PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Architecture of habitat: design for life

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Phil. Trans. R. Soc. Lond. A 1997 **355**, 1389-1403
doi: 10.1098/rsta.1997.0064

Architecture of habitat: design for life

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The construction industry and the industries which supply it have a vital role to play in the evolution of a culture of clean technology. Buildings have a crucial impact on the physical and economic health and well-being of the individuals, communities and organizations which they are intended to support. The global impact of the built environment is increasingly evident. It is necessary for everyone involved to recognize the role of buildings in the quality of our lives and the extent of our responsibilities in creating a sustainable habitat.

Buildings and their components are basic needs which should be socially responsible products able to contribute to our physical, psychological, cultural and economic well-being; yet they frequently contribute to ill health and alienation, undermine community and create significant financial liability. Modern planning, construction activity, building management and demolition processes are innately unclean and environmentally exploitative. We need to identify the consequences of our actions and to process these to show how we might create a healthy built environment within the ecological limits to which we must all defer. The existing culture of control of the environment must give way to a culture of appreciation and participation.

This paper will investigate ecological principles to identify mitigation strategies and the cultural shift which is required to create the intergenerational buildings upon which our future development depends. A critical appraisal of the new generation of self-declared, environmentally benign buildings could assist in determining appropriate directions for evolution of the built environment.

1. Basic needs

> Creation is not an act but a process. (Dobzhanskey 1994)

> How long can we go on and safely pretend that the environment is not the economy, is not health, is not the prerequisite to development, is not recreation? (Caccia 1987)

Buildings are enclosures created almost exclusively with the aim of providing improved environments for individuals, organizations and communities. We spend the greatest part of our lives, up to 90% in industrialized nations, within these artificial enclosures and we should expect them to enhance our well-being, be functional, efficient, joyous and healthy. Buildings should not constrain us as individuals or communities but facilitate us in our leisure, work and other activities.

Buildings should provide good internal air quality, comfortable conditions with regard to noise, heating, cooling and freshness, the safe disposal of sewage and other wastes, adequate and clean water, transport and communications systems, safety and security. These are basic rights of individuals and basic needs of an economy.

However, building designers, owners and users also have a responsibility to protect and, where possible, enhance the environment outside the building both locally and on a global scale. This means paying attention to the inefficiency, waste and pollution inherent in the technology which services these needs. Thoughtful design and management of energy demand, water demand and discharges, stack emissions, noise, waste production and visual impact can contribute to reducing the impact.

The way in which the built environment is planned should also be enhancing to our quality of life. This means paying attention to the needs of communities and respecting the natural environment and amenity.

2. Resources

Infinite growth on a finite planet is an impossibility. (Schumacher 1973*a*)

It is a commonly held belief that consumption is a measure of success, yet it is increasingly evident that the ability to meet social goals with minimum use of resources and minimum pollution should be the mark of a successful society.

3. Energy resources

The environmental debate has progressed largely as a result of concern for the atmospheric environment. Emissions due to service systems in buildings—pumps, fans, lights, ducts, controls, boilers, air handling plants, air conditioning, storage tanks, etc.—are the biggest single source of UK CO_2 pollution and a significant factor in ozone depletion and acid rain.

(*a*) *Mechanical or passive design*

Mechanical systems are an ever growing proportion of the capital expenditure of commercial and leisure buildings. They take up valuable space and present an ongoing burden with respect to running costs which is a vital aspect when determining feasibility. They are frequently more prolific, less functional and less efficient then they need be and therefore can be difficult to operate economically to meet real user needs, requirements and aspirations. In the UK domestic sector, central heating is now perceived as a vital element in new building design even where good passive design could remove the requirement. The currency of energy efficiency is ever in danger of being devalued and energy savings related to an ever rising and inappropriate datum. All too frequently design is driven by extremes leading to oversizing and inefficiency under most conditions. They are also on a short-term replacement cycle which makes them a substantial aspect of the life-cycle cost and much misunderstood by an economic culture dominated by capital cost considerations. Mechanical systems can also contribute to poor air quality, from poorly maintained air ducts for example, requiring yet more technology to resolve and adding to the vicious cycle of degradation.

It has not always, and need not always, be this way. In the past, buildings often made good use of orientation sunshine natural light and air, local materials and landscape features. Simple environmentally benign solutions are often possible with mechanical and electrical building services operating as efficient supplements to natural systems rather than as complete substitutes for them. The main requirements are not for increased complexity but for more care and forethought, more attention to the environmental impact of material and energy supplies and more focus on the genuine needs of organizations and users.

(*b*) *Context free or context dependent*

There has been an increasing inclination to design buildings removed from their context. Indeed, the rapid growth in building services technology in the 1960s facilitated a design approach which encouraged the architectural vision to be context free. So, new developments need have no respect for the local climate and many an office block has identical opposing facades which are physically 13 m apart but which have climates which may differ by the equivalent of 2000 miles.

New boiler designs and CHP systems provide opportunities to improve fuel conversion efficiencies over old techniques, though not radically enough to meet the need without use of passive techniques and renewables. Much could be achieved by serious attention to traditional techniques, innovative development and contemporary knowledge, which may differ from conventional wisdom. Concentration on the building form and fabric is vital and expenditure on design thinking, insulation and/or thermal mass are cost-effective means of reducing long-term heating and cooling demand in most situations. Careful window design to enhance daylighting without glare is important to reduce a major expenditure and because centrally generated electricity has poor conversion efficiencies from irreplaceable fuel sources. Windows are important because they interface with ventilation, heating and daylighting strategies. However, lighting technology has become increasingly sophisticated in recent years and much can be done with fixtures and fittings to reduce quantity without loss of quality. Internal layout of components and sensible control strategies which fail safe, fail efficient, fail obvious and can operate as manual on and manual/auto off can contribute hugely to savings.

Refrigeration and cooling technologies were until recently dependent almost totally on ozone depleting refrigerants but those manufacturers, clients and building managers who retained and maintained propane-, ammonia- and butane-based systems are now gaining the benefits as proponents of the new technology are forced to defend themselves against ever changing legislation resulting from the ratchet effect of international agreements. Maintenance and leak detection have achieved a great deal in meeting the requirements of the Environmental Protection Act. The threat of more stringent legislation plus overseas competition have combined to move the airconditioning industry toward seeking more environmentally sound solutions.

Air conditioning has become the normal defensive response to a hostile environment in city environments and, by extension increasingly, in rural environments too. The iconography is such that the development of a naturally ventilated building in a rural setting is now perceived as innovative. Instead, natural ventilation strategies are required which are able to deal with diverse comfort requirements in an internal space without exposing inhabitants to noise and pollution. Sealing buildings and providing controlled mechanical ventilation is one approach, although there are inherent dangers of moving from one technology to another of more damaging environmental impact. Increasingly, building physics and scientific approaches are seeking to replace technological solutions in buildings and advanced computer techniques are being used to model facilities at the design stage.

Active solar elements can also be applied to provide for electrical requirements. Some recent examples of innovation serve to highlight the frustrations and commitment of those who passionately want to turn our attentions to radical improvements.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Too often they result in absurdly expensive technology being applied to chase minute electricity bills when much more could have been achieved with rational investment.

Bioregional power generation and distribution from wind, wave, tide and solar thermal all remain options, although recent mainstream developments have been largely concerned with grid connection to satisfy supply side approaches rather than the demand-side approaches which are based on genuine user needs and requirements. Security of supply remains a major obstacle to greater application of renewable techniques. Landscape can provide an excellent resource aesthetically, for amenity and as a source of shelter from prevailing wind or excess solar gain. Natural materials are increasingly being investigated for energy and construction. Farmed crops, such as willow, offer a valuable energy source. Biogas generation and pyrolyses offer advanced forms of renewable energy generation from a wide variety of waste. The use of plants indoors is being used as a means of offsetting ventilation requirements without loss of indoor air quality.

Transport energy is a major factor in environmental pollution which is influenced both by planning policies, where they mitigate against mixed use development, and the aesthetic and environmental poverty of much of the built environment, which provides the impetus to travel. Out of town retail, business and science parks encourage a culture of pollution and disempower non-car owners.

(c) *Application of science not technology*

The last 23 years has seen concerted and substantial efforts at energy conservation within the UK which have failed to produce net savings. The role of greenhouse gases in raising awareness of environmental constraints, in the UK, is driving solutions which are singularly energy related to the detriment of holistic solutions. Constructions have been made increasingly airtight in the name of energy conservation. Problems which have occurred with respect to air quality and moisture control have ironically required energy consuming systems to remedy with the result that energy use per m^2 in buildings has increased.

Over the same time-span there has been a development of naturally ventilated and 'breathing' buildings which have aroused increasing amounts of interest. Dynamic insulation (sometimes called pore-ventilation) has been pioneered in Scandinavia. It is an exciting new approach to the heating and ventilating of buildings which has come about through an interest in developing the fabric of building construction rather than the supporting mechanical systems. Slowly it has also been introduced into housing, schools and office buildings and to great effect in sports halls. The perceived contribution of the breathing envelope to sustainable design results from reducing dependence on polluting forms of energy and the creation of a healthy indoor climate.

(d) *Dynamic insulation*

Nature hates a barrier and, given that human skin and clothing is permeable to air and water, a strategy of hermetic sealing of buildings is a questionable approach. Static insulation prevents air movement within a construction. Understanding the operation of natural systems has given rise to investigation into breathing membranes. Dynamic insulation operates when a pressure differential across a building membrane creates a controlled and constant airflow through a porous fabric which acts as a heat exchanger between the cold air being introduced into the structure and the conduction heat loss. The air is typically exhausted through a fan-assisted

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

vertical flue, although there are examples of pressurization being achieved through natural means, exploiting or enhancing the stack effect.

The heat loss in a dynamic insulation construction is expressed by a dynamic U value which is dependent on the U value of the construction and the air velocity through the construction. The airflow control through the dynamic elements is achieved by creating a resistance within the structure mostly in the R layer—a perforated (unwoven) cloth. It is crucial to protect 'air open' construction from the effects of wind pressure. This can be done using a wind protection layer combined with a pressure equalizing chamber, or by mechanical means, where the benefits can be proven. Understanding of the wind regime around the building is important to avoid reverse flow of air through the structure and careful detailing is necessary to prevent short-circuiting of airflows which would undermine the performance.

Ventilation noise can be reduced by careful design and, because air enters at low speed, it does not raise dust or other particles, thereby contributing to improved air quality. The membrane is also acting as an air filter, although experience indicates that clogging to an extent which would undermine performance of the fabric would take several times the buildings life.

One of the most significant properties of 'air open' construction is in the nature of gas diffusion through the building fabric, which allows CO_2 and vapour-linked pollution to diffuse out of the building as O_2 diffuses inwards. This phenomenon, in combination with hygroscopic water absorbing emitting materials, could reduce swings in indoor relative humidity and thereby reduce the indoor activity of mould, mite, bacteria and viruses.

The development of dynamic insulation in the sphere of ecological design has led to its specification in conjunction with environmentally benign materials such as cellulose insulation and cloth. It may be that for contingency reasons, in circumstances of compound innovation, other materials may be used which have the appropriate stringent performance guarantees.

Current feedback information on dynamic insulation indicates small savings in building costs and up to 30% of running costs, depending on building type and the amount of servicing technology displaced. The space and capital cost requirements of ventilation technology can be significantly reduced. Dynamic insulation also allows much lower ventilation rates—normally a major aspect of building heat loss—in part, because the ventilation system, in combination with the material specification, is not giving rise to indoor contaminants and also due to the potential for outward diffusion of pollutants through the pores of the structure. Energy savings are achieved not merely by improved U values, but also by the removal of the hot air cushion at the underside of the ceiling, which serves no useful purpose but cannot be readily avoided in conventional systems. The contribution to CO_2 reduction will be less dramatic in the UK than in Norway, with its high percentage of hydropower, as displacement in the UK is typically from low to high-impact fossil fuel technology.

(*e*) *Project development in Scotland*

Interest has been aroused in Scotland regarding application of dynamic insulation in sports buildings, where the pursuit of cost manageable, healthy buildings for healthy pursuits has been seen as a very exciting opportunity. There are presently plans to use pore ventilation in a swimming hall. Associated research aims to provide information on the energy and health implications of the completed building; the porosity of the key elements of the ceiling structure will be examined through laboratory studies and the monitoring requirements of the completed building established in order to seek to optimize the design and feed information into future projects.

4. Water resources

Water presents a challenging ecological limitation and provides an interesting example of the nature of design. Water is a renewable, albeit increasingly scarce, resource but the energy expenditure involved is usually not and purification techniques involve toxins which can give rise to secondary pollution. Non-industrial water consumption accounts for around 60% of delivered public supplies, all of which is purified to drinking quality using a range of chemicals. Significant amounts are lost in badly maintained pipelines and most of it is used for purposes inappropriate to the level of purification, including flushing the majority of it down the toilet. Increasingly, automatic flushing systems are applied which operate inefficiently. We drink about 3%.

The water closet was a major technological innovation in its day, introduced in an attempt by the water companies to conserve water. While it was clearly a major leap forward in technology, it now proves to be a poor environmental legacy which is being replicated across the globe. It is a mechanism for diluting, with many litres of water, substances that the body has expended considerable evolutionary skill in separating and concentrating. In so-called advanced societies, these valuable nutrients are largely lost. Such a technology must have minimum application where water is an increasingly expensive resource or where manufacture of nutrients by other means is expensive or environmentally detrimental.

Technologies and techniques are available which could be used at an individual or community level to provide low maintenance, low cost solutions with benefits to users and to the environment. Conservation techniques and water conserving fixtures and fittings are available. Low flush water closets and urinals, shower and tap fittings, water fuses and leak detectors are available. These are hardly space technology, incur no change for the user and yet are rarely installed. Rain water collection and storage is suitable for low grade uses such as gardens, car washing and toilet flushing, provided certain precautions are taken. Composting toilets can have no water requirement, though some designs involve user management which may be disagreeable.

Reed beds and restored and managed wetlands provide safe and pleasant amenity as well as ecological solutions for sewage and other organic waste and can slow run off to provide amenity and for landscaping or fire provision. Reed beds and more engineered systems, so-called living machines, which comprise a hugely diverse ecology to provide robustness, have been applied successfully in treating both industrial and farm waste.

5. Material resources and products

The construction industry consumes large quantities of materials and these ultimately constitute a substantial proportion of landfill. Careful specification can contribute to reduced pollution as well as improved indoor health and indoor climate control.

Extraction of building materials damages the landscape, natural habitats and eco systems and almost always constitutes irreversible depletion. In addition, materials

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

have a significant amount of embodied energy and may give rise to air, land and water pollution during any part of their extraction, processing, transport, use and disposal cycle. Sourcing of materials from recycled or benign sources, use of low embodied energy, low embodied pollution and low embodied water materials can reduce the overall impact of construction. Design for long-life, reuse, upgrading and recycling should be the norm if we are to transform the present human-centric linear model of material consumption to a circular biodiverse model. Social factors in material and product manufacture should be a consideration.

Products should as far as possible, and without detracting from fitness-for-purpose, optimize the use of limited resources and energy intensive materials, facilitate maintenance, recycling, reuse and safe disposal. Production of locally manufactured goods and services could make a contribution by enhancing the local economy and offsetting unemployment with strategic economic and social benefits to local communities.

6. Human resources

Buildings of architectural and engineering interest are essentially new, commercial and large scale, yet there is an urgent need to turn the viscous circle of decline in the existing small scale and public sector built environment into a virtuous circle of continual improvement. In many areas, poor quality housing and schools, lack of amenity, poor transport infrastructure and high unemployment, combined with lack of investment and vision have conspired to create low expectation, low achievement, state and utility dependence and atrocious environmental performance.

Local authorities have a responsibility for putting in place strategies to meet the UK government's commitment to sustainable development. If they are successfully to implement Agenda 21, then strategies are required to transform these estates which present major opportunities for benchmarked improvements from net sinks to balanced, safe, healthy and productive communities of the future.

Top down approaches cannot hope to be successful given the scale of the challenge and the imperative for local solutions. A sustainable built environment cannot be achieved without the active participation of communities able to take ownership of their habitat and demonstrate stewardship. Any approach must therefore stimulate local participation and support existing local initiatives. Many of the opportunities which present themselves provide opportunities for local employment and local empowerment as well as enhancing the local economy.

7. What will eat your building?

While there are limits to growth there are no limits to development.

(Meadows *et al.* 1992)

Buildings generally last a long time and badly designed buildings inflict unnecessarily high demands on the environment and are a poor legacy for future occupants and future generations, due to excessive running and maintenance costs and dwindling value over time. If they are demolished or overhauled prematurely they represent a wasteful use of capital, human resources and embodied energy and water. Specifiers and designers could be very effective in reducing waste and pollution.

Government has a wide range of instruments to choose from in its role as legislator and as initiator. In recent years there has been substantial growth in environmental

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

legislation and a commitment by government to a range of environmental initiatives. The general direction of the legislation has been towards emission and discharge controls, essentially 'end-of-pipe' through taxation on fuel and landfill; and employer liability such as COSHH and Duty of Care. There is evidence that government action is moving from end-of-pipe, through process controls such as BATNEEC, to design codes of practice and ultimately designs of processes of systems in which there is incorporation of environmental considerations at the design stage. Manufacturers and designers are increasingly expected to consider environmental impact at the design stage. Disclosure of environmental information is a natural progression.

Many building products are difficult to dismantle and are composed of composites from different materials, many of them indestructible. Disposal costs are rising and resale value becomes of increasing interest. A negative resale value, paying to have something taken away, is unattractive. Hence, as well as embodied energy and embodied water and pollution, we also see the rise of the economic instrument in embodied disposal cost.

What are we doing making and proliferating non-degradable detritus? If we are to live within the carrying capacity of the Earth we have to reuse all our goods effectively and make lasting, upgradeable and recyclable technology for buildings.

8. Green buildings

Buildings are not exempt from the growing market for 'green' products and the development of environmental labelling. Increasingly, they will be required to satisfy a number of criteria, including that they should not: endanger the health of the occupants, or any other parties, through exposure to pollutants, the use of toxic materials or providing host environments to harmful organisms; cause damage to the natural environment or consume disproportionate amount of resources, including land during construction, use or disposal; cause unnecessary waste of energy, water or materials due to short life, poor design, inefficiency or less than ideal construction and manufacturing procedures; create dependence on high impact transport systems with their associated pollution; use materials from threatened species or environments.

Conversely, they should: enhance living, working and leisure environments for individuals and communities inside and in the wider world; consume minimum energy and water over their life-cycle to meet real user needs and requirements; generate minimum waste and pollution over their life-cycle; evolve from, integrate with and enhance the natural environment; use renewable resources wherever possible.

9. Life-cycle

> It is often necessary to take a decision on the basis of knowledge sufficient for action, but insufficient to satisfy the intellect. (Kant 1988)

The most important decisions affecting the impact of a building are taken at the earliest stages in building conception and design. At present, many of these are of limited vision—the brief, location, selection of the design team, clarification of the client or user requirements, building management, future operational plans, design approach, local impact, orientation and form in relation to resources amenity, transport and microclimate—all have a fundamental and crucial impact on the environmental impact. Some of this is technological, some relates to the user and client interface in buildings.

Unfortunately, the tendency has been for the architect to design a prestigious icon and the engineer to then service it. As a consequence, the building rarely lives up to the vision but instead reflects the fee structure of the mechanical electrical engineer, generally based on percentage of equipment. Less than ideal buildings result from poor communication between the disciplines and their differing priorities.

It was clear some time ago that the issue was a matter of process not product and that what was required was an interdisciplinary approach and a strategic means of navigation through the environmental aspects of a project. In 1994, a Code of Practice was produced which aimed to: reduce the waste streams through buildings; create the foundation of a common language for all of those involved; encourage continual improvement consistent with the increasing adoption of environmental management systems of which feedback forms a vital element; and provide questions as a basis for discussion.

The target audience for the Code was anyone involved with the building process. The procurer can achieve a great deal by setting the right priorities and by clearly instructing the design team with respect to the requirements of the users, and also by being prepared to move away from the syndrome of lowest price and by supporting as far as possible, design selection and plant procurement on the basis of life-cycle cost and environmental impact.

The design team who by responding to—challenging and influencing if necessary—the procurer's requirements can contribute to the best result. Designers must think through issues leading to overdesign and inefficiencies, pay attention to detail and give forethought to maintenance, commissioning and manageability, and the needs and well being of the users. There is a need to integrate the architecture, structure and services strategies.

The professional institutions need to accept and promote a wider interpretation of engineering and construction than simply that of hardware provision and to encourage interdisciplinary design and appropriate fee structures.

Contractors, manufacturers and suppliers can contribute by minimizing any wastage, pollution, hazards and risks associated with their products, services and working practices; also, by supporting occupiers with better training and information. Owners and occupiers could assist by managing in a sound way and making improvements where practicable.

Everyone could assist by recognizing and pursuing quality. Feedback is a crucial part of any design and management process and yet the UK's architectural and engineering work stages stop at building completion. Opportunities for building users, managers and owners, designers and consultants to contribute to the enhancement of the design process are at present predominantly piecemeal and, in the extreme, litigious. Structured feedback mechanisms provide users of a product or service with the opportunity to express their satisfaction or otherwise in a coordinated way. To providers of goods and services, feedback is a resource, an information pool. Feedback is a means of quality control and a marketing tool, as well as a recognition that all activity can represent a learning opportunity. Wisely used it can enhance beneficial innovation and reduce expensive, dangerous and short-sighted errors from being perpetuated.

With hindsight, all of those involved could have something to contribute to the design process. Hence the structure of the resulting code completes the life-cycle and

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

identifies key issues during occupation, refurbishment and demolition. A structure for providing feedback is included. The Code of Practice has been used by developers, clients, designers, consultants and contractors in relation to new build, refurbishment and demolition projects in housing, commerce and public buildings. The Code itself is a dynamic document which will need to be updated to reflect changes in culture, technology, experience, guidance and best practice.

10. Intergenerational equity: children's EcoCity

> It is an injustice, a grave evil and a disturbance of right order for a large and higher organization to arrogate to itself functions which can be performed efficiently by smaller and lower bodies. (Handy 1994)

The UK commitment to sustainable development has been translated as 'not cheating on our children' or 'intergenerational equity' and it seems appropriate that initial planning for long-term development should have the participation of the eventual users, many of whom are presently children.

Within Scotland there is interest in seeking strategies by which children can be enfranchized and a team of educators, facilitators, planners and architects have developed a framework, the EcoCity Project, within which children's contribution to the built environment development process might be explored. The EcoCity Project provides children with an opportunity, at present uniquely, to consider and comment upon their living environment and their needs, requirements, aspirations and vision. Through a workshop process the children, aided by a professional and interdisciplinary team, design, plan and build their vision of their future community.

(a) *Craigmillar EcoCity Project*

A major development of the southeast wedge of Edinburgh will entail the construction of a new hospital, support services, new housing for 20 000 people and the associated infrastructure; one of the biggest developments in the region for decades. While the EcoCity Project has been undertaken several times as an imaginary project, the very real development plans at Edinburgh provided the first opportunity for the EcoCity team to work with the children to explore and deliver their vision for a real project. Simple ecological principles were followed.

The EcoCity team worked with four schools from the peripheral estate at the edge of the planned development and took an area approximately three miles by two miles which was modelled in relief, this included a scaled model of the existing estate. Ten children from each of the four schools were challenged to come up with their ideal city in an intensive week long session.

(b) *Concepts*

The children's concerns reflected pollution toxicity and energy and water conservation, waste recycling, infrastructure development and biodiversity. The children integrated environmental, community and economic aspects through job creation, recreation, support services and mixed use development.

Amongst the first element that the children considered in planning the site was water. Each group showed streams, rivers and lochs. They were encouraged to work with neighbouring groups and to develop a rational system of waterways based on the existing river system and the collection of water at high points of the site. The result was a central loch connected to a network of streams. This was recreational and also handled the site drainage. They also considered reed beds to treat sewage and grey water and located these close to housing areas. Some of the houses incorporated individual water recycling schemes.

Various forms of energy were used ranging from wind and solar farms, to photovoltaics on individual buildings. The children were very aware of the need to insulate houses to save energy. Transport around the site was a tram system with cycle and skate paths and walkways. Recycling centres were located at tram stations. The children paid close attention to the need to provide emergency access to particular buildings but otherwise cars were considered undesirable because of accidents, pollution and congestion. The aesthetic contribution of flowers and plants to the site was considered fundamental from the outset and the landscape strategy provided for a wildlife corridor through the site. Food production in local farms were a strategic consideration. The city evolved into a collection of village units connected by trams and walk/cycle ways. The children chose to regenerate the existing housing and landscaping, rather than demolish it, which they did with imagination and flair. New settlements took village and courtyard forms. The model is presently being displayed at a series of venues and a video is available which documents the week's activities.

An intergenerational element is fundamental to the implementation of sustainable development and the EcoCity case study shows there are real benefits to be had which should be widely acknowledged and incorporated into consultation processes with user groups.

11. Sustainable construction

If you're not part of the solution you are part of the problem. (Cleaver 1974)

It has become increasingly evident to those in positions of responsibility that it is no longer tenable to do other than seek to identify sustainable development strategies given that the alternatives are unsustainable development or no development at all. Serious debate is focused only on the pace, means and methods of achieving sustainability and agreement is sought regarding a common understanding of how it might be measured and targeted. There is presently no consensus of opinion regarding a definition of sustainable construction, but the definition proposed here is: 'sustainable construction involves participation by all in the creation and stewardship of a healthy built environment based on resource efficient and ecological principles'.

This definition makes clear that: construction is a responsibility; ecology needs to be an integral part of the design process and requires understanding and experience; construction is a process, not an act; and construction requires the interdisciplinary participation of professionals and non-professionals.

(i) *Construction is a responsibility*

Every aspect of construction has a consequence which needs to be processed in order to aid future decision making and to determine future approaches. This requires feedback from buildings in use and the generation of radical innovative techniques. Potentially appropriate techniques need to be rigorously researched, monitored, optimized and disseminated and mitigation strategies need to be established and implemented. All new building, and existing building management or demolition, needs to be undertaken with a view to minimizing the long-term liability of the building and its components. Strategies will include increased use of passive design, knowledge- and procedure-based rather than technology-based solutions, interdisciplinary design, user consultation, local resource and infrastructure management and design for reuse and recycling as the norm. There is a particular responsibility for the long-term liability of mechanical and electrical systems in economic, management and environmental terms which needs to be analysed from the outset.

Given that the challenge is almost inevitably context dependent, only rarely will there be 100% right answers. Decision making may appear as a complex and difficult task. None the less, professionals are required to make decisions as a matter of course and incorporation of environmental concerns is a modern requirement of the professions. The institutions can contribute to the process by providing appropriate and valid support from all fields of ecological design.

(ii) *Ecology needs to be an integral part of the design process and requires understanding and experience*

Ecological design is based on knowledge, understanding and observation of natural processes. If construction professionals are to provide for the client of the future there is a need for more symbiotic design approaches. All involved need to gain experience in the application of fundamental design principles. Ecological design involves a systematic appraisal of biodiverse systems which can guide our actions based on a balanced and precautionary appraisal of response to risk.

There are simple principles which can be followed at a strategic level which will assist us slow the rate at which we approach the carrying capacity of the Earth. These principles provide a point of reflection for discussion and debate in order to develop and communicate a clear and sophisticated understanding: minimize non-renewable resource consumption; reduce, restore, reuse and recycle; enhance the natural environment; recognize and pursue quality; elimination of control toxins; network to create constructive interdependencies; learn from experience; transmit positive and negative experiences; minimize waste and prevent pollution; utilize outputs from processes as inputs; and edges are interesting.

(iii) *Construction is a process, not an act*

Construction activity extends from inception to demolition and beyond, to the recycling of components. Decisions at each stage are all relevant and will positively or adversely effect the economic, social and environmental liability and ecological impact. These can be concerned with a range of aspects from procurement strategy to location, materials, management and tender-related issues. While significant attention is presently focused on life-cycle analysis, much could be achieved by a more strategic life-cycle approach which set construction activity within the closed system global context to which we must all defer.

(iv) *Construction requires the active participation of professionals and non-professionals*

Total design approaches are perceived as one way to achieve a functional, efficient, joyous and healthy built environment. Meeting real needs and aspirations requires users and management to participate in the design process at an early stage to understand the opportunities and constraints. The involvement of technicians, those responsible for ongoing use and management, and users in the design process as

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

members of the design team, and at an early stage, puts them in a position to contribute to the development of innovative strategies for the servicing of cost-effective environmentally benign buildings.

12. Culture shift

Man has become too clever to be wise. (Schumacher 1973*b*)

Sustainability isn't just about the environmental ether. It is also about social fabric, the glue, about economics, wealth and matter. It is about value systems, educating children who can educate their children, about building lasting communities, enriching the soil and not depleting it. It is about developing permanent cultures with an ethos of continual improvement, buildings which contribute and don't deplete, which increase in value over time. It is about dignity. A culture shift is fundamental to the pursuit of sustainability and the direction of this shift is increasingly evident. It is appropriate that this culture shift is accompanied by hindsight which can allow us to benefit from past experience, by increased effectiveness to provide time for development of insight and foresight to develop a vision for the future built environment which is compatible with sustainable development.

The common features of this culture shift signify a move from the scientific, reductionist world view to a holistic world view which began with Fourier & Owen and was developed into an applied human ecology by Geddes. It remains the path not taken.

The culture of construction is essentially profligate with respect to energy and material resources and is largely indifferent to the environmental, economic and social consequences of short-term strategies. However, environmental design is increasingly perceived as a fundamental means of achieving client and user aspirations for a comfortable, maintainable, flexible, affordable and healthy indoor environment with minimum local and global degradation. We need global solutions, innovative future concepts for human settlements with the diversity necessary for our future survival. The economic case for a longer-term approach is becoming increasingly apparent as maintenance repair, demolition and replacement become less and less feasible as options. The buildings and technologies which are required are those which are most fitting to a sustainable economy, those which are functional, efficient, manageable, joyous and healthy and consequently increase in value over time rather than decrease.

The overriding question which results from a review of this nature is 'what kind of construction industry do we want for our future and what kind of built environment can we expect subsequent generations to provide in our dotage when we have left them so little of lasting quality and value?' The first concerns for global warming, acid rain and ozone depletion were expressed by responsible scientists in the 1970s and we chose largely to ignore them. Clean technology must mean listening to what we are being told and not settling for lipstick on the gorilla.

It is not acceptable that anyone should simply borrow the rhetoric of ecology and apply it to commercial ends. Commercialism will inevitably breed opportunists who will hijack the agenda and seek to inoculate us against genuine and effective solutions. The futuristic green visions are already emerging and, where they rely on the old theory of control and beating nature into submission, they should be treated with scepticism. Where they use the language of environmentalism and turn it to naive, tokenist or cynically unjustified ends, they should be exposed. Solutions

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

need to be rigorously scrutinized for their validity and examined with respect to the environmental approach, the priorities of the clients and design teams and the actual achievements.

Precautionary action begins with learning from our own experiences and those of others. If we suspect a problem or can envision a better solution, we should deal with it constructively and not talk it down. Feedback should aim to identify how good ideas in theory work in practice, identify the most cost-effective opportunities for significant improvement and identify the generic and strategic measures necessary to encourage responsible building design and responses adequate to the risk.

There is an inclination to read Darwinism as survival of the fittest, the biggest, boldest and strongest. In reality, it becomes clear that it involves survival for those most fitting and that involves the application of precaution and humility in the face of ecological limitations to which we must all ultimately defer.

Thanks to Cathy McCulloch of the TASC Agency and Howard Liddell and Drew Mackie of Gaia Planning for permission to use material from the EcoCity Project.

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Discussion

K. Kendall (*Department of Chemistry, Keele University, UK*). Ms Halliday describes architecture structures, and how these are made from bricks, for example, and how they relate to the environment. However, she makes no mention of concrete, surely the most important and pervasive building material on the planet. What is her vision of concrete as a contributor to clean technology in the future?

S. Halliday. I would counter that earth remains the most important and pervasive material on the planet, making up around 40% of the world's buildings and with good reason. It is sustainable, locally available, cheap and tolerant of local conditions and skills, with low embodied energy and minimum toxicity.

My thoughts about clean technology have often been guided by my experience in the Middle East, where, for example, concrete housing has replaced earth structures and, unlike the local vernacular buildings, led to unacceptable internal temperature extremes and major discomfort. When people moved out and animals were moved in, this proved equally unsatisfactory and eventually the buildings were abandoned. (In the UK they would then be listed!)

This is clearly an example of inappropriate application and it is unfair to judge on the basis of this in isolation. There are doubtless cases where concrete is an appropriate and even noble material. But if we are to provide genuine solutions and avoid waste we have to be wary of imposing solutions generated for one acoustic, economic, climatic and social context too widely without thorough investigation of the appropriateness.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES