

Towards Environmentally-Responsive Architecture

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ABSTRACT: The paper discusses three key issues that are of critical importance in the evolution of an environmentally-responsive architecture, -that is an architecture aimed at achieving occupant thermal and visual comfort with little or no recourse to non-renewable energy sources. These are: knowledge, performance and the urban context. Two of this year's projects serve to illustrate these issues in an educational context.

1. INTRODUCTION

The architectural literature is abounding with recent buildings that are claimed to be products of a strong environmental agenda. On closer inspection, however, few of these buildings are as "environmental" as claimed. Invariably, projected energy savings are more modest, and the thermal and visual comfort improvements less consistent or widespread than assumed. So although regular exposure in the architectural press helps spread awareness of environmental issues among young designers and students, the image that emerges is hardly promising or inspiring. For commercial buildings, this is essentially little different from "pre-environmental" models, that is a highly exposed external skin, heavily engineered to counteract the negative effects of excessive glazing, at least partly air-conditioned and closely controlled by a building management system. Being more sensitive to climate and site conditions, new built residential schemes may display more architectural and environmental variety, but claims of environmental-responsiveness need close scrutiny when looking at schemes across climates and site conditions.

It could be argued that the disparity identified above is mainly a matter of opinion, that is a reflection of different environmental criteria and expectations than those that informed the design of these buildings. If so, where do such opinions, criteria and expectations come from to inform the environmental-responsiveness and performance of buildings? And, how do these change over time and as a function of building type, climate, site and local or national differences in lifestyles or building construction?

One of the lessons of PLEA, now into its twentieth international conference, is that our field is ever changing. An environmentally-responsive architecture is not a fixed ideal, but an evolving concept that must be redefined and reassessed with each new project. The notion of environmental responsiveness should

relate to occupants and their activities, to the city, and to change, as well as to the outside climate. For our teaching programme at the AA Graduate School this process starts by looking at three key issues:

- the *knowledge* that informs design and decision making
- the environmental *performance* targets to be achieved
- the environmental attributes of the *urban context*.

These are briefly discussed below. Acquiring and maintaining the proficiency needed to create and sustain an environmentally-responsive architecture requires motivation, dedication and a considerable amount of time. There can be conflicts with other criteria. For some designers environmental aspects are just an additional concern; for them environmental design is then essentially mainly corrective rather than generative. These issues are briefly discussed in the final section of the paper and illustrated with some of this year's projects.

2 COGNITIVE DOMAINS

Interactions between buildings and the natural or manmade microclimates that surround them vary across space, as well as over time, generally affecting indoor conditions in counter-intuitive and unexpected ways. Predicting the outcome of such interactions and modulating their effects to provide thermal and visual comfort in and around buildings are tasks that require specialist knowledge and tools.

Such knowledge and tools derive from three main sources. First, a good *theoretical* grounding is essential to provide designers with the ability to conceive ways in which building physics can translate into architecture. We acquire this type of knowledge by following specialist studies during or after an

architectural or engineering degree course. Second, *empirical* knowledge is needed that can tell us how different techniques have worked in practice, and the extent to which their performance has satisfied the environmental design criteria set at the design stage. We acquire this type of knowledge from fieldwork, with direct observations and measurements, and by interviewing occupants after the buildings are completed. Third, we need *analytic* tools and simulation techniques to use at different stages of design to make performance predictions on which to compare and fine-tune designs thus helping to test hypotheses derived from theoretical knowledge, as well as to draw generalised conclusions from limited measurements and observations. For successful results we need proficiency in all three of these cognitive domains. At present few architects and students of architecture have specific knowledge in any of these three cognitive domains. It should be possible to introduce all three into the architectural curriculum without marginalizing them in the form of technical or auxiliary studies. However, there are also important questions concerning the current state of available environmental design knowledge and tools. Essentially, both are at their weakest, least accessible and most complex in the areas of highest design uncertainty where most help would be needed by students and designers. For example, the characterisation of urban microclimates, the study of airflow in and around buildings, and the design implications of interactions between lighting and thermal processes. Given the propensity of architects and students of architecture to invite complexity from the earliest stages, it is invariably disappointing when the tools available are unable to handle such complexity, or when the right tools are themselves too complex to use or unavailable to designers. Theoretical and empirical knowledge and analytic tools must continue to develop closer to design.

3 PERFORMANCE

What should we expect from an environmentally-responsive architecture? What kind of environmental conditions should it attain, what margins of variation should it encompass to accommodate variations across spaces, over time and between different occupants and activities? What materials and construction techniques should be chosen? How much non-renewable energy use should be targeted for construction, operation, reuse or recycling of a building? Should we aim to displace all conventional HVAC equipment? How should environmental performance relate to building form and function?

These are critical questions that we have to go on asking. Most of the answers will change each time we ask the questions. For new buildings a trend towards zero use of non-renewable energy seems to have begun in some Northern European countries. For these cooler climates this was fostered by successive improvements in the levels of thermal insulation applied to the building envelope. For the UK such trend can be observed in Fig. 1 that shows the normalised annual space heating energy demand of

low-energy residential buildings of the last twenty years as a function of the buildings' total heat loss coefficient [1].

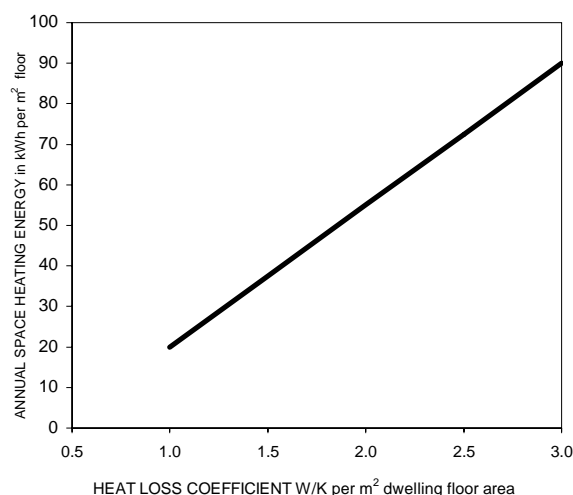


Figure 1: Normalised annual space heating energy use of 1980's UK low energy houses (after [1])

In the mid-1980's a building heat loss coefficient in the region of 1.0 W/K per m² dwelling floor area represented a level of thermal insulation that was termed "superinsulated" and was considered to be experimental for the UK construction industry. Today this should be achievable by any new built scheme that considers itself "low energy". In conjunction with good solar access and judicious distribution, orientation and specification of window frames and glazing this would bring the line on the graph closer to making the installation of a conventional heating system redundant. In Northern Europe the high levels of internal heat gains that have been common to office buildings could have displaced conventional heating for that building type. Moreover, the sensitivity of office work to solar gains should have resulted in more attention to orientation, lower levels of glazing and better solar protection thus improving daylighting, preventing overheating and avoiding the need for air conditioning. These, together with clearer notions of what would constitute acceptable ranges of thermal and visual comfort for occupants should be the performance targets for this building type, though not yet commonly achieved. Other building types and other climatic regions will require different strategies.

Consideration of performance also leads to questions on how any given performance is to be achieved. Will it be a matter of prosthetic technology, that is the addition of a further layer of skin over or under another? Is it the product of the use of new materials, such as high-tech glazing systems, or recycled and recyclable ones? Are there special merits in biomimetic applications derived from natural and biological processes?

4 THE URBAN ENVIRONMENT

It is well known that urbanisation changes the climate of a place. This change initiates a feedback

loop that affects inhabitants' choices, way of life and use of energy resources. For example, the heat island that follows high density urban development accelerates the take-up of air-conditioning equipment which in turn steps up demand for electricity, as well as contributing to further warming-up of the city environment [2]. There are further issues arising from the urban climate change that should have a bearing on urban design. One such issue is that the urban tissue accommodates distinct microclimatic niches of unknown characteristics and variability. On any given urban site, air and radiant temperatures, relative humidity and air movement may vary both considerably and unpredictably in relation to data available from nearby weather stations. On the other hand, the coexistence in close proximity of different microclimates suggests that a process of ecological regeneration can be initiated in the form of local interventions [3].

5 TEACHING PROGRAMME AND PROJECTS

The one-year Master of Art (MA) programme in Environment & Energy Studies at the Architectural Association Graduate School looks at these issues through its taught programme of lectures, seminars and practical workshops, and through projects that combine design research with environmental analysis. Two of this year's design projects will serve

to illustrate the programme's current approach and some of the issues faced in the process.

5.1 Form and Performance

This year's first project highlighted the relationship between form and performance and provided opportunities for using a variety of tools and techniques to develop building-like forms with specific environmental design attributes. The project started with the analysis of some well known recent buildings. Critical information derived from these studies was used as input for the investigation of new forms using exploratory modelling techniques, Fig.2. The forms created by this process were tested and modified to achieve desirable environmental design attributes. Following a stage using physical models and testing based on measurements, heliodon and wind tunnel, work continued with digital modelling so that the environmental simulation tools introduced by the taught programme could be applied to assess the relationship between form and performance. As students' knowledge and use of tools improved the project's brief was directed on the design of a new built structure for a village school outside Accra, Ghana, Fig. 3. Designs for the school structure were developed over the last few weeks of the first trimester of the academic year. In early February 2003 design proposals were merged and in the course of a ten-day study trip a structure was erected by student teams at Pankese village, Ghana, Fig. 4.

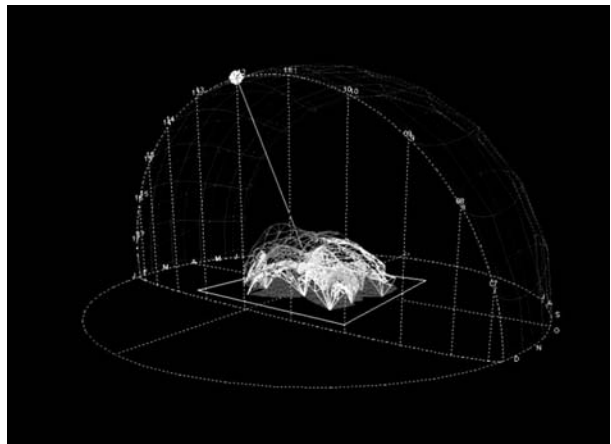
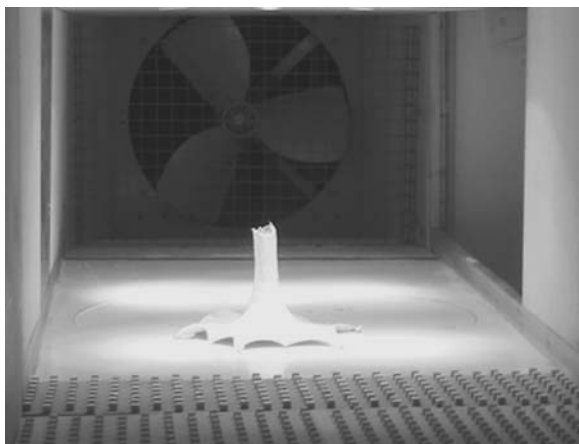


Figure 2: Models produced and testing of forms developed for tropical climate on wind tunnel and digital heliodon



Figure 3: One of the designs developed for the village school at Pankese, Ghana

Research on the structure's roof finishing to provide solar control without inhibiting air movement forms part of an ongoing dissertation project.

5.2 In the City: Goodsyard, Bishopsgate, London

The brief of this year's second project was aimed at mixed-use development combining residential units with workspaces and shops. The site, Goodsyard, in London's Bishopsgate area is a redundant 19th century railway interchange adjacent to the city's financial centre. The project's building programmes and spatial organisation of uses were to be developed by student teams from studies of the changes in family structure and household composition that have

shaped current trends in housing demand in London. The brief also called for research on the relationship between home and work, and on consideration of processes and techniques for responding to future change and upgrading. The site's elongated form and its elevation above street level over a network of Victorian brick arches offer excellent conditions of access to sun and wind. London (latitude 51°28'N) has a temperate climate with a mean annual air temperature of 10.6°C and annual average of 4.18 sunshine hours per day. Monthly values vary between means of 4.2°C and 1.54 sunshine hours in January to 17.5°C and 6.34 hours respectively in July [4]. New buildings on site were expected to be self-sustaining

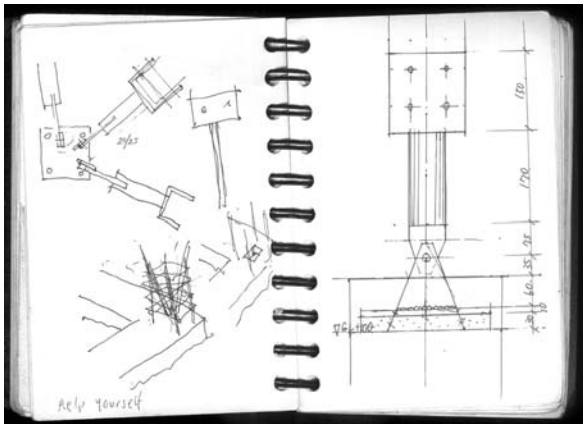


Figure 4: Students on fieldwork at Pankese village, Ghana and views of structure erected for the village school

in energy and to contribute to the urban microclimate by making use of local resources.

Design research and environmental analysis procedures for the project consisted of the following steps:

- 1 Development of building programme
- 2 Setting of environmental design targets
- 3 Climate and site analysis
- 4 Reference thermal studies
- 5 Review of options for building form
- 6 Research, design and representation of proposals
- 7 Testing and revisions.

Steps 6 and 7 were to be repeated as needed to refine solutions. Figures 5-8 highlight some of the key concepts from four out of a of twelve schemes produced for this project by the MA students. Figure 5 shows proposals for the narrowest section of the site. The building form is oriented and shaped to provide daylighting and solar control as a function of orientation and space functions with variable responses built into the southern elevation. Figure 6 shows a proposal for the wider section of the site with a building form that is shaped by voids defined in response to solar access, air movement and

rainwater collection. The roof of the organic form resulting from this study is then developed as a green landscape. Figure 7 illustrates the generative concepts of another scheme that was inspired by extrusion and transformation of the forms of the 19th century brick arches resulting in a series of linear building forms facing into transitional spaces and landscaped segments. Figure 8 shows a scheme for which the zoning of uses by orientation (residential to south, offices to north) became the generative concept for the building form and environmental design strategy.

5.3 Educational issues

Given the single calendar year span of the MA programme the amount of time available to each of the projects described above is limited to about 10-12 weeks each. The projects take place in parallel to an intensive programme of lectures and seminars which restricts further the time available to students for in depth study. Working in teams can balance time with manpower and complementarity of skills within a team can provide further advantages. Irrespective of duration, the scheduling of projects in parallel to the formal programme of lectures and workshops helps

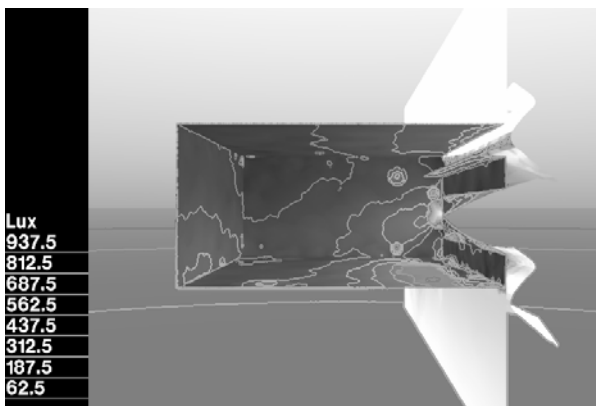
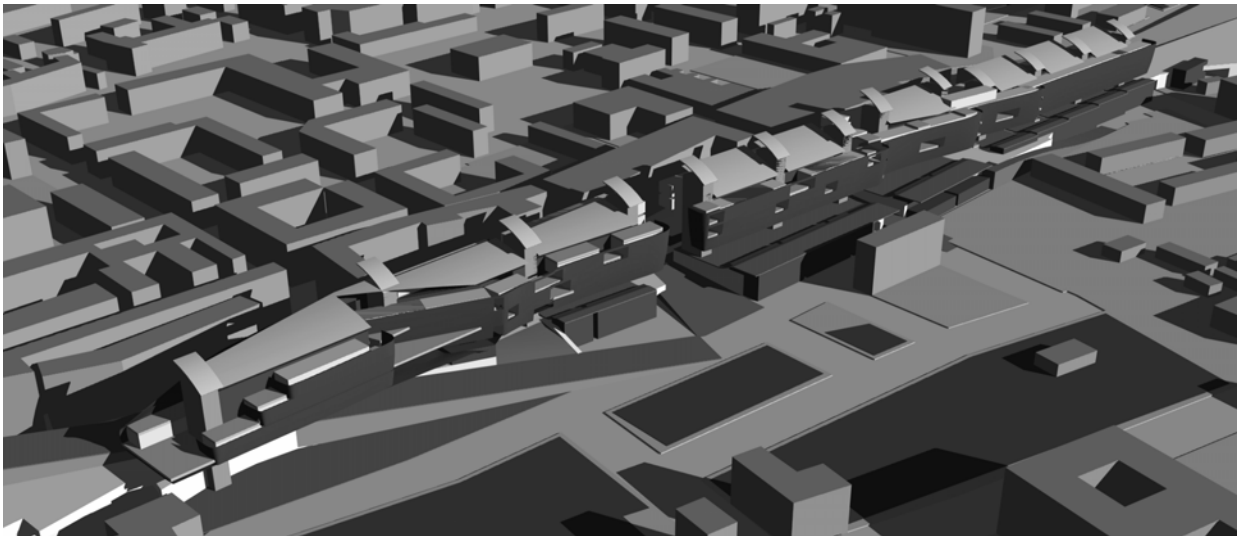
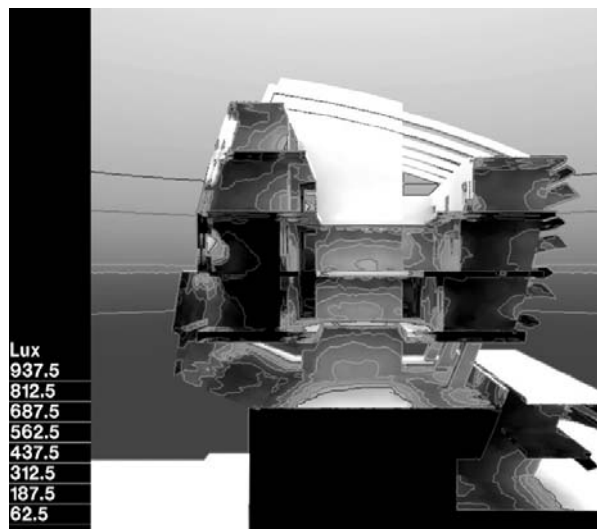


Figure 5: Single, long building form for narrowest segment of site with building section design reflecting space functions and orientation.



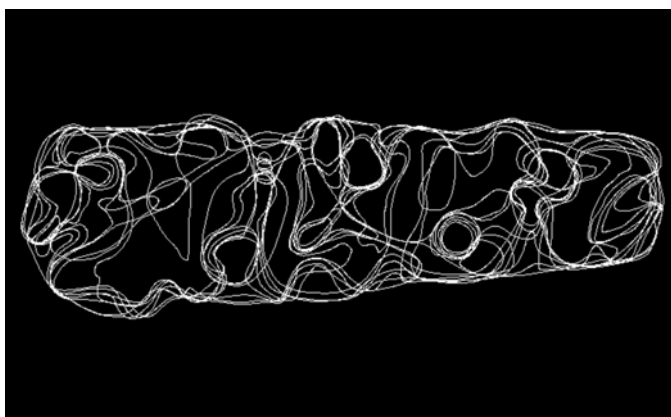


Figure 6: Heliodon studies to help shape the “sun voids” and resulting plans overlaid.

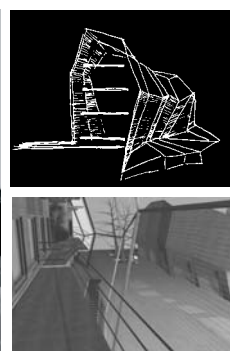
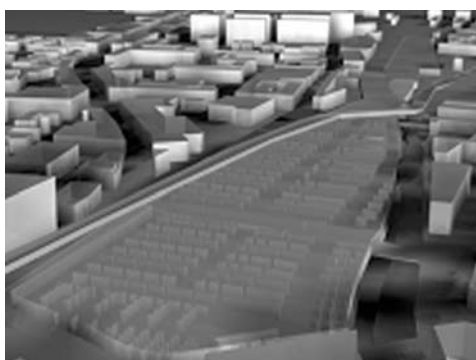


Figure 7: Generative concept for Goodsyard site

students assimilate and apply the knowledge and tools provided by the course. Jointly they provide the basic training on which is built the more in-depth research that characterises the work for the dissertation projects which occupy the second half of the one-year MA Programme.

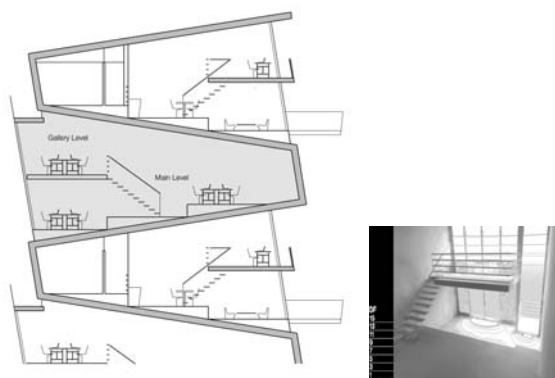


Figure 8: Section folds zoning residential to south and office to north

CONCLUSION

An environmentally-responsive architecture is not a fixed ideal, but an evolving concept to be redefined with project. Education should take a driving role in this evolution. We need to move beyond the technical fixes perpetrated by current practice and start extending the architectural vocabulary towards expressing the temporality of natural and operational cycles in more diverse and creative ways.

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ACKNOWLEDGMENT

Models and drawings illustrated in Figs. 2-8 produced by Santiago Aguerrebere, Paolo Cascone, Angeliki Chatzidimitriou, Annie Cheung, James Erickson, Robert Fryer, Werner Gaiser, Anthony Gavalas, Alexander Herrera-Rojas, Ren Ito, Hrishikesh Kulkarni, Autumn Peterson, Cheryl Pilliner-Reeves, Anuradha Sabherwal, students in the 2002-03 MA programme. The structure erected at Pankese village, Ghana was built in collaboration with the AA School's Intermediate Unit 4 led by Mark Hemel.