropriateness of this type of recycling scheme, both in terms of reliability and cost effectiveness. In addition, a variety of water-saving devices were used in the public toilet blocks in the core buildings, allowing comparative research into water usage, and educational material displayed to ascertain the influence - if any - of education on visitor behaviour.

The fast-track and constantly evolving nature of the project required a collaborative team approach, with the New Millennium Experience Company, Thames Water, various consultants, contractors and suppliers combining expertise to ensure completion of this unique facility on time.

The implementation of a recycling scheme at the Millennium Dome site with the potential to use the venue for on-going public education and academic research in water efficiency and conservation is a major opportunity for the UK water industry and anyone with an interest in sustainable water management into the 21st century.

Chew Pieng Ryan is a Senior Engineer at Buro Happold

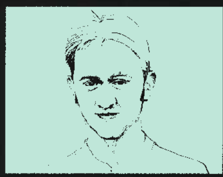
This article is based in part on **'A Recycling Showcase at the Millennium Dome'**, a paper presented at the CIWEM conference in May 1999. The assistance of its authors, **Sian Hills** and **Roger Ford** of **Thames Water**, and **Peter English** of **the New Millennium Experience Company**, is acknowledged with thanks.



> ‘ water resources will be ever more stretched and new solutions to meet demand will have to be identified ’

Department of the Environment,
WATER RESOURCES AND SUPPLY: AGENDA FOR ACTION, 1998

One approach to reducing building heat loss while overcoming the perceived decrease in comfort levels of buildings that 'breathe less', is the incorporation of 'dynamic' insulation into the building structure. **Iain Gillespie** explains this Scandinavian technique and its implementation on two Scottish buildings



The air that we breathe

The Dynamic Insulation Concept

In order to reduce the energy input into buildings, heat loss must be limited. There are two primary methods to reduce the heat loss (Q) from buildings:

- **Reduce heat escaping out through the fabric by increasing the thickness of the building insulation (i.e. lowering the thermal transmittance, or 'U' Value)**

$$Q = UA\Delta t$$

Q heat loss
U thermal transmittance
A area of fabric
Δt temperature differential

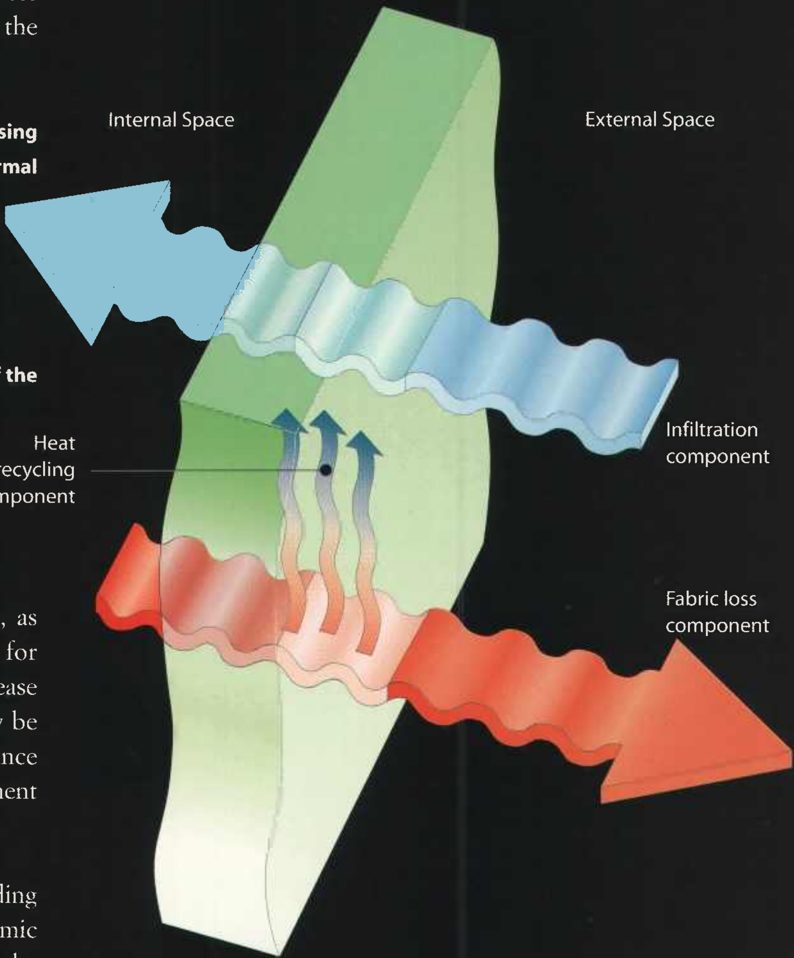
- **Reduce cold infiltration into the building by a reduction of the fresh air volume introduced - improved air-tightness**

$$Q = \frac{1}{3} NV\Delta t$$

Q heat loss
N number of air changes
V volume
Δt temperature differential

An increase in thermal insulation can be expensive, as envelopes become thicker and heavier than required for structural capacity. Improved air-tightness has seen an increase in perceived discomfort, as the natural ventilation rate may be too low to control contaminant levels, with consequent reliance on mechanical and energy intensive solutions to supplement fresh air rates.

The introduction of dynamic insulation into the building fabric seeks to alleviate these problems. In particular dynamic insulation allows a regulated flow of external air to enter the occupied space via either mechanical or natural means. In addition, a reduction in the total heat loss is achieved since the heat leaving the building is effectively recycled by the external air passing - in the opposite direction - through the building structure.



REDUCING HEAT LOSSES:

LIMITING HEAT ALLOWED OUT, AND COLD ALLOWED IN BY MAXIMISING THE HEAT RECOVERY BETWEEN THE TWO

The air that we breathe

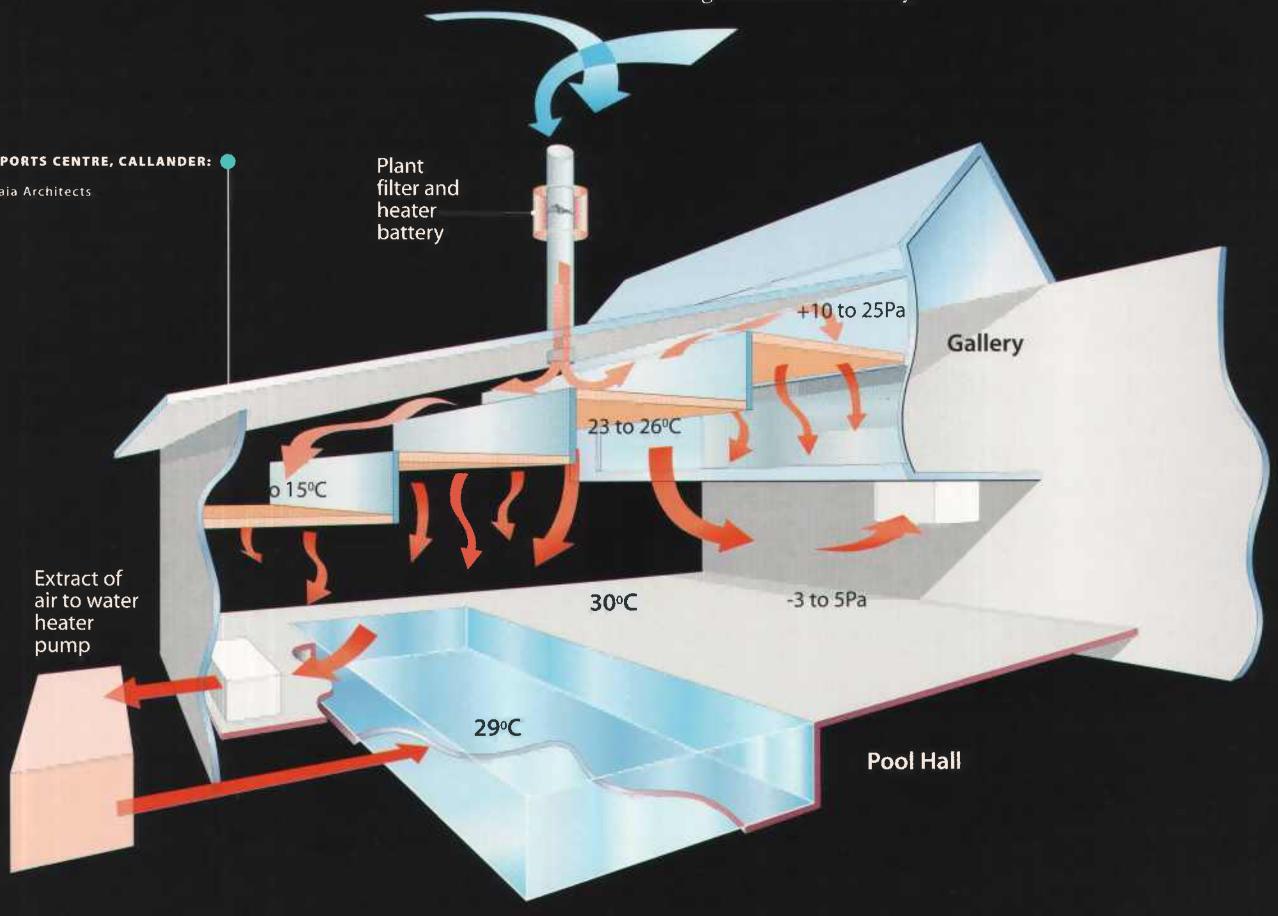
Dynamic Insulation Application in two sample projects

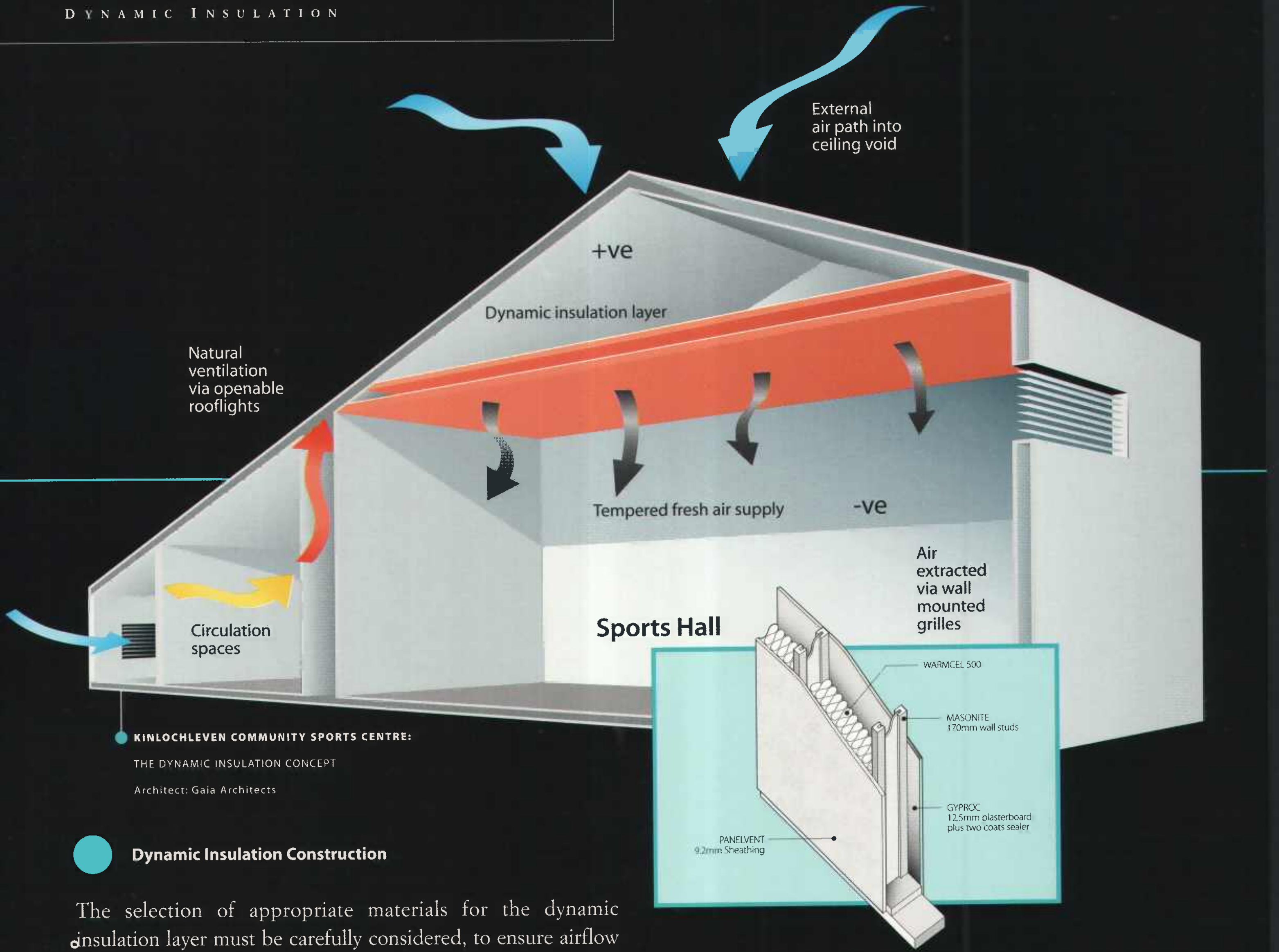
Gaia Architects has incorporated the dynamic insulation concept into a number of recent buildings. The **McLaren Sports Centre in Callander** incorporated a dynamic ceiling construction with the ceiling void being slightly pressurised. This provided a mechanism to allow tempered fresh air to enter the swimming pool and sports hall in a controlled manner. This effectively reduced the load on the air-handling unit heater battery supplying these zones.

At **Kinlochleven Community Sports Centre** the scheme design team sought a solution that reduced the level of air infiltration whilst providing key areas with high levels of fresh air. For the main community hall, external air is introduced into the ceiling void via a supply fan, slightly pressurising the ceiling void (a 10Pa differential) encouraging the fresh air to transfer to the space through the dynamic insulation layer. Incoming fresh air is sufficiently tempered to preclude the use of a heater battery. The air is extracted via wall mounted grilles and passed over a run-a-round coil to reduce the load on the gymnasium air handling unit heater battery.

McLAREN SPORTS CENTRE, CALLANDER:

Architect: Gaia Architects





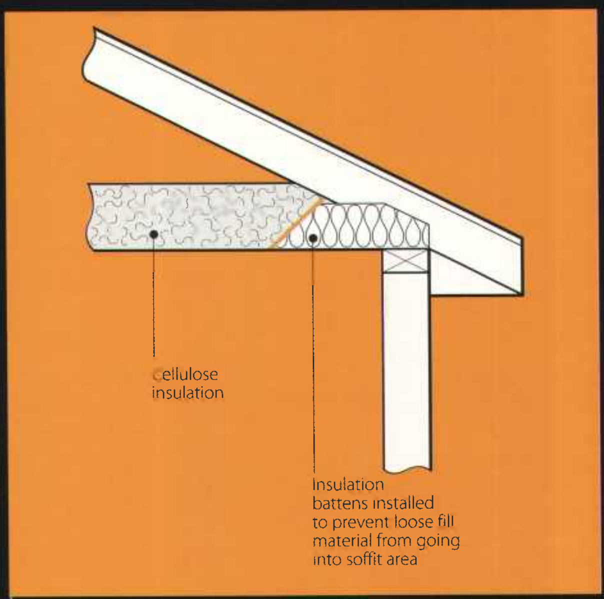
KINLOCHLEVEN COMMUNITY SPORTS CENTRE:

THE DYNAMIC INSULATION CONCEPT

Architect: Gaia Architects

Dynamic Insulation Construction

The selection of appropriate materials for the dynamic insulation layer must be carefully considered, to ensure airflow is maintained whilst minimising the risk of interstitial condensation. Generally materials were selected with decreasing vapour resistivity from the internal boarding to the outer membrane. (The British Standard recommends a differential factor of five).



DYNAMIC INSULATION LAYER

The dynamic insulation layer consists of three materials:

- **The internal lining**

A series of softwood boards screwed through to battens allowing a 16mm gap between each board. This arrangement has a high vapour resistance and minimises the vapour diffusion into and out of the space.

- **The insulation layer**

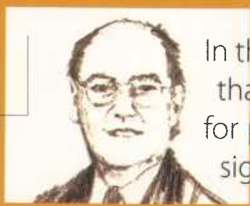
A 150mm thick layer of cellulose with fire retardant properties and an extremely low thermal conductivity value of 0.035 W/mK. It also has good sustainability credentials being produced from recycled newspaper and, being hygroscopic, it has the ability of 'smoothing' any moisture peaks, by retaining the vapour before diffusing, in a controlled fashion, to the external atmosphere via openings in the roof soffit.

- **The external lining**

A flameproof PVC membrane, providing the required 30 minute fire resistance whilst allowing free transfer of air.

Iain Gillespie is a Building Services Engineer with Buro Happold

Resilient Envelopes for the Middle East



In the Middle East, where the climate is more extreme than temperate Europe, **TonyMcLaughlin** argues for positive change to the way we design to achieve significant energy savings

Historical Context

Historically, building designers in the harsh climate of the Middle East evolved a vocabulary of elements that allowed man to temper the extremes of temperature and survive comfortably without the benefit of modern building technology. From the Bedouin tent to the distinctive clusters of stone buildings that seem to have grown organically out of the sandy soils, every facet of construction responded to environmental demands. Too arid for trees, the mishrahbia and kafess were developed into intricately decorative lattices and canopies providing dappled shade. Hollow towers that provided an architectural feature were used to encourage the slightest breeze to move through dwellings. Echoes of these traditional forms have been successfully incorporated into modern Middle-Eastern architecture, but the desire to mimic the glass skyscrapers of the west has seen an increasing dependence on artificial systems of environmental control.

Buildings in the Middle East are high-energy consumers due to the simple fact that they are predominately air-conditioned. For the sustainably-minded designer, it may not be possible to completely remove the need for air conditioning, but it may be possible to reduce its prevalence and its demand on fossil fuels, whilst maintaining comfort and efficiency within the working environment. Building services technology should not be seen as the only means of controlling the built environment, rather, it is the final element in the design equation, applied after consideration is given to climate, site and materials. There are a number of approaches to the problem: one is to reduce the extent that a building relies on air conditioning by a range of passive cooling measures; another is to establish alternative energy sources to fossil fuels to feed the continuing demand. Collaboration at an early stage with client and architect will allow the environmental engineering design to be proactive, to help shape the brief, rather than be reactive and result in a bolt-on selection of mechanical systems to counter difficult conditions.

Passive Cooling Measures

In a desert climate these are some of the primary passive measures:

- **Orientation**
- **Shading**
- **Thermal mass**
- **Thermal insulation**
- **Avoidance of dark coloured materials**
- **Reduction in the amount of glazing**
- **Using thermal buffer zones**
- **Night time cooling**
- **Wind movement to enhance heat dispersion**

THE EVOLUTION OF DESERT ARCHITECTURE:

SKYSCRAPERS AT SHIBAM, YEMEN. THESE HIGH BUILDINGS, ERECTED LONG BEFORE AMERICA EXPERIMENTED WITH SKYSCRAPERS PROVIDE NATURAL FRESHNESS FOR THOSE WHO LIVE WITHIN AND WELCOME SHADE IN THE NARROW STREETS BETWEEN THE BUILDINGS

MASSIVE AND TENTED FORMS ECHOED IN THE DIPLOMATIC CLUB, TUWAIQ PALACE, SAUDI ARABIA

AL FAISALIAH CENTRE:
CANOPY OVER DROP-OFF AREA PROVIDES SHADE AND PROTECTION

Outdoor climate conditions in the Middle East can be so severe that both buildings and their external spaces need to be protected as much as possible from the intense solar radiation and the hot dusty winds. If energy loads are to be reduced, surfaces exposed to the sun should be minimised. Site constraints permitting, the longer elevation should preferably face north and south as these orientations receive the lowest heat loads from solar radiation. The worst orientation is west, as although solar radiation is similar on the east façade, peak intensity on the west tends to coincide with higher external air temperatures. Planning of non-habitable and service rooms on the western side of a building can serve as a thermal barrier or buffer zone.

Shading needs to be provided to glazed elevations to reduce the impact of solar radiation into the internal spaces with the glazing itself reduced in extent as far as practical whilst still allowing good levels of natural light penetration. Thermal mass can be used to effectively delay the heat build-up within spaces so that unacceptable temperatures are only experienced when the building is unoccupied during the night-time, and combined with 'free' night-time cooling to ensure a cool start to the working day. Thermal insulation should always be to the outside of the thermal mass, although this may be hard to achieve. The harnessing of the wind as a cooling medium is beginning to be explored as modern architecture echoes historic forms with the introduction of wind towers to induce cooling draughts.

These are some of the ideas that can be incorporated- although since we live in the real world, site, brief and financial restraints will always test the design team's ingenuity.

FULLY GLAZED SKYLINE, DOWNTOWN RIYADH: THE AL FAISALIAH COMPLEX

Alternative Energy Technologies

In the Middle East, it is obvious to think of active solar technology with something like 3,000 hours of solar availability per annum, equating to a mean annual solar irradiation on horizontal surfaces of 2500kWh/m²/annum. This may be great if the demand is for heating, but is not so good if it's for cooling. Still, there are two areas where solar thermal systems can be used:

- Domestic hot water heating (a year round requirement). This can be satisfied with solar energy directly heating water filled panels to meet the domestic water demand. This technology is well developed so there is no reason for not using it in the future on any scale of project.

- Solar cooling with absorption refrigeration. The collector and storage subsystems must operate at temperatures approaching 90°C to achieve maximum performance. This is a developed technology operating in many parts of the world and as a system it is suited for the Middle East where a year round demand for cooling exists.

Architect: Foster and Partners

Buro Happold worked with Solargen (Europe) Ltd on the development of a new concept of solar thermal power plant. The concept features a fixed primary mirror constructed in the ground and a receiver/gas turbine package, which tracks the sun by means of a finely controlled tracking system. An initial prototype has been built in Southern Crete, using a fixed primary mirror, which produces approximately 35kW of power. A second phase prototype is currently being developed which will feature an extended primary mirror together with a secondary mirror surrounding the receiver. This will produce approximately 200kW. A gas turbine has been specifically developed for this application, able to operate on solar power only or to be fuelled by a combination of solar power and fossil fuel. There are possibilities for both stand-alone installations at individual locations and for groups of installations being linked together and connected into the local grid, and the Middle East is seen as a key market.

Case STUDY

Al Faisaliah Centre

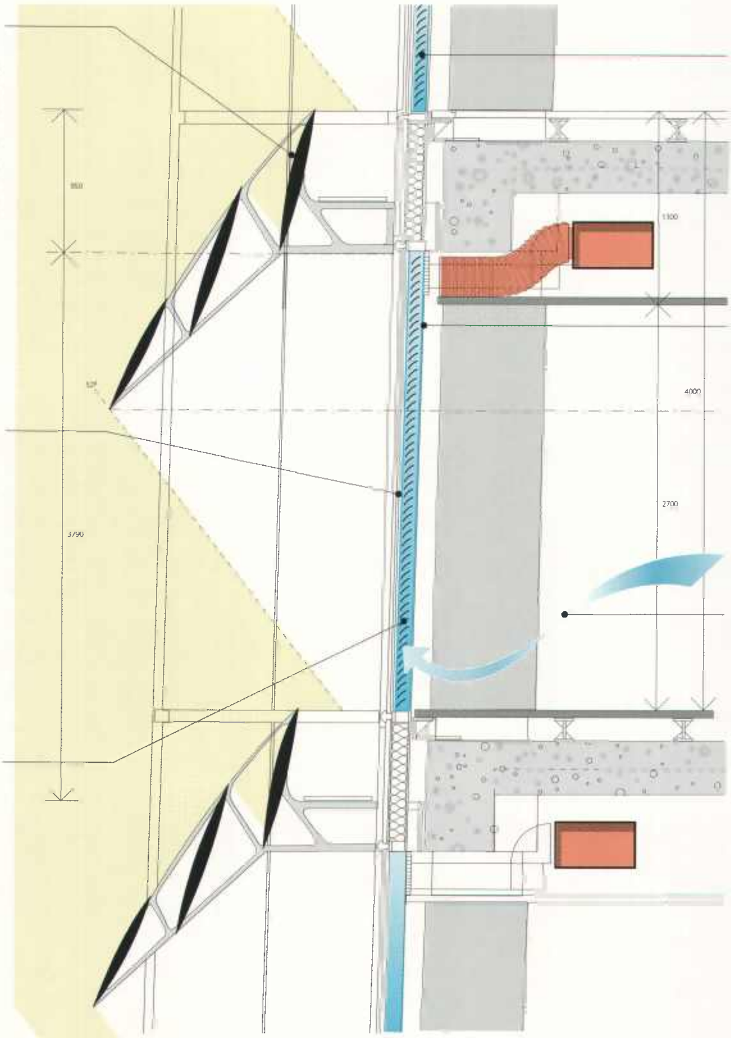
The **Al Faisaliah Centre** in Saudi Arabia is a large landmark development in the commercial centre of Riyadh comprising a 30 storey office tower, a 220-bed luxury hotel, a residential complex, a 40,000m^2 retail centre, a 65m clear span banqueting hall for 2000 guests and associated underground car parking and landscaping. The façade of the office tower is an area where architecture and engineering combine to offer possibilities for energy conservation.

The King Faisal Foundation is an enlightened client whose desire was to procure a modern development that reflected current thinking and technology. Operational energy costs were of particular concern. By working in a joint venture of world class architects, Sir Norman Foster and Partners together with Buro Happold, there was never any doubt that the development would be a strong statement of modern architecture and façade technology. The team evolved two quite different responses to the harsh Riyadh climate in the detailing of the tower and the hotel.

Tower Façade

The tower's striking façade is a multi-layered construction, each layer playing an important part in the façade's thermal and visual performance.

The energy efficiency of the façade produced a design which uses 40% less energy than its contemporaries, and an internal environment which will be comfortable in all respects, not to mention providing excellent views out across Riyadh. The external shading element did offer the opportunity of integrating photovoltaic technology and a feasability study was undertaken. Had the economics been favourable, it would have resulted in a unique response to the design of the tower façade. However, with the exceptionally low energy costs in Riyadh, and the still high installation costs for photovoltaic technology, it was perhaps inevitable that the finances would not stack up.



Hotel Façade

The hotel elevations are designed to be dynamic, guests choosing combinations of internal blinds and external timber screens to moderate the internal environment. There are air conditioning systems within the rooms, but individual control is intended to introduce a simply-operated element of personal choice. The sandstone finishes and timber shutters evoke the more traditional domestic architecture of the area, albeit electronically rather than manually controlled.

Conclusion

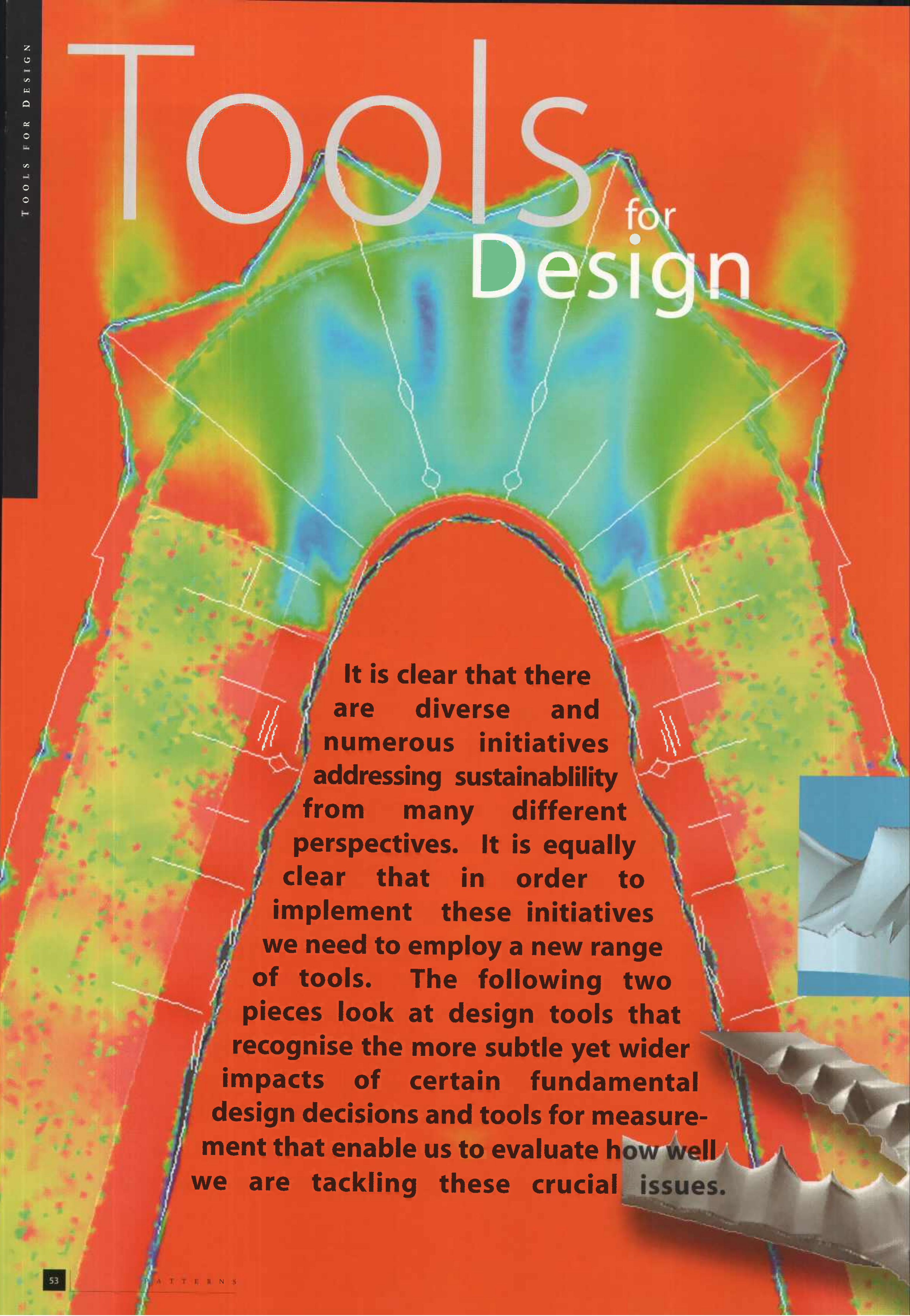
The unique energy situation in the Middle East means that renewable energy systems are unlikely to prove economically viable, at least in the short term. However, these 'new' technologies may be applied to buildings in such extreme climates, with potentially dramatic effects on global energy consumption, when the full consequences of carbon trading become known. Currently, high capital costs coupled with uncertainties over reliability have seen low take-up on the part of clients. Designers need to refine the systems available, educate the market if necessary and keep putting the opportunities in front of clients for more environmentally responsible building methodologies.

Tony McLaughlin is a Partner of Buro Happold

DETAIL OF TOWER FAÇADE

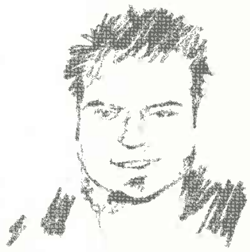
DETAIL OF THE LOBBY ROOF

THE AL FAISALIAH CENTRE SHOWING THE TOWER, WITH THE HOTEL TO THE LEFT



Tools for Design

It is clear that there are diverse and numerous initiatives addressing sustainablility from many different perspectives. It is equally clear that in order to implement these initiatives we need to employ a new range of tools. The following two pieces look at design tools that recognise the more subtle yet wider impacts of certain fundamental design decisions and tools for measurement that enable us to evaluate how well we are tackling these crucial issues.



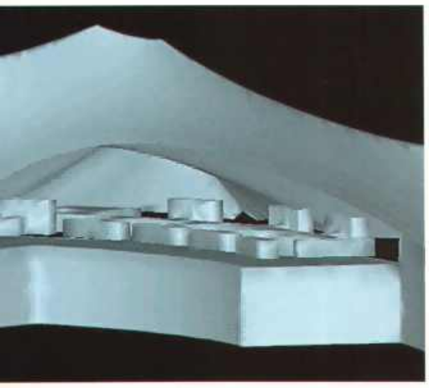
Natural ventilation is difficult to predict, and can be difficult to control. Draughts can cause discomfort and are an indication of inefficient energy usage. Garry Palmer explains how Computational Fluid Dynamics (CFD) will help.

Computational Wind Engineering as a Design Tool

Supermodels

UNCONTROLLED VENTILATION OF SEMI-INTERNAL FOOD COURT

The McArthur Glen Retail Village is a new development in Kent with a distinctive tented roof structure. In establishing the optimum building orientation and access positions, computational fluid dynamics (CFD) analysis of the structure was carried out.



Methodology

The food court area and the immediate surrounding environment and structure were modelled in full geometric detail. This model formed part of a larger domain which included the full building structure and surrounding terrain, modelled to create a realistic external flow regime. Detailed simulation was carried out using an unstructured mesh and non-isotropic roughness. The solution of the model utilised the high-powered multi-processor computer necessary to cope with the size of the grid, complex geometry and realistic wind turbulence.

McARTHUR GLEN RETAIL VILLAGE:

FABRIC ROOF PROFILE

Architect: Richard Rogers Partnership

Results

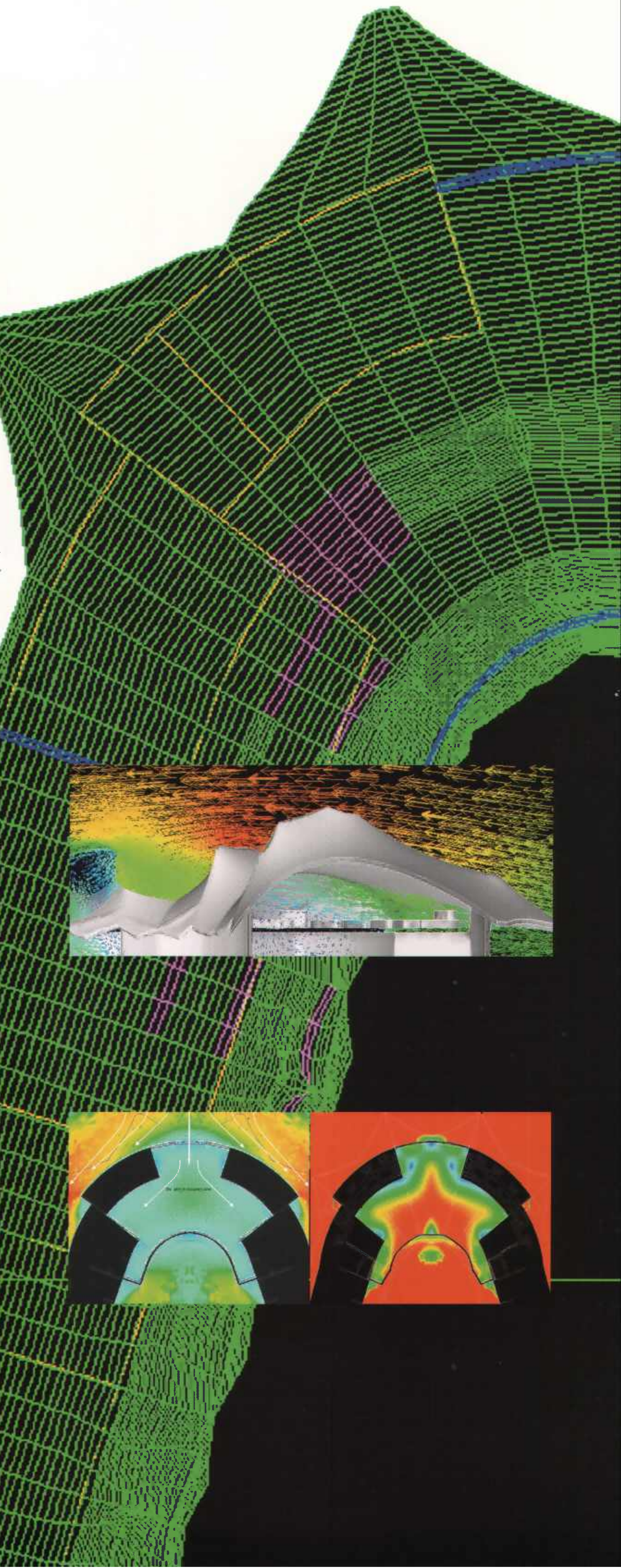
Wind Speed

Analyses were carried out for the current structural arrangement with two primary wind conditions - a mean wind speed of 5.0m/s and gale conditions of 17.0m/s. As designed, the air speed in the occupied zone reaches 1.2m/s for a prevailing wind speed of 5.0m/s. This scenario will not be uncommon over the full yearly operation of the building. During gale conditions, the analyses indicate an air speed of 6.0m/s in the occupied zone. These constitute unacceptable conditions for any internal space.

Flow Regimes

There were shown to be two major flow regimes in the internal spaces, a general through flow at high level and a recirculation flow through the occupied zone. Even at normal prevailing air speeds, this recirculating flow reached 1.2m/s and would increase when doors into the space were open.

Very high wind speeds were seen occurring due to an aerofoil effect over the fabric structure. The increase in flow path length results in a rapid acceleration of wind speed over the apex. Uncomfortable air velocities occur throughout the occupied zone, partly due to ingress at a position above the glass entrance screens and partly due to ingress at each side, above the retail structures.



Remedial Works

In order to mitigate the unacceptable velocities, a number of structural additions were proposed. The addition of structure between the under side of the fabric and the existing structure on three sides, saw a significant improvement in environmental conditions under the prevailing wind direction. Worst-case air velocities were reduced from 6.0m/s down to less than 1.5m/s with additional structure. However, reversal of flow produces draughts in the occupied zone, partly due to the turbulent flows creating a fluctuating pressure profile. This, in turn, causes uncontrolled ingress into the space, which can only be prevented by providing additional structures at the rear of the food court as well.

Simulations incorporating horizontal 'canopies' in the occupied zone predict the continued occurrence of draughts in areas of the food court. The dominant flow regimes in the interior spaces (a function of fabric geometry) show that low-level structural windbreaks are not sufficient to prevent uncomfortable draughts. Although there is a horizontal component to draughts, the flow above the occupied zone drives air into the seating areas. An assessment of the frequency of occurrence was carried out determining that additional structures were required on all sides of the food court area.

Conclusion

CFD analysis enabled internal conditions to be predicted with some accuracy, and a range of possible remedial measures to be explored by modelling, rather than 'trial and error' implementation.

Garry Palmer heads the Buro Happold Computation and Simulation Analysis (COSA) Group

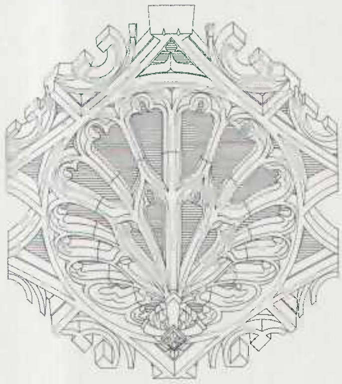
Sustainability may appear to be intangible and hence unquantifiable. **Dr Bill Addis** argues that engineers need to take the lead in establishing methods of measurement so that realistic assessments of the sustainabilty of solutions can be made.

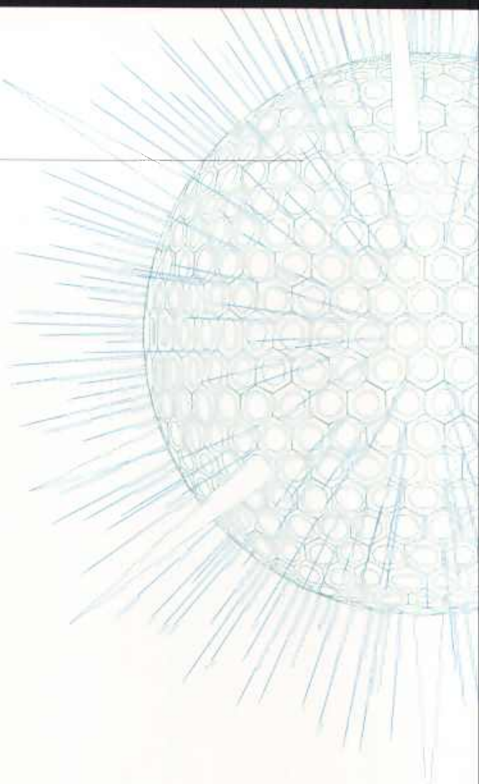
Sustainable measurement

Familiar and Unfamiliar Territory

The world of sustainability may seem unfamiliar to the modern engineer - full of subjective judgement and imprecision. The modern role of the engineer is devising the quantitative description of the performance of buildings - both the structural behaviour and the internal environmental conditions. The basis of engineering thought and action is the mathematical model. For structural behaviour, models of loads - snow, wind, people, for example - are caused to interact with models of material arrangements - input and response. For internal climate, models of heating loads act upon a thermal model of a building. The predicted responses are then compared with predefined limits that must not be exceeded.

Engineering has not always been so precisely conceived. Renaissance mathematical concepts of load and stiffness are still used today. Before these thoughts were formulated, the behaviour of structures was considered in different ways. Today's engineers would now describe the engineering of the pre-Renaissance era as full of subjective judgement and imprecision. If our ancestors managed to move beyond such native wit by devising the mathematical models we now know, then surely we can achieve the same in the realm of sustainability.



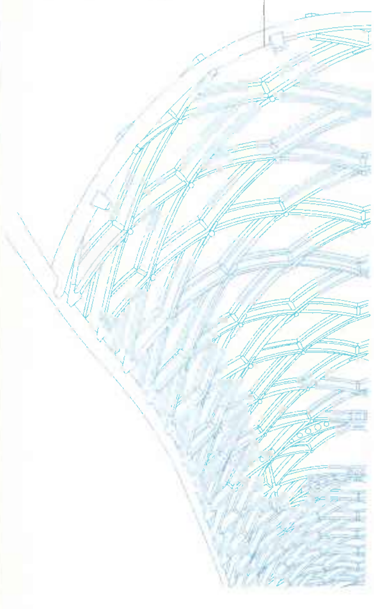


NATURAL MICRO STRUCTURE:

THE OUTER SILICEOUS NET
OF THE MICROSCOPIC SINGLE-CELLED
ANIMAL HALIOMMA ECHINASTER

Development of engineering design methods

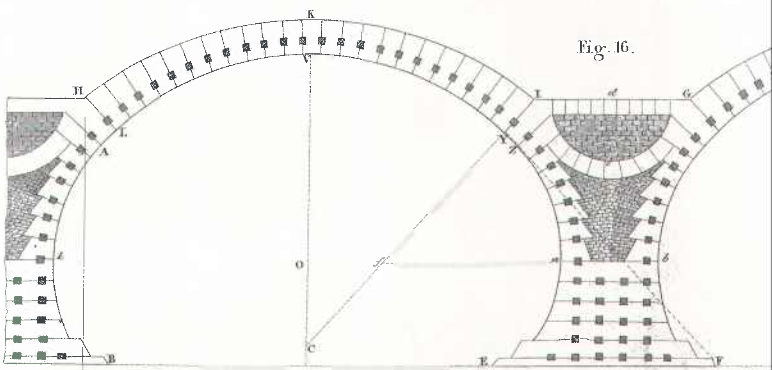
Designing construction projects with economy and environmental concern is not new, builders striving to use as little material as possible, if only out of financial common sense. Galileo first described the most efficient elevation for a beam (i.e. reflecting the bending moment diagram) in 1638. The design of minimum-weight structures dates from the first use of cast iron in buildings in the 1790s. Using traditional materials of timber and stone, elements must be cut down to size, so there comes a point when the benefit of reducing size further to achieve the minimum possible amount of material is outweighed by the extra labour needed. When making a structural element from cast iron there is economic and structural benefit in using only the minimum amount of material, i.e. building it up to size. The 1830s search for the most effective use of material for a beam cross-section led to the development of the I-section.



GEODESIC STRUCTURE:

SECTION OF AIRFRAME
DEVELOPED IN THE 1930's
BY BARNES WALLIS

Minimum weight was always the goal of builders of long-span roofs and bridges and, in this century, builders of aircraft. However, the most profound study of minimum weight as a design philosophy was by biologists looking at natural structures in the early years of the last century. Out of this philosophy came the ideas of specific stiffness and specific strength - the amount of stiffness you get per kilogram of material. Using this approach, timber beats steel for most structures and is similar to aluminium.



VICTORIAN TUNNEL SECTION:

SHOWING TRADITIONAL USE OF INTERLOCKING CUT STONE
WITH RUBBLE IN-FILL

The development of design methods has followed a similar sequence as the craft approach was superseded by that of the modern engineer.

- **The first approach to design is prescriptive (the 'building regulations' approach).**
- **A clear qualitative understanding of how the system works must be developed.**
- **The first stage of quantification involves comparison with norms or earlier precedent.**
- **Definitions of new ideas only acquire significant use when they can be measured.**
- **The concept of load is allied to that of a response - a response of the system to which the load is subjected (whether the load is a weight, a fire load or an environmental load).**
- **As mathematical models and design procedures develop, the way in which subjective judgement informs decision-making in design changes, but does not disappear.**

FILIGREE IRONWORK OF THE EIFFEL TOWER

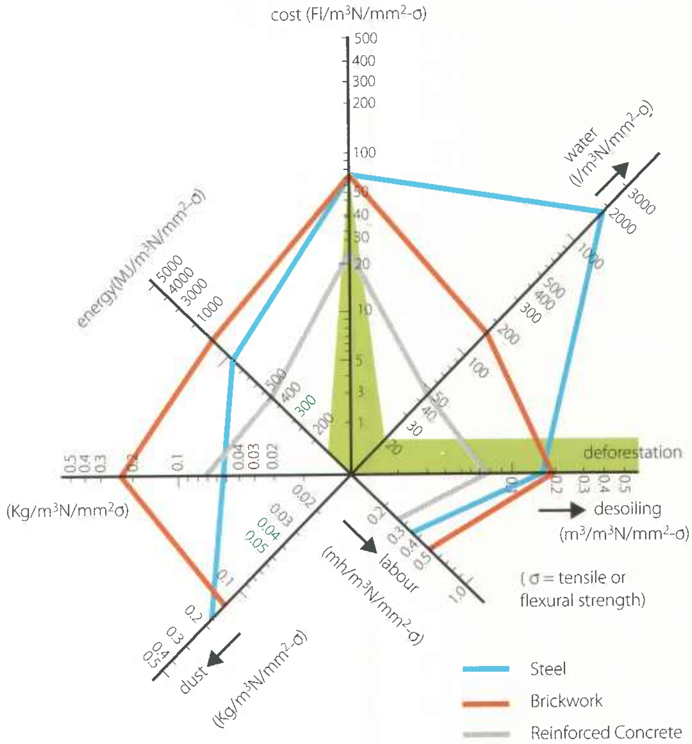
Introducing Sustainability into Design Methods

Engineering design for sustainability is in the earliest stages of its development. Much is still qualitative, with no consensus about what should be considered as the load (or the environmental burden). There is also little consensus as to which system or what boundaries should be considered. On the timescale over which the use of statics made its way into structural engineering, we have now reached the equivalent of about the year 1600. However our rate of progress is now quicker and we will probably need only another few decades for sustainability to 'catch up' with statics. The principle of optimisation is now well-established - adding a few new parameters against which to optimise is a far smaller intellectual leap forward than that taken by the great medieval mathematicians.

The first steps towards taking account of sustainability issues were taken in the 1960s when a concern for the finite quantities of resources in the earth began. In the wake of this concern came the logical progression from the biologists work. Rather than consider the weight of structures, the energy (and, hence, fuel resources) needed to produce a kilogram of a material should be considered - the embodied energy. Then quantify the structural utility obtained for a certain amount of embodied energy - an energy-based equivalent to specific stiffness. On this scale timber generally rates well, steel and aluminium less well.

Material	Embodied Energy	
	By Weight	By Volume
	MJ/kg	MJ/m³
Concrete	2	4.800
Timber	5	3,500
Steel	35	266,000
Aluminium	145	377,000

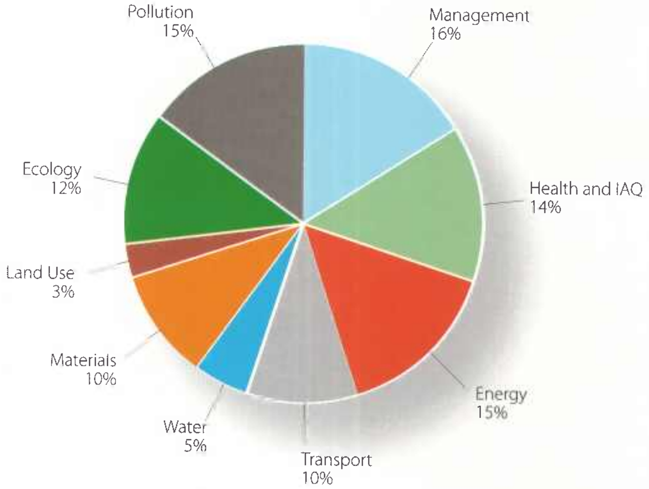
TABLES OF EMBODIED ENERGY FOR VARIOUS MATERIALS



ECOLOGICAL PROFILE OF VARIOUS MATERIAL PROPERTIES EXPRESSED PER UNIT STRENGTH

However, already a lack of objectivity and a degree of contention has crept in. The methodology for calculating embodied energy is not universally agreed - should an energy calculation include provision of the infrastructure used to transport the materials before and after manufacture? Furthermore, embodied energy is not strictly a material property - it is location specific. The energy needed to produce a ton of concrete or steel, and to produce a certain component from these materials varies with the efficiency of the processes used. Then there is the energy needed to deliver the component to site as well as the energy needed to maintain it in service in different climates and the energy needed to dis-assemble the structure at the end of its useful life...

The role of the achieving



WEIGHTING GIVEN TO DIFFERENT ENVIRONMENTAL ISSUES USING THE BREEAM INDICATORS

When one starts to consider recycling and other aspects of environmental impact (which correctly should incorporate economic, social and political issues) the picture quickly becomes horrendously complex. To some academics, this complexity seems to have become an excuse for generating more and more data. There are some people active in the world of Life Cycle Assessment (LCA) who say that LCAs should not be used to compare projects or alternatives because the circumstances surrounding each assessment are unique.

Sustainable construction is an achievable goal, and we can help this come about more rapidly rather than waiting for legislation. Such skills will form an important part of marketing strategies for consulting engineers in the future, contributing to their continued prosperity and commercial sustainability.

Clients and Project Managers

As the key stakeholders in most construction projects, clients are likely to dominate the degree to which sustainable construction can be delivered.

- clients with long-term aims and vision are likely to be more receptive (government departments, education establishments, infrastructure providers, the church)
- as a high-profile political issue, clients whose work is dependent on Government will want to be seen to embrace sustainability (energy producers, transport, education, some manufacturing)
- clients who deal with that part of the public for whom it is fashionable will respond positively (banks, supermarkets, etc.)

Architects

The role of architects in helping to deliver sustainability is ambiguous, for they have the greatest potential for inputting the vision that is needed in qualitative ways, yet little opportunity to address sustainability issues in quantitative ways - just as they have little role in influencing performance specifications of structural, environmental, geo-technical issues.

Building Occupiers and Infrastructure Users

The majority of energy is used during the building's operational life, rather than during construction (approximately in the ratio 10-to-1). The building occupier can thus have the major influence on how sustainably a building is used; this is generally beyond the influence of the original client, designers or contractor. For a building to achieve low environmental impact, the user must be prepared to adapt behaviour patterns to those envisaged by the designers as the most effective. While first occupants or owner-occupiers are likely to be keen to learn and change to sustainable lifestyles, later occupants or tenants are less likely to do so, as they have less interest in the long-term benefits.

Contractors

As the party most closely involved with using materials, contractors are well able to minimise waste and pollution due to the construction process. They may be able to select materials from sustainable sources, and are most likely to be able to make effective use of ISO 14001 BS EN: Environmental Management Systems - Specifications with guidance for use.

Construction Team in Sustainability

As engineers, we need to take a different approach. We must not let complexity lead to 'information overload' and confusion to the point of stagnation and inaction. Full incorporation of sustainability issues in engineering design will take many decades, but as engineers it is important that we begin taking it into account now, even though it may be in an imprecise way.

The Role of the Consulting Engineer

Engineers now need to describe and understand in quantitative terms the sustainability performance of a building. We need to step outside our familiar territory of accurately known loads, temperatures and the like, and enter the realm of imprecision.

Here we have another vicious circle. Professionals do what is required or paid for. So, unless clients, architects or regulating authorities demand quantitative performance specifications of sustainability, engineers are not likely to provide them. Most clients do not yet perceive a good sustainability performance as of sufficient value to justify any added cost. Governments have been hindered from imposing such regulation by the difficulty of establishing a consensus of views about which measures should be taken into account, how performance targets should be set and establishing an appropriate balance between incentive and compulsion ('carrot and stick').

At present the loudest cry tends to be 'we still need more data'. This is where engineers have a major role to play, to demonstrate how to break these vicious circles. History tells us that one of the engineer's skills is achieving action despite inadequate data. In the past we have successfully tackled other complex issues through a number of approaches:

1 Take a lead

- Anticipate legislation by taking the lead in demonstrating what can be done. Organisations are waiting for others to show such leadership.

- Do not expect others to devise ways to embrace sustainability - different players in the construction game have their own agendas.

2 Limit the problem

- Sustainability embraces social, political and economic issues as well as environmental issues. For the present, engineers should focus their attention on the more tangible environmental issues.

- When assessing the impact of individual projects, the boundary should be clearly defined, and be drawn in such a way that quantitative assessment of the impact is possible.

- The sophistication of the assessment method needs to reflect both economic reality (the time and resources needed) and the design stage (the precision of the data available). It is likely that different limits and assessment methods will be needed for different stages.

3 Develop design procedures which incorporate sustainability in qualitative ways

- Achieving sustainability is as much about the means as it is about the ends. A quantitative assessment cannot be undertaken until the process is understood in qualitative terms.

4 Select appropriate quantifiable indicators

- The indicators should reflect those matters that we are able to influence. Engineers should not be 'penalised' for constructing unsustainable structures on the instructions of others (clients, architects, contractors, etc.).

- While there is argument about precisely which indicators give a 'true' quantitative indication of environmental impact, there is consensus about the underlying relevance of the following:

- Use of energy and water
- Economy of material use in design and waste reduction during construction
- Use of recycled materials, including reuse of whole buildings
- Design for recycling
- Choice of materials with low toxicity
- Reduction of transport of construction materials
- Use of renewable resources (sun, certain trees, etc.)

- Engineers should differentiate their approach to quantifying sustainability from approaches used by others.

5 Create demand for their services by new approaches to marketing

- Armed with the design procedures and basic tools for assessing environmental impact we will be in a very strong position to persuade the other players in the construction process to start taking sustainability into account.

- Overt demonstration of a building's environmental credentials - the publicity value of a windmill or photo-voltaic array may far exceed its cost.

Bill Addis is an Associate with Buro Happold

Accepting the Challenge for the Future

The young engineers' view by Ruth Haynes

Sustainable development is about allowing there to be a future. But what kind of future do we want? We should experience more than just continuance of society and survival

As engineers at the beginning of the 21st Century, we are becoming used to using the words 'sustainable' and 'sustainable development', but do we understand what these words mean and are we using them correctly? Our first challenge is to understand the process of sustainable development.

As identified by Crispin Tickell:

Humanity has the ability to make development sustainable - to ensure that it meets the need of the present without compromising the ability of future generations to meet their own needs.

BRUNDTLAND, 1987

Then there is the following:

Sustainable Development is a process which enables all people to realise their potential and improve upon their quality of life in ways which simultaneously protect and enhance the Earth's life support system.

FORUM FOR THE FUTURE, 1999

Both definitions make it clear that sustainable development is about allowing there to be a future. But what kind of future do we want? We should experience more than just continuance of society and survival. The 1999 Forum for the Future definition reminds us that all people should be able to realise their potential within society, and improve upon their quality of life. At the same time we should not just be sustaining the Earth's life support system, but enhancing it - improving upon the present.

As engineers, we need to decide how this process applies to our day-to-day working life, and how we should develop to encompass sustainable development within our business. We are familiar with solving technical problems, but are less familiar with extending our remit to cover the 'people' facet of sustainable development. Our projects can make a big impact on our built environment - think of the Millennium Dome - and therefore we are making a big impact on people and society. This impact should always be positive. We need to be able to understand the 'big picture' which surrounds our projects.

As multi-disciplinary consulting engineers, our main business is construction. Construction is a business that deals with materials, products and energy. The engineer is closely involved with a supply chain, which starts with raw materials and involves their conversion into products and power. Many people are involved with this supply chain and the nature of the process will affect the stock of not only natural and manufactured capital, but also human and social capital. As engineers we are able to understand this chain, and the way that we manage it and choose our materials will impact significantly on achieving sustainability.

Sustainable development is as much about ethics and values as it is about science and technology. It is our values and ethical principles that give us the reason to pursue a new technology. Often our personal ethics and values are enshrined in legislation and law. During the design and realisation of an engineering project we are required to follow this legislation. However, legislation often lags behind current thinking, and as younger engineers we should be looking to the future instead of following the past. Our professional development should include education on ethics and values so that we are able to make informed decisions and push forward the frontiers, achieving more for less.

Engineers like facts and figures. But even the hardest facts are value judgements. We need to be very aware of the value judgements in the quantitative tools that we use, whether we are using cost benefit analysis to decide whether a project should go ahead, or the BREEAM (Building Research Establishment Environmental Assessment Method) scheme to judge how sustainable a building is - reading Bill Addis' article shows just how complex the issues are with measuring sustainability.

"We may need to rethink the role of the engineer. Perhaps we should re-enter the limelight, and become more involved in policy making and social comment. Engineers are creative people, but our creativity is directed towards adding value by cutting costs and making things beautiful. Maybe we should direct some of our creativity towards designing sustainable solutions, thinking about the wider social context of our work and pursuing sustainable development for the benefit of the youth of tomorrow as well as the clients of today. We, as young engineers with a forty-year career ahead of us, are prepared to tackle these difficult issues, to spend our energy and time wisely in pursuing truly sustainable building solutions, but we need the support and experience of our colleagues in Buro Happold and across the industry, in order to make the change."

Anthony Edwards/Image Bank

Ruth Haynes is a Graduate Structural Engineer with Buro Happold

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