

Sustainable Environmental Design

Prepared by Architectural Engineer

Twana Ibrahim Dhahir

CONSULTANTING RESEARCH

Sustainable Environmental Design

Introduction

While much international research over the last forty years focused on energy efficiency and the engineering of environmental design, little of this dealt directly with architecture or answered any of the environmental questions commonly encountered by architectural students in the course of their studies. As a result, doubt, ignorance and preconception still prevail and need to be addressed in architectural education as well as in practice. Providing alternatives to the universal architecture and brute force engineering that are still the norm for architects in most countries requires new knowledge on what makes a good environment for inhabitants and how architecture can contribute to this, reclaiming and enhancing its historical role as a tool of environmental design.

The urban environment

By getting in the way of pre-existing energy flows, buildings alter the energy balance of their surroundings, interfering with solar radiation and wind directed toward other buildings, forcing microclimatic changes in their vicinity as well as impinging on pedestrian activities. Moreover, whether heated or cooled, free-running or mechanically controlled, buildings will release all of the energy used in them into the urban environment around them

in the form of waste heat, thus constantly and relentlessly warming the surrounding air, acting like giant heaters for the city. In these ways urban morphology has a dramatic influence on the climates of cities. The outcome is the fragmentation of the urban landscape into what appears to be a random assemblage of accidental microclimates. It is these microclimates we encounter walking in the city between its urban blocks and terraces, its parks, squares and roofscapes. At any moment, as well as over any period of time, the air and surface temperatures, sunshine and wind we might experience while walking through any of these microclimates are likely to be quite different to those on which the buildings that are housed there would have been designed. Even if we did design environmentally architected buildings, they might still fail badly unless we could account for the climatology of their site (no wonder that many recent buildings failed to live-up to their environmental expectations). This is the environmental inheritance of the contemporary city, an outcome of the architecture and urbanism of the last century.

Learning environmental design

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 (SED) 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. Key objectives are to improve environmental quality in cities, achieve independence from nonrenewable energy sources and promote an architecture of sustainable environmental design. In the last five years the programme's continuing research agenda on "Refurbishing the City" has initiated over 350 student 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 briefs of these projects combine on-site observations and measurements with design research that makes use of computational tools calibrated with measured data. For architectural students the undertaking of case studies of occupied buildings provides valuable insights on fundamental environmental issues that affect the comfort and wellbeing of occupants as well as the environmental performance and energy use in buildings, and which are of an architectural origin, Fig.1.

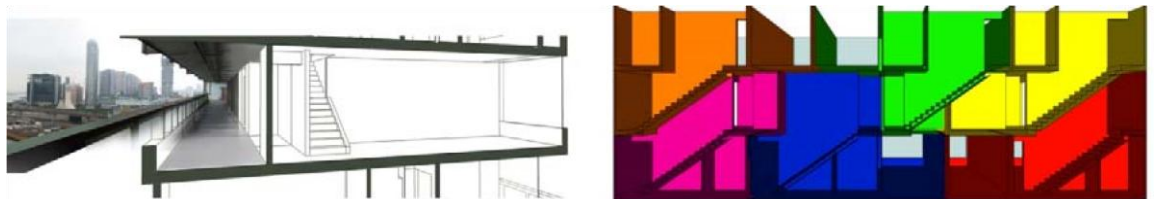


Figure 1: Robin Hood Gardens, an iconic scheme designed by Alison and Peter Smithson in the late 1960s which is now being demolished. Measurements and simulations performed for this scheme highlighted both the ingenuity of its complex interweaving of dwellings (coloured section, right) and the

environmental weaknesses this built form and its “streets in the sky”(left) entailed (Calleja et al 2011).

The combination of on-site empirical studies with analytical work provides students with the means for testing theoretical propositions, as well as supporting design research and its generative processes, Fig. 2. The empirical work consists of short-term measurements of environmental parameters, surveys and interviews (with occupants, architects, engineers, building managers). Measurements provide comparative indications of the environmental conditions achieved and how these have varied over time, as well as between and across different spaces. Surveys and interviews provide useful information on how things work in practice, highlighting key issues identified by the measurements. Data collected this way on environmental conditions, occupancy schedules, usage of appliances and on other operational characteristics, form a useful environmental profile of the case study buildings. They also provide the inputs needed for the calibration of digital models. There is no substitute for the knowledge acquired by students this way and even if such case studies were to be undertaken solely as an environmental exercise it would still teach students more about architecture than any lecture.

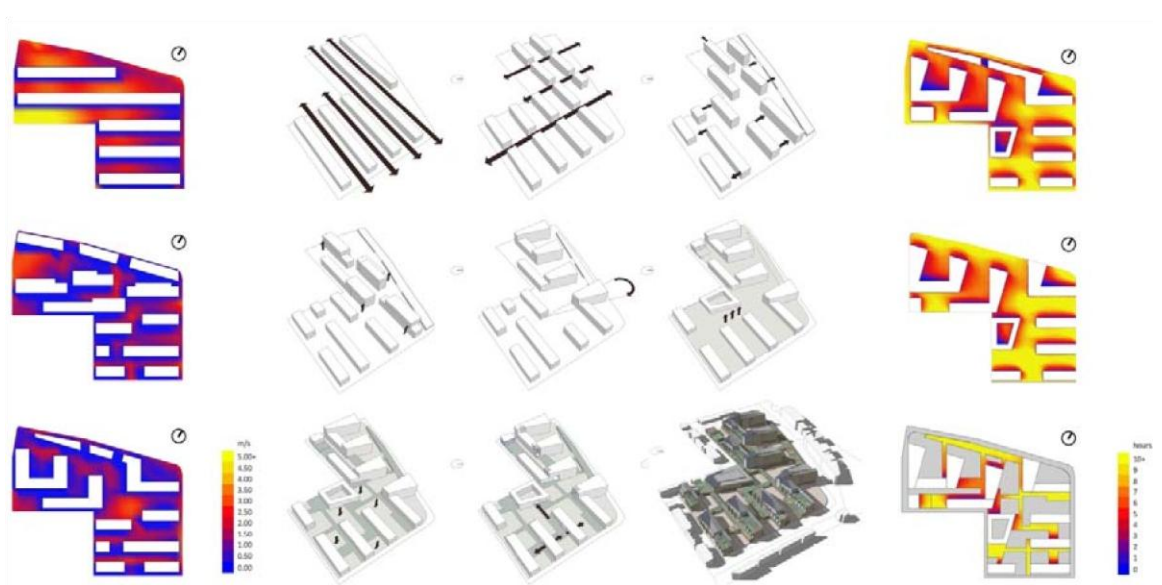


Figure 2 : Generative processes for new residential development showing the evolution of site layout and building form based on environmental studies, mixed-use requirements, on-site food production and links with adjacent urban setting in Brixton, South London, UK, 51° 30 N 00° 07 W (Guzman et al 2013).

The role of computational simulation

Simulation software is introduced early on, so that students can use it on projects as soon as they have a reasonable grasp of the principles. Environmental simulation software has improved over the last ten years, having become more visual in its interfaces and easier to use, as well as much faster to run. It still leaves a lot to be desired, lacking the capability to deal with all the main environmental processes interactively, being limited both in what is covered and in how the output is given. While such limitations are a source of confusion and disappointment for students (who are generally extremely ambitious in their approach and expectations), they are also useful reminders that

it is the knowledge and judgment of the software user that designs the buildings not the software. Experience with the teaching of environmental software over the last thirty years has shown that architectural students, both undergraduate and postgraduate, can master the mechanics of software of any complexity very quickly. The task of creating digital models of real or virtual buildings for the purpose of environmental simulation is akin to designing a building and commissioning it to its intended functions. The process of preparing and running simulations is also akin to the tasks of the architectural design process. Thus up to this stage architectural students are by far the most capable users of such software. On the other hand, the predictions of environmental conditions that result as the output of simulations are new and unique outcomes. They provide critical knowledge never previously available to architects that characterises a design and its constituents in new ways, Fig. 3. Understanding and interpreting these predictions allows students and their teachers to assess a design and, by varying its specifications, to modify the design and improve environmental performance, thus employing the outcome generatively. Such predictions can now be made with a high degree of accuracy and at great speed with any of the several mature software readily available on the educational market.

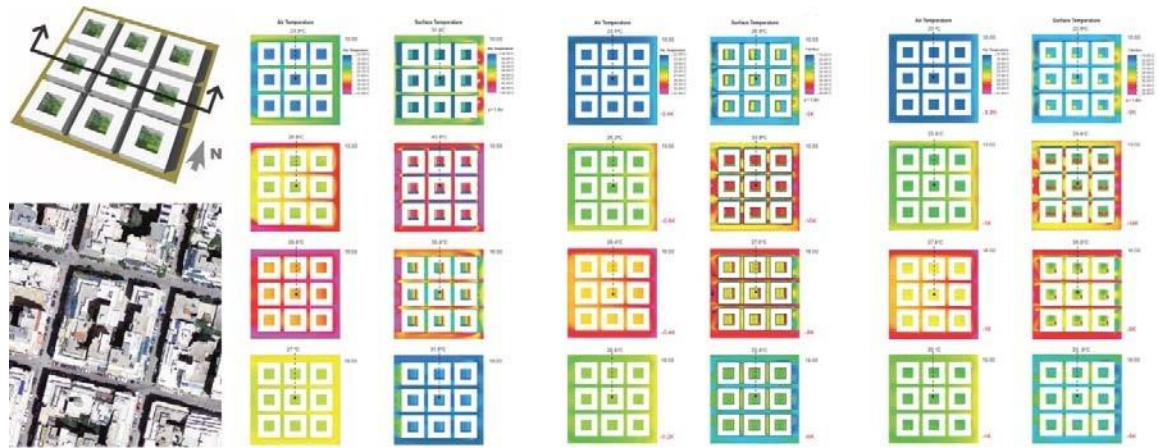


Figure 3: Simulated air and surface temperatures in urban blocks exploring potential for microclimatic improvements by planting in the central courtyards, Athens, Greece $37^{\circ} 58' N$ $23^{\circ} 43' E$ (Kapsali 2012).

A first round of modelling is typically simply in order to recreate the existing conditions of the buildings being studied. This is followed by parametric and sensitivity runs aimed at answering questions that would have arisen from building visits and occupant comments, and potentially also more widely from presentation of other recently completed buildings in the architectural literature. Subsequent simulations can then pinpoint the effect that different design features have on occupant thermal and visual comfort and on energy use. Students will typically consider the geometry and exposure of individual spaces; the position, shape, orientation and surface area of openings; the thermal and solar-optical properties and solar protection of glazed surfaces and other external building elements; occupancy profiles and occupant activity and use of home / work appliances. Some understanding of the environmental design principles is essential at this stage in order

to avoid wasting time and getting frustrated by performing meaningless runs. With guided practice students can learn to orient themselves productively so as to obtain useful results quickly. Simple models of real or virtual buildings can be run in seconds to provide hourly output for a selection of periods. Environmental simulation then becomes a natural extension of the design process, Fig. 4. Moreover, within the limitations of its theoretical principles, each software is an excellent tool for learning how the principles on which it is based apply to a climatic context and set of design conditions of the user's choice. With practice, by the time students come to apply the software on a second or third project, they will have become capable of anticipating the general outcome of the simulations; running the simulation then simply fills in the detail. Acquiring this skill reduces dependence on the software thus freeing time for other tasks.



Figure 4a/b: Extensive fieldwork and simulation studies were undertaken to assess the potential from passive techniques and

protected transitional spaces as alternatives to all-year airconditioning in the hot-dry climate of Kuwait City, 29°22 N 47°58 E (Dib 2013).

Adaptive Architecturing

The knowledge gained from field studies in real buildings and from running simulations of solar, thermal, airflow and daylighting processes shows that designing near zero-emission buildings is now feasible in most climatic regions. It also shows how important the role of architectural design is in providing good environments. As architects we have always claimed that. Measurement and simulation help objectify such claim. Architecture *is* environmental design, but it needs the knowledge to provide *sustainable* environmental design. If we are to have free-running buildings, that do not depend on mechanical heating and cooling systems, they need to be capable of matching daily and seasonal variations in occupancy and weather by acquiring their own variable properties and adjustable components. I have referred to this task elsewhere as *adaptive architecturing*, a generative process by which we aim to provide the means to adjust the built form and its properties to suit occupant activities inside and the daily and seasonal cycles outside (Yannas 2013). The projects undertaken for the AA SED Masters programme have demonstrated that this is applicable to all building types and built forms in all inhabited locations and climates. They also highlighted a number of research topics of global interest, as well as local issues arising directly from particular urban contexts and design briefs. Of

primary importance among the former are fundamental design considerations such as plan depth, room geometry, the relationships between spaces in plan and section, the admission and control of sunshine, daylight, airflow, and the adaptive mechanisms to occupants for thermal and visual comfort and indoor air quality Fig. 5.

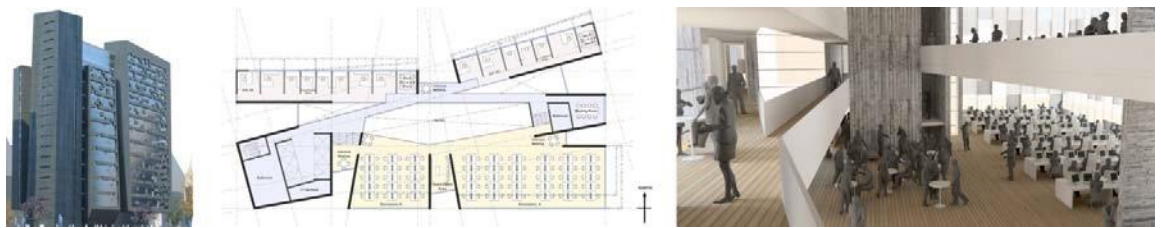


Figure 5 : Design proposals for office building in Santiago, Chile, $33^{\circ} 26' S$ $70^{\circ} 39' W$, show built form resulting from functional and environmental considerations to suit new work relationships and with window positions and sizes optimised parametrically (Swett 2013).

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 issues arising from lifestyle trends and technical developments Fig. 6.

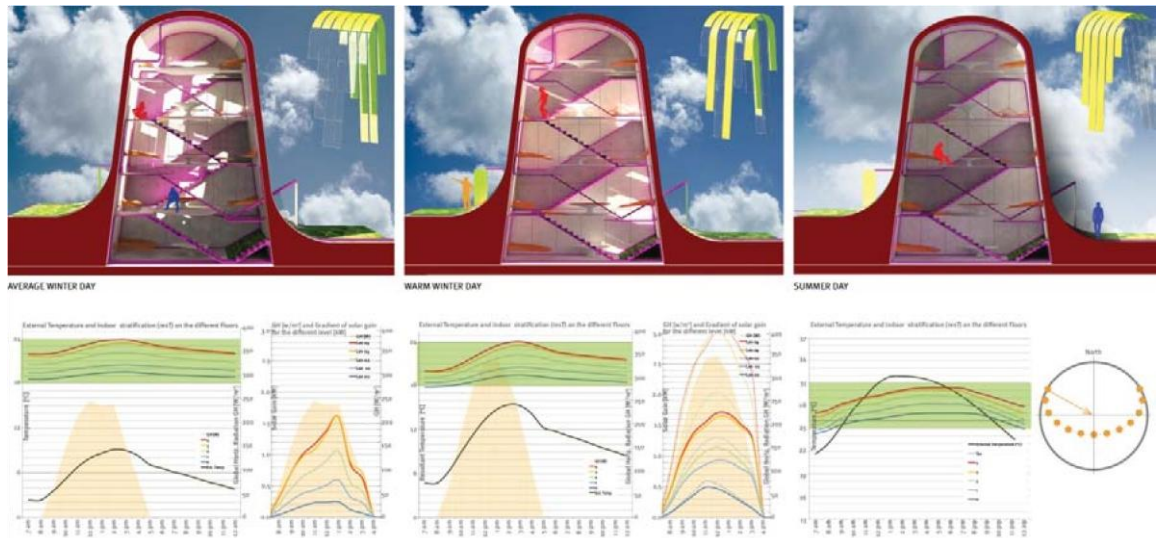


Figure 6: Project for a site outside Florence, Italy, $43^{\circ}47' N$ $11^{\circ}15' E$, exploring a future scenario of portable appliances and multiple adaptive opportunities for occupants to enjoy environmental diversity provided by passive techniques at different times and in different parts of the dwelling (Weber 2013).

While all of the above might be of equal interest wherever a building may be located or however its spaces may be occupied and used, their implications on environmental performance and occupant comfort can be very different depending on building function and location. Figs. 7 and 8.



Figure 7: Most architects and engineers tend to give-up on passive design when considering projects in Dubai, UAE, $25^{\circ}15$ N $55^{\circ}18$ E. Yet when studied closely the city's climate is actually quite mild and nice for some six months of the year, while its more extreme periods sets design challenges well worth pursuing as attempted by this scheme for a university campus where the layering of spaces and building elements smoothens the transitions between inside and outside (Mogali 2012).



Figure 8 : This proposal for self-sufficient social housing in Bangkok, Thailand, $13^{\circ} 45$ N $100^{\circ} 29$ E, draws its inspiration from the life and built form of the Thai vernacular; it eliminates the use of glass on external elevations replacing glazing with screens that are permeable to airflow and light while protecting from direct sun (Tedkajorn 2013).

Conclusion - A shortlist of essentials

- 1. Learning from precedents* by taking existing buildings as case studies, combining fieldwork and computational studies. What makes a good environment for occupants, what worked, what did not turn out as expected.
- 2. Learning the principles* with a taught course covering the basics is essential and must slightly precede the introductions to any software.

3. ***Learning from computational tools*** as the fastest and most effective means for contextualising knowledge and for generalising the findings from other sources. However, skills development and meaningful application critically depend on experienced support. To be introduced from first year.

See also the following:

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4. ***Basic numeracy is essential*** as protection from errors and to help provide direction
5. ***A sense of judgment*** to avoid splitting hairs and wasting time
6. ***Global principles, local applicability*** something working well in one context may not work the same or at all elsewhere or in the future
7. ***Understanding the climatology of the urban environment*** millions of buildings and urban blocks around Europe requiring urgent attention
8. ***Daylighting & solar control*** these are generally poorly understood by students and will require special teaching effort and support
9. ***Thresholds, transitional spaces, boundary conditions and variable properties*** where architectural and environmental becomes one and the same

10. Lifestyle trends, technical developments, climate change
good topics for imaginative speculation and futuristic architectural utopias.

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