Adaptive Architecturing
a learning process

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ABSTRACT: The paper reports on research undertaken at the Architectural Association School of Architecture for the Masters programme in Sustainable Environmental Design. The programme's pedagogy is driven by adaptive architecturing, a generative process that proceeds from inside to outside, providing the means to adjust the built form and its properties to suit occupant activities inside and the daily and seasonal cycles outside. Common objectives of all projects are to improve environmental quality in cities, achieve independence from non-renewable energy sources and promote an architecture of sustainable design.
Keywords: adaptive architecture, sustainable design, occupant comfort, free-running buildings

INTRODUCTION

The conditions for a symbiotic relationship between buildings and the urban environments they form and occupy are the main concern of the Masters programme in Sustainable Environmental Design at the Architectural Association School of Architecture in London. Knowledge and understanding of the physical principles underlying this relationship, along with the conceptual and computational tools to translate them into an ecological architecture and urbanism, form the core of the taught programme. In the last five years the programme's continuing research agenda on "Refurbishing the City" has initiated over 350 projects in 70 cities and some 40 countries, both north and south of the equator, encompassing a wide range of building types and climates with proposals for both new and existing schemes. The research process combines on-site measurements and interviews of designers and occupants, with simulation studies using computational tools calibrated with data from the fieldwork. Case studies of occupied buildings and outdoor spaces undertaken in different climates, have provided valuable insights on fundamental environmental issues which affect occupant comfort and well being, as well as building performance and energy use, and which are essentially architectural in nature, Fig.1.

Most of the programme's participants come from warm climates where the effect of climate change is quite pronounced in large cities. Providing alternatives to the universal architecture and brute force engineering that are still the norm for architects in these climates requires new knowledge on what makes a good environment for inhabitant comfort and environmental quality, and how architecture can contribute to creating such environment, Fig. 2. While much research over the last forty years was focused on energy efficiency and on the physics and engineering of environmental design, little of this research directly addressed any fundamental environmental questions of architectural design. As a result preconceptions continue to prevail on what role architecture might have as a tool of sustainable environmental design, Fig. 3. In addressing such preconceptions the programme is driven by the notion of *adaptive architecturing*, a generative process that proceeds from inside to outside, providing the means to adjust the built form and its properties to suit occupant activities inside and the daily and seasonal cycles outside [2,3]. Key objectives are to improve environmental quality in cities, achieve independence from non-renewable energy sources and promote an architecture of sustainable environmental design. These are illustrated here with some recent projects.

Figure 1: Robin Hood Gardens, one of some fifty housing schemes studied in London for the Masters programme in Sustainable Environmental Design. This iconic building designed by Alison and Peter Smithson in the late 1960s is now being demolished. Measurements and simulations performed for this scheme highlighted both the ingenuity of its complex interweaving of dwellings (coloured section, right) and the environmental weaknesses this built form and its "streets in the sky"(left) entailed [1].

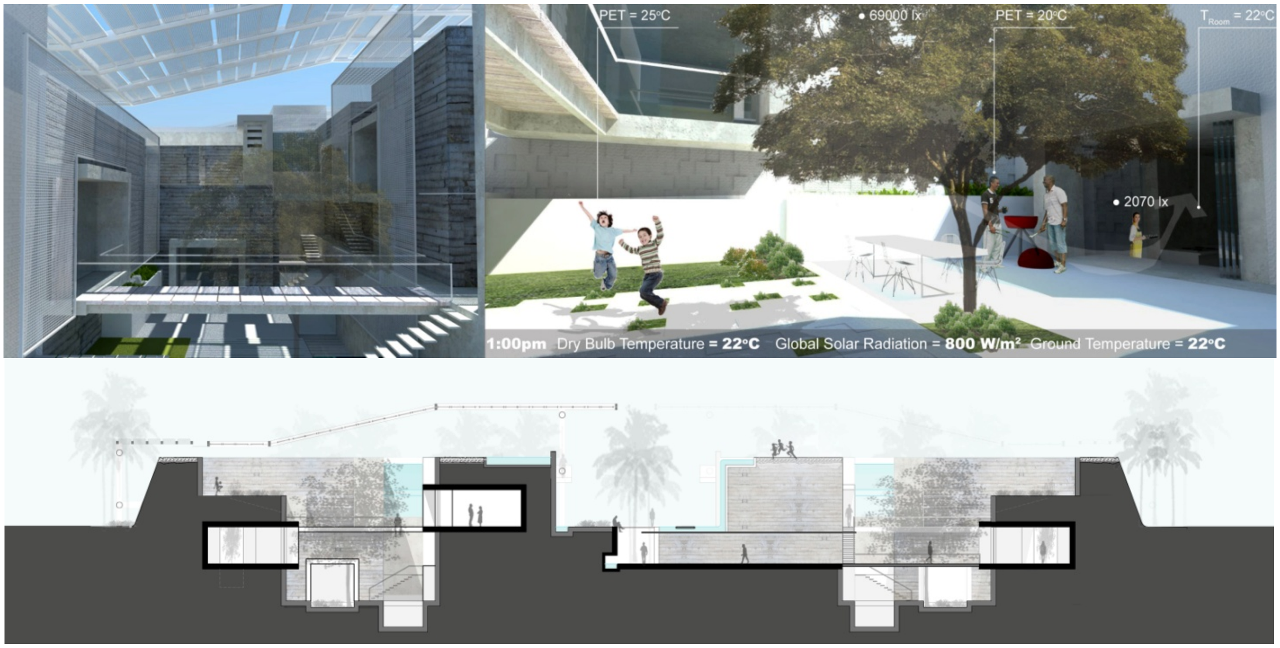

Figure 2: Extensive fieldwork and simulation studies were undertaken to assess the potential of passive techniques and transitional spaces to provide environmental diversity as alternative to the monotonous constancy of all-year mechanical airconditioning in the hot-dry climatic conditions of Kuwait City, Kuwait, 29°22 N 47°58 E [4].

LEARNING PROCESS

Sustainable environmental design is not a fixed ideal, but an evolving concept that should be reassessed and redefined with each new project. This follows from the principles of *adaptive architecturing* which encompass the urban realm, as well as the individual building. Adaptive architecturing refers to capabilities that are embedded by design into the built form and its constituent elements so that environmental conditions can be varied selectively to suit occupancy and occupant preferences, Fig. 4. The kind and range of adaptive mechanisms involved and the manner in which these may be applied are the subjects of research following the objectives and performance targets introduced above. The knowledge needed is provided by taught courses that deal with the theories and practices of sustainable design and with the use of data acquisition and environmental simulation tools.

Taught courses and research projects address both cold and warm climates, as well as highlighting the distinct programmatic characteristics and design priorities of different building types. The combination of fieldwork, which involves measurements and direct observations in occupied buildings, with systematic simulation studies using advanced computational tools, provides participants with the means for testing theoretical propositions as well as developing design research, Fig. 5. With all of the programme's participants coming from outside the UK, from different climates and urban contexts, London and its notoriously variable climate provide a good environment for learning how to deal with unpredictability and rapid change. London is also home to a rich variety of new as well as older buildings worth

Figure 3: Most architects and engineers tend to give-up on passive design when considering projects in Dubai, UAE, 25°15 N 55°18 E. Yet when studied closely the city's climate is actually quite nice and mild for some six months of the year and the more extreme nature and intensity of the other six months sets design challenges well worth meeting as did this scheme for a university campus where the layering of spaces and building elements smoothens the transitions between inside and outside [5].

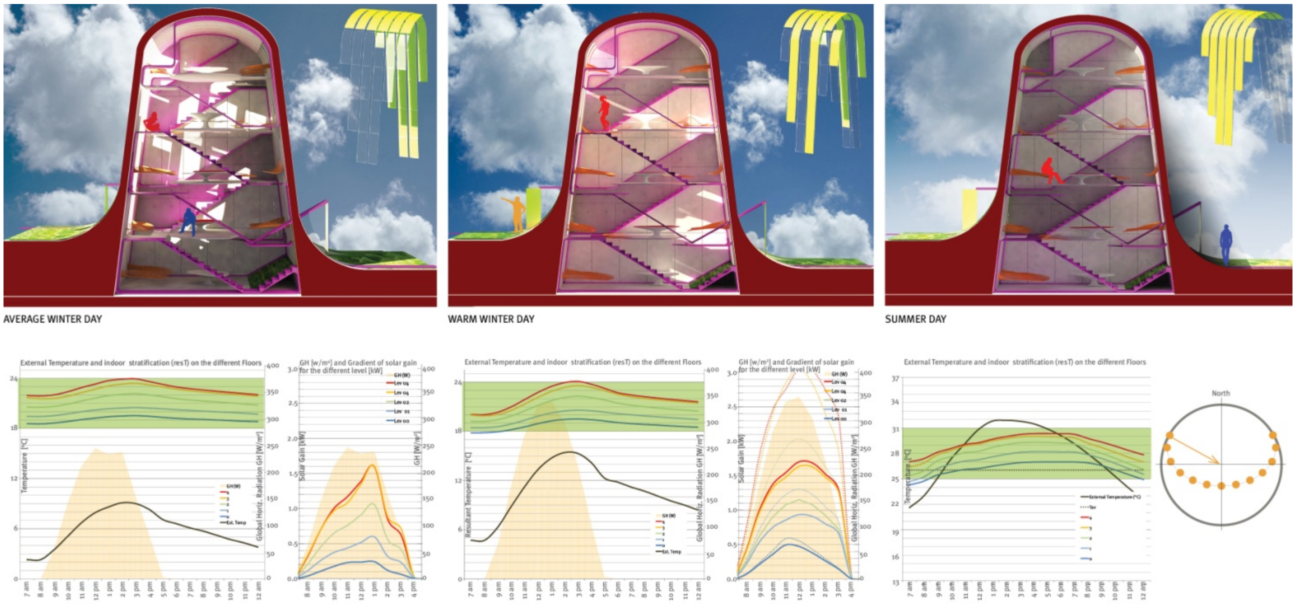

Figure 4: Do what you like where you like! This project for a site in Florence, Italy, 43^{o}47 N 11^{o}15 E, aims to demonstrate that with many household appliances becoming portable, occupants can be free to move around the house to enjoy the environmental diversity that passive design can offer at different times and in different parts of the spaces [6].

studying. Over the years a wide range of building types and urban settings have been studied for this Masters programme. Field studies have combined monitoring of environmental parameters with interviews (with occupants, architects, engineers, building managers). Measurements taken with dataloggers over a number of days can give useful comparative indications of how environmental conditions may vary in and around the buildings. Measured data are also of use for the calibration of digital models. A base case model will then be produced to represent existing conditions and current environmental performance in the selected building. Starting from this and from issues identified in the course of the fieldwork, project teams perform simulations of solar, daylight, thermal and airflow processes reviewing site as well as indoor spaces in terms of how environmental performance might vary as a function of a building's architectural design,

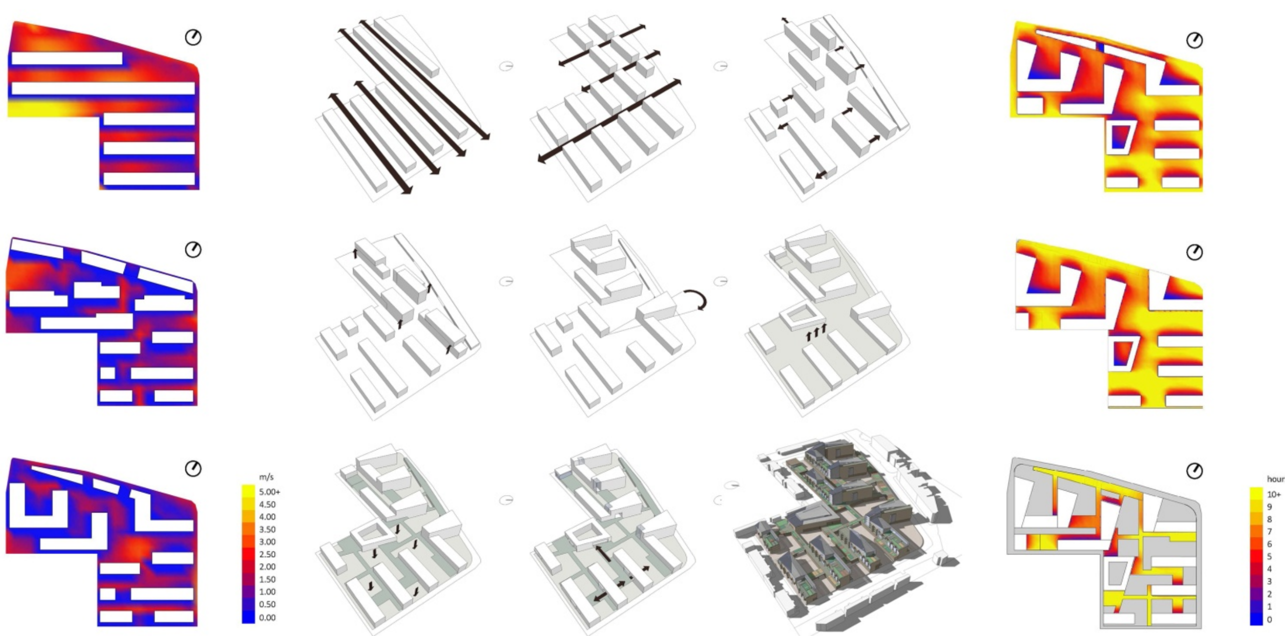

Figure 5 : Generative processes for new residential development showing the evolution of site layout and building form based on environmental studies, mixed-use requirements, on-site food production and links with adjacent urban setting in Brixton, South London, UK (51^o 30 N 00^o 07 W) [7].

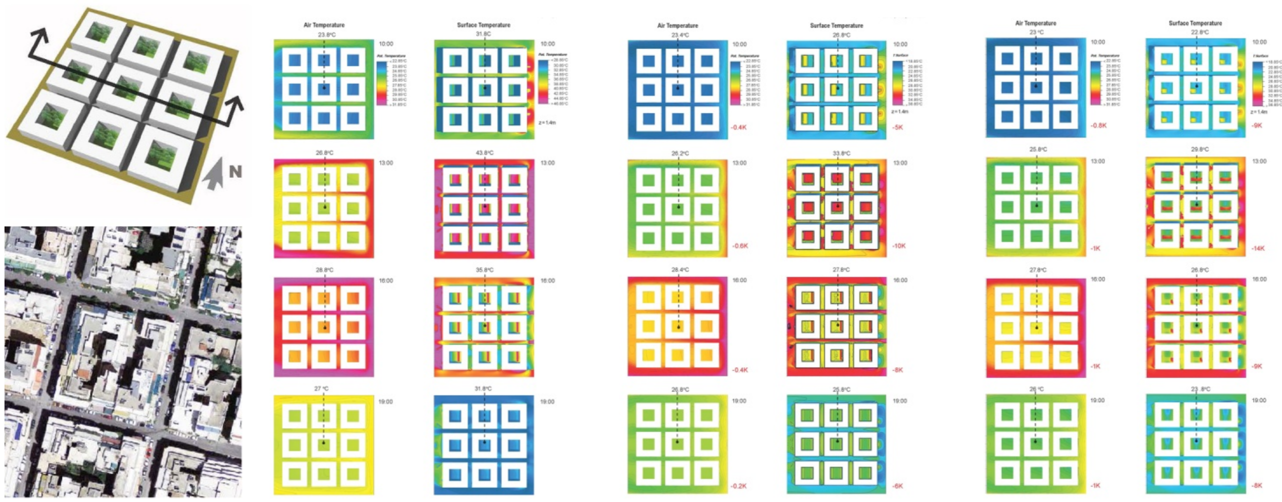

Figure 6 : Simulated air and surface temperatures in urban blocks exploring potential for microclimatic improvements by planting in central courtyards, Athens, Greece 37^{o} 58 N 23^{o} 43 E [8].

occupation and operational conditions. Invariably these early field studies produce results that challenge participants' expectations and preconceptions. Perhaps the most notable of these is the observation that while older UK housing requires conventional heating almost all-year in this climate, rooms in recent multi-storey residential buildings can reach high temperatures without mechanical heating even in early winter. Thermal simulation can then show that with improved design of the building envelope and better control over fresh air supply for ventilation, mechanical heating is no longer needed at all. Such striking demonstration of the dynamic nature of thermal processes and of the fine-tuning that may be feasible offers an early lesson that takes a while to be fully understood. Thermal simulation software is introduced early on to give participants sufficient time in which to acquire the skills and experience required for application on design projects. Initial computational work involves parametric and sensitivity studies aimed at clarifying questions arising from field observations and occupant comments. Subsequent simulation studies will typically explore the effect on daylight and thermal performance of design aspects such as the depth and exposure of spaces, the surface area and controllability of openings, the thermal properties of external building elements, lifestyle trends and changes in work habits, and operational aspects including occupancy schedules and ownership of appliances. Simulation results provide starting points for the formulation of design research that is pursued in follow-up projects. These may focus on refurbishment, new buildings or include both. The programme's research agenda on Refurbishing the City encompasses individual buildings and outdoor spaces such as courtyards, streets and squares, as well as urban neighbourhoods and urban blocks of varying functions and sizes, Fig. 6.

RESEARCH AGENDA

Projects undertaken during the course have encompassed a wide range of building types and built forms in many different urban locations and climates. Team projects carried out in the first half of the course (October to April) are normally for sites in London. However, participants' dissertation projects for the MSc and the MArch are invariably set in their countries of origin. These have highlighted a number of recurrent themes and research topics that are of general interest, as well as more specific research questions arising from regional features of climate and/or urban context. Of particular interest among the former are issues relating to spatial proportions and the relationships between

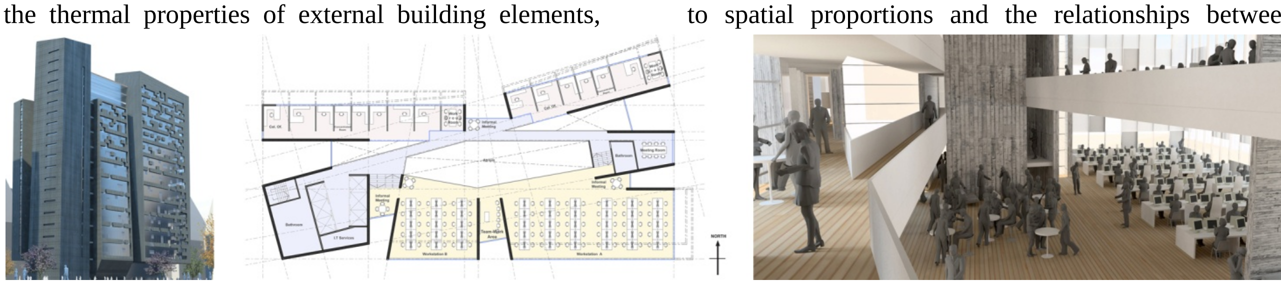

Figure 7 : Design proposals for office building in Santiago, Chile, 33^{o} 26 S 70^{o} 39 W, redefining the workspace to suit new requirements and relationships [9].

Figure 8 : This proposal for self-sufficient social housing eliminates the use of glass on its external elevations replacing them with a screen that is permeable to airflow and light while protecting from direct sun drawing inspiration from the life and built form of the Thai vernacular in Bangkok, Thailand, 13^o 45 N 100^o 29 E [10].

spaces, in plan and section, as these come into visual and thermal contact with each other and with the outside thus impinging upon functional, constructional, aesthetic and environmental aspects, Fig. 7**.** These open multiple research questions relating to the admission and control of sunshine, daylight, airflow, indoor air quality and the adaptive mechanisms of thermal comfort available to occupants. The occupation of spaces, the nature and energy intensity of occupant activity and the use of appliances have a strong bearing on these questions, as well as introducing further questions arising from social trends and technical developments. While all of the above might be of equal interest wherever a building might be located or however its spaces might be occupied and used, their implications on environmental performance and occupant comfort would be very different depending on a building's function and location. At the urban scale, the microclimates generated by the morphology of the urban tissue and its grid of streets and blocks provide another important area of research that encompasses a number of further topics. Both theory and practice show that designing for low energy consumption does not in itself entail any particular architectural style or quality. A good environmental performance is in principle achievable with both new and refurbished buildings that are designed to a specification meeting an appropriate benchmark. Clearly occupant behaviour can have a strong influence on this, which is why adaptive architecturing is of fundamental importance. Should there then be an architectural expression of sustainable environmental design and how would that manifest itself? Perhaps the strongest and clearest potential for such an expression can be given by a building's openings. When function, orientation, urban setting and adaptive controls for view, privacy, daylight, airflow and solar control are brought to bear on opening design the result would be a strongly asymmetric pattern of openings varying with orientation and height above ground as well as with form, size, appearance and materiality of external surfaces. In tropical climates where glazing openings creates undesirable heat traps, the appropriate architectural expression is one of high permeability to airflow combined with good daylighting based on effective solar control prohibiting admission of direct solar radiation, Fig. 8.

CONCLUSION

Much funded research over the last forty years has been devoted to the technicalities of energy efficiency in buildings. While this has clearly produced significant energy savings or improvements to occupant comfort and indoor air quality, it was mostly applied as an add-on that has contributed little to our understanding of the role of architecture in making cities more sustainable. With interest in sustainable environmental design increasing among architectural students and young architects, it is important to focus the environmental design research agenda on architecture to explore its adaptive potential with respect to occupants as well as for a symbiotic relationship with the city.

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