"Our biological model needed a new set of rules. We chose to work within three parameters; nature, resources and aesthetics. By 'nature' we mean the Gaia theory of natural systems in which life itself controls the biosphere. Designers need to see the city as an ecosystem in which all parts are interlinked and influence each other. 'Resources' are human, natural and economic. By 'aesthetics' we refer to a new relationship between designer and nature where the former copies the processes of nature and not nature itself." Mick Pearce, Pearce Associates.


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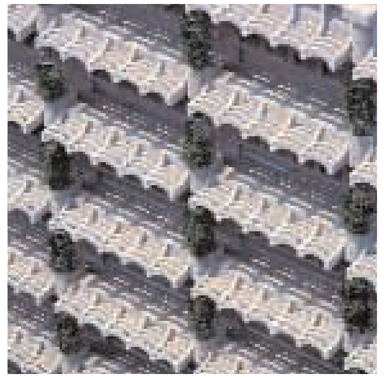
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■ **Mick Pearce was born in Zimbabwe**, schooled in South Africa and studied architecture at the AA in London under the Smithsons – contemporaries included Michael and Patti Hopkins. Following a period in 'exile' in Zambia and Britain during the Ian Smith years, he returned to Zimbabwe and joined Harare's oldest and largest architectural practice, subsequently becoming managing partner and principal. A visit by Australian Bill 'Permaculture' Mollison to Zimbabwe in the late 1980s was a pivotal event and Pearce's 'manifesto', already rooted in the cultural context of old Zimbabwe, acquired a 'green' agenda and committed to addressing issues of global warming, carbon emissions, energy minimisation and waste reduction. ■ Zimbabwe is a land-locked country to the north east of South Africa. Its capital Harare (pop. two million) lies 18˚ south of the Equator with a subtropical climate modified by its altitude of 1500m resulting in low humidity (increased in the wet season Nov-Mar) and significantly high diurnal temperature range – warm dry sunny days and cooler nights, typically 28˚C day and 19˚C night. Average annual rainfall is 850mm.

Environmentally Sustainable Design.

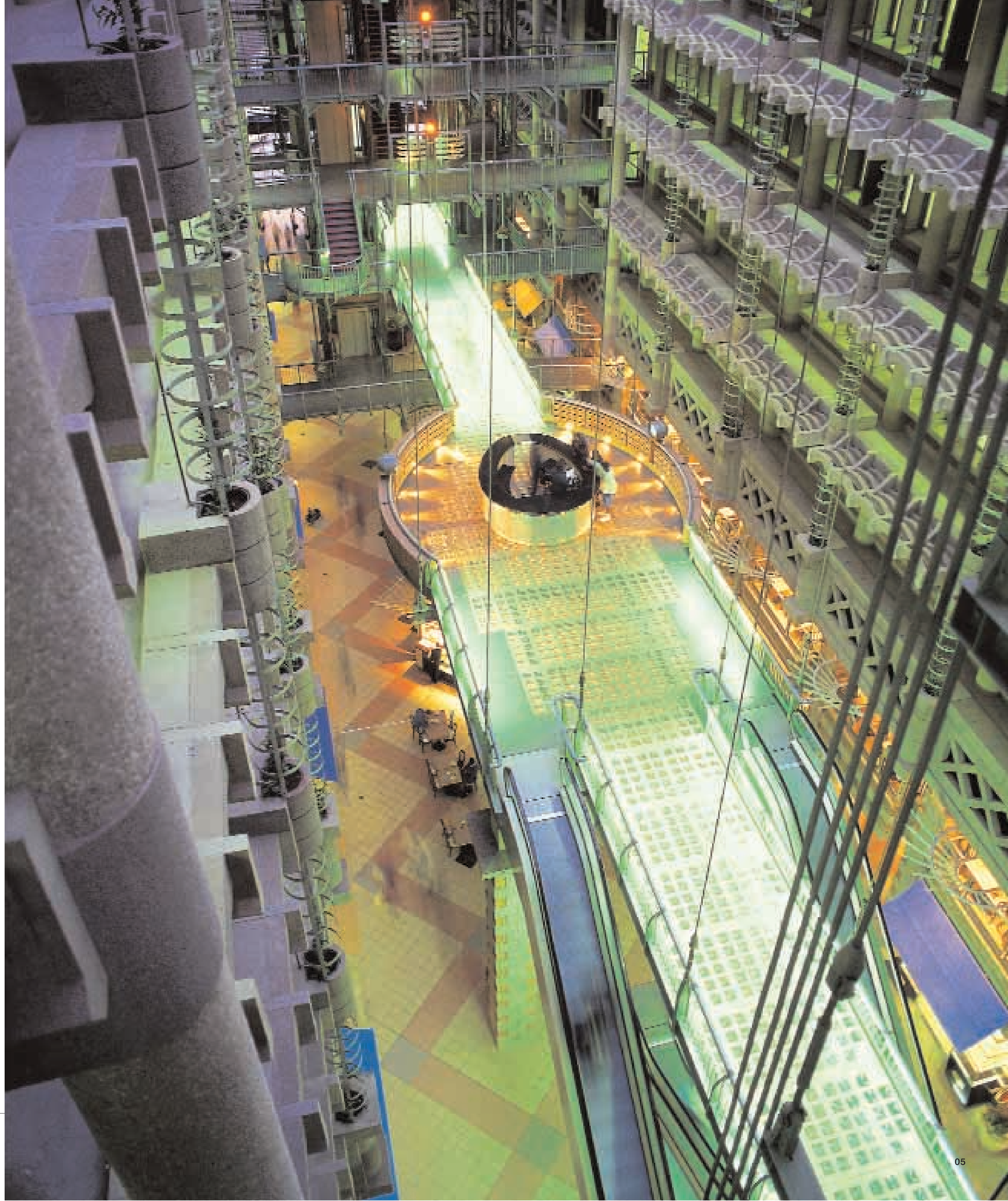
Ant Hill

A case study on the environmental performance of a development in Africa reveals a green agenda for international appropriation.

Eastgate Shopping & Office Complex
Harare, Zimbabwe
Pearce Associates. Architects

Lindsay Johnston. Review
David Brazier. Photography

01 Architect Mick Pearce in Harare, Zimbabwe.
02 The distinctive and strangely ornate exterior.
03 Internal fixing detail. **04** The 'furry' facade.
05 The atrium, a hollow core running through the entire building.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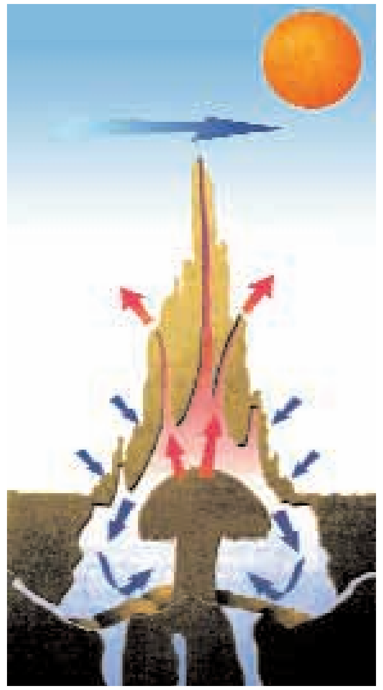
06 The 'busy-ness' of the atrium is created by a network of suspension bridges and walkways weaving through and across the space.



07 The anthill or termitary is a model of environmental soundness, built without consuming power or producing waste.

08 Exposed structural elements characterise the language of the interior to create a layered texture in keeping with the facade.

09 Pearce favours a 'gritty' exterior with natural and built shading playing across the building's shell.

10 A 'light-industrial' effect is created internally by exposed steel work, pulleys and bridges.

Columns of vegetation, seen maturing in recent photographs, enhance the deep shade on the face of the building and bring natural life to the building and the city – aesthetic greenery, air filter, habitat.

■ The Eastgate shopping and office complex in Harare was the largest development in Harare at its inception in 1991 consisting of 36,000 sq.m on a 9000 sq.m site. The completed project is in the city centre and accommodates 2000 people in 26,000 sq.m of office space and 600 people in 5000 sq.m of retail space. The institutional client Old Mutual Properties took an innovative approach and agreed at the outset to a low-rise traditional development with no air-conditioning – acknowledging the high cost of imported equipment and local maintenance limitations. The client also agreed to the appointment of Ove Arup and Partners to be environmental consultants on the design of a naturally ventilated development and agreed to pay them the fees equivalent to a fully air-conditioned building. The crucial early stages of the design process brought the whole design team together, before any sketch designs or preconceptions, and then the key principles of the project were established in the first few days of collaboration.

■ Mick Pearce refers to the 'anthill' or termitary and talks of this metaphor demonstrating the capacity of termites to build structures that control the environment without consuming power or producing waste. Pearce proclaims – "Eco-tech architecture should be embedded in its social and economic environment" and in contrast the Miessian glass office tower is "detached from the circumstances which nurtured it and is a false and inappropriate model".

■ The following were the agreed aims of the Eastgate design team: air cooling by passive means; complete sun control; external glass, no more than 25 percent of the external wall; natural and artificial light balanced and glare controlled; a large part of the surface area of the structure exposed to an internal space; the building air-sealed as far as possible, although windows would be available for individual control. These aims have been achieved and it has been demonstrated that with these criteria it is possible to produce acceptable comfort conditions without air-conditioning provided the occupants accept some seasonal variation beyond that experienced in a fully air-conditioned environment.

■ On plan the buildings are correctly oriented with the long axis east-west presenting short gables to the low east and west sun. The cross-section demonstrates the close affinity with the 'anthill' model. Two blocks each side of a central atrium provide an opportunity for natural 'stack-effect' air movement ventilation up the middle of the building – an earlier section 'diagram' with solar warmed flues on the outside of the building was rejected as obstructing prime aspect and as thermodynamically unnecessary. Pearce also talks of a 'prickly' building with high surface area performing better, to gain and dissipate heat, than a smooth shear envelope. Columns of vegetation, now seen maturing in recent photographs, enhance the deep shade on the face of the building and bring natural life to the building and the city – aesthetic greenery, air filter, habitat.

■ The language of the building refers to the stone Great Ruins of Zimbabwe built by the Shona people in 1100 to 1500 AD utilising the natural cracking of the rocks, through diurnal temperature fluctuation, to provide precise stonework courses transferred course by course from the natural source to the built walls. Granite sand used in the numerous expressed precast elements on Eastgate has a brushed finish that enhances the natural stone language. Pearce refers to stone details in the work of Ledoux and to vernacular wood-carved decoration in the portable stools of the Shona.

■ Two levels of shopping mall and parking are surmounted by two seven-storey office towers. The central atrium rises nine storeys from the floor of the shopping mall to the naturally ventilated canopy glazed roof. Circulation to the office floors, for security reasons, is from a dramatic sky bridge two levels up suspended by steel tension rods from elegant steel trusses across the top of atrium. Lift cars are similarly suspended down the atrium from the roof. There is a counterpoint between the traditional – the mass of the precast and masonry – and the innovative – the 'light tech' steel trusses, suspension rods, internal bridges and balconies. The old and the new. The visual impact of the project is dominated by the stunning images of the filigree of external precast concrete sun control devices and vegetation columns and the 48 chimneys on the roof that drive the day and night air movement through the building.

■ **Orientation.** The long axis is east-west, presenting short gables to east and west sun and facilitating sun control from high sun on long north and south façades.

■ **Sun control.** Extensive structural overhangs and precast concrete elements on all façades, including the façades facing into the atrium, combine with 'vegetation columns' to provide full sun shading to windows and external walls.

■ **Insulation.** Surprisingly, there is no introduced thermal insulation in the building other than that provided by the structure, walls, roof and floor elements. The strategic design of this building and the benign climate of Harare obviate the need for insulation as exterior night temperatures seldom fall below 17˚C and day temperatures seldom exceed 28˚C.

■ **Thermal mass.** Crucial to the successful environmental design of this building is the use of high thermal mass to moderate internal temperatures, particularly to store 'coolth' at night and to release it during the day. The high climatic diurnal temperature range of up to 9˚C facilitates this. The building has high primary thermal mass provided by the structure, masonry walls, concrete floors and restricted glazed areas. Used in association with a clever ventilation system, cold night air is transferred through and into the structure. An ingenious system of precast concrete floor cassettes forms a sub-floor air void at each office level – rather like a concrete version of a raised computer floor – through which cooling air is directed. The concrete cassettes have projecting teeth into the sub-floor air cavity to enhance thermal transfer – better than a smooth slab. The exposed vaulted soffits of the precast concrete floor slabs form the ceilings to the office areas facilitating dissipation of the 'coolth' during the day.

■ **Ventilation.** Again crucial to the environmental design is the system of air movement through the building by day and night. The windows are operable but this is not encouraged due to dust and noise, and is not part of the primary air movement strategy. The key feature is the ability to draw filtered cool air through and into the thermal mass of the structure at night, store it as 'coolth' and then release it during the day. The 48 chimneys on the roof exhaust air out of the offices below, while 32 banks of low and high volume mechanical fans draw filtered air in at low level at the base of the office blocks. Vertical ducts allow ‘new’ air to enter each floor void and then enter each office floor below window level. Warm ‘old’ air is discharged through wall portholes at ceiling level into further vertical ducts which discharge into the roof void and out through the chimneys. The ducts for the ‘new’ air progressively decrease in size rising up the building, and the ducts for warm ‘old’ air increase in size – accentuating the ‘anthill’ form of the cross section. By night, 10 air changes per hour cool the structure flushing out the previous day’s heat. By day, two air changes per hour, pulled though the structural floor voids, allow the stored ‘coolth’ to chill the warm incoming ‘new’ air and then discharge under the windows into the office spaces. Potential for formation of condensation, during the wet season of higher humidity, and associated bacterial mould growth in the inaccessible floor voids, is unlikely as the concrete temperature never reaches dew point. Independently, stack effect draws air from the top of the atrium out through the ends of the glass canopy roof, thus neutralising heat gains from the exposed glazed roof – the latter actually enhances stack induced air movement through the atrium. (See sections below.)

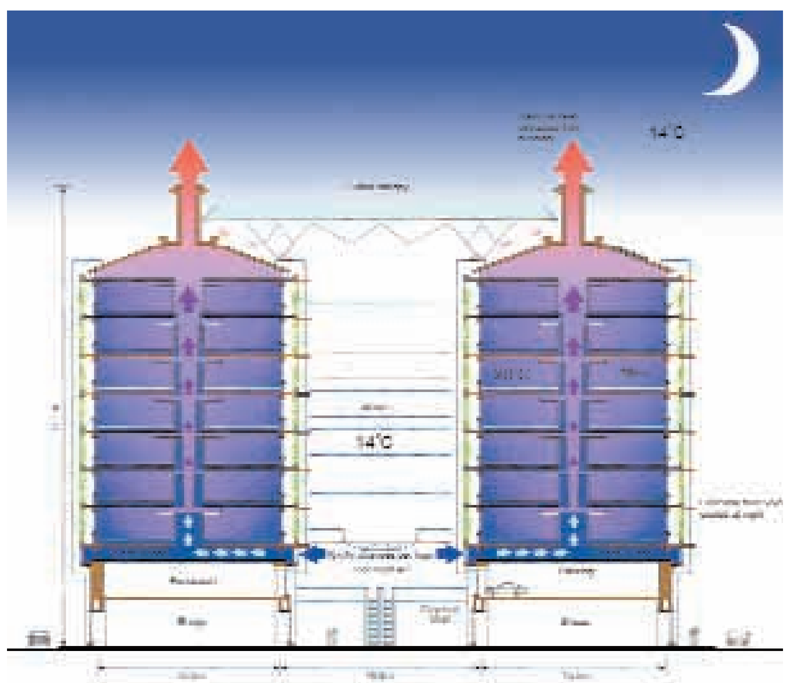
■ **Double roof.** The roof of the two office blocks is, in fact, a double roof creating a ventilated roof void between the pitched primary roof covered in clay tiles and the flat secondary concrete slab roof, which is the ceiling slab of the upper office floor. The 48 chimneys extract air from the roof void into which the vertical ‘old’ warm air ducts discharge from the office areas. What rain that comes in through the open chimneys falls on the corrugated steel secondary roof. This ventilated roof void reduces direct heat load on the roof.

■ **Thermal performance.** The internal air temperature of the building is reported, as was predicted, at up to 3-4˚C cooler than outside ambient temperatures on a warm summer day of 28˚C at 24-25˚C – it is claimed that perceived comfort is better than this would suggest as the human body is more sensitive to radiated ‘coolth’ than conducted ‘coolth’. The concrete thermal mass in the floor slabs holds a quite constant temperature of around 20˚C in summer and winter and room temperatures do not fall below this. Human activity and equipment add around 1.5˚C each day and this is flushed out at night. There is a tendency for the structure to warm up towards the end of the working week and cool down over the weekend. It was established at design stage that heat emitted from the fluorescent lighting ballasts could add 1˚C to the room temperature, and this has been avoided by placing the ballasts in the centre of the warm ‘old’ air outlet portholes into the vertical exhaust ducts. In October/November hot humid days and cloudy nights adversely affect the thermal performance with a worse case 2 –3 hours over 27˚C at the end of the working day and an occasional 29˚C situation.

■ **Natural and artificial lighting.** Natural light is purposely restricted due to small windows and heavy sun shading and façade vegetation. Inexpensive fluorescent strip lights are used as uplighters bouncing light off the exposed vaulted soffits of the concrete ceilings. A lower than normal level of artificial lighting at 300 lux is reported to have been acceptable. In the lower office floors facing into the atrium, natural lighting is reported to be poor necessitating high use of artificial light.

Crucial to the successful environmental design of this building is the use of high thermal mass to moderate internal temperatures, particularly to store ‘coolth’ at night and to release it during the day.

Project Summary ■ **Architect** Pearce Partnership, Harare, Zimbabwe ■ **Project team** Michael Pearce, Paul Castle, Radhan Cumaraswamy ■ **Structural, mechanical & electrical engineer** Ove Arup & Partners ■ **Quantity surveyor** Hawkins, Leshnick & Bath ■ **Retail design consultants** Development Design Group ■ **Project manager** Old Mutual Properties



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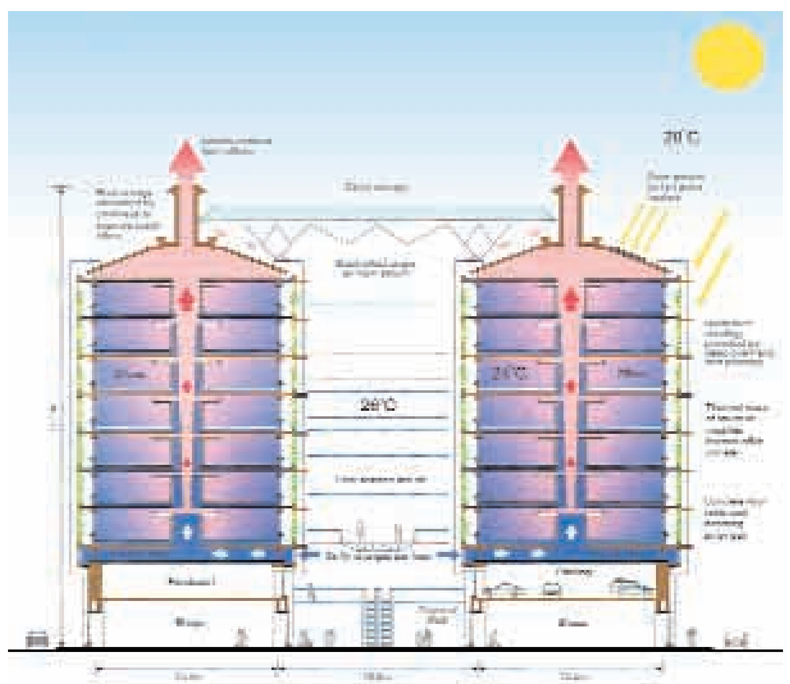

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11 & 12 Night and day sections of the structure illustrate the principle of passive air-conditioning.

■ **Utilisation energy.** This has been analysed in the offices areas and reported at 108 kWh/sq.m/year, this is from 20–50 percent below five other office buildings surveyed in Harare. A NSW SEDA five-star rating using all electricity equates to 132kWh/sq.m/year

■ **Greenhouse gas emissions.** As electricity in Zimbabwe is produced 40 percent from hydro (rainfall permitting) and 60 percent from low grade coal, greenhouse gas emissions for Eastgate are calculated at 68 kg/sq.m/year. A NSW SEDA five-star rating equates to 125kgCO_2/year and a one-star rating 290-345kgCO_2/year.

■ **Embodied energy.** There are no figures available for embodied energy in the materials incorporated in the building. It is possible to speculate that the high thermal mass of the building may signify high-embodied energy in cement, concrete and bricks, but this in turn pays dividends in reducing utilisation energy demand through improved thermal performance. Steel and aluminium elements would be expected to have high-embodied energy. Mick Pearce sees this as a long-life building and it is designed to be converted for residential use in the future. Thus annual energy consumption attributable to embodied energy is reduced. Relatively ‘low-tech’ production methods in Zimbabwe, associated with hydroelectric power, may reduce the embodied energy.

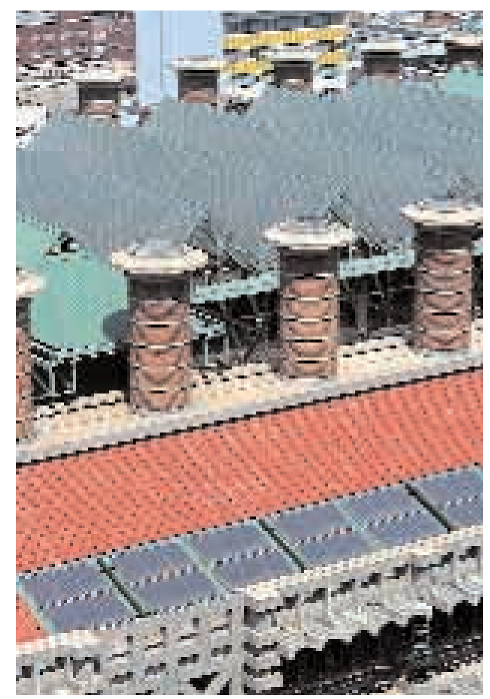
■ **Water consumption and hot water.** The total water consumption of the building is 10,000,000 litres per year (10,000 cu.m) representing 4000 litres per worker/person per year or approximately 15 litres per worker/person per working day. This excludes a count on public using the building and includes the retail food court, which serves 800 meals a day. Ground water is used for flushing wc’s and irrigation. Hot water is supplied by solar water heaters located on the roof.

■ **Travel.** Public transport in Harare is non-existent. The major mode of transport is ‘private’ Kombi taxis. Seventy-five percent of the building’s population travel by foot or Kombi taxi. The city centre location minimises dependence on private cars, against the trend for suburban office parks. People spend 10–22 percent of their income on transportation – rising due to the falling currency and increased oil prices.

■ **Cost and fees.** The total cost exclusive of land was US$35 million – under US$1000 per sq.m gross. There was an estimated saving of US$3.5 million in plant cost due to omission of air-conditioning. The project cost 20 percent less than a neighbouring air-conditioned building built at the same time. Energy savings of 20–50 percent over similar buildings are reaping financial dividends in the current climate of escalating energy costs. The consulting engineers were paid fees equivalent to a fully air-conditioned building to provide the research on the passive systems.

■ “If we recognise that cities are ecosystems like rainforests or coral reefs, but built by humans, we can find meeting points between nature and technology. ‘Eco-tech’ is a thesis that believes that redirected technological innovation can be beneficial and work in harmony with nature.” Mick Pearce, Pearce Associates.

Professor Lindsay Johnston is Dean of the Faculty of Architecture, Building and Design, The University of Newcastle, NSW, Australia.



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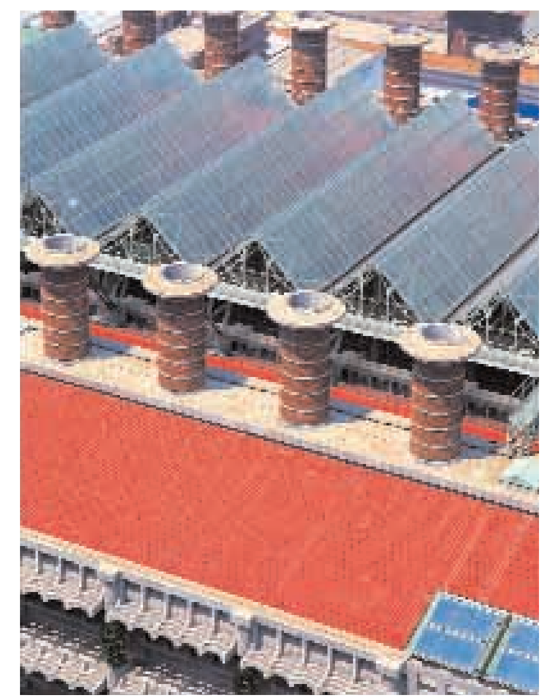

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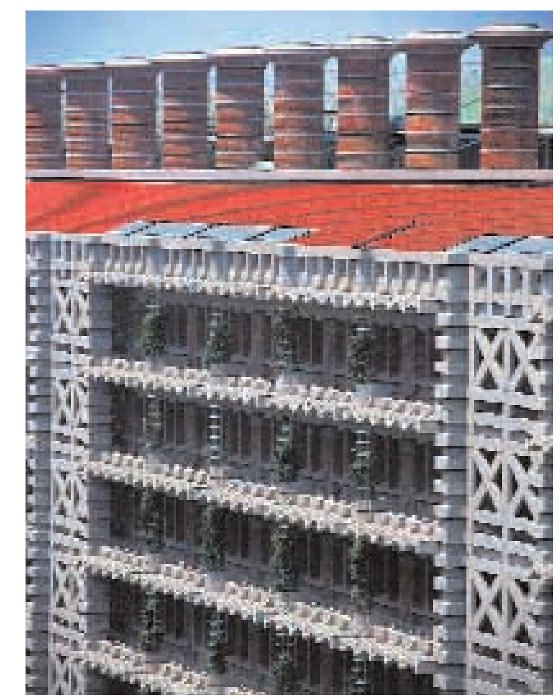

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13 - **15** Forty-eight chimneys distinguish the roof line, and extract the warm air that has been discharged from the offices below and trapped in the double roof void.