Climate-responsive urban and building design

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CLIMATE-RESPONSIVE URBAN AND BUILDING DESIGN

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Urban Design Criteria in hot-dry climate areas

- Urban grid layout allowing northern wind penetration in streets and public spaces for summer outdoor comfort.
- Barriers (walls, vegetation) protecting buildings from southern sand-bearing wind.
- Multi-storey residential buildings laid along the N-S axis to allow for the apartments being naturally ventilated and cooled by airflow crossing the rooms from a inlet north-facing malkaf to outlet south-open solar chimneys; both elements are serving a single apartment for each storey of a vertical row by organ pipes-like ducts, distributing cold room-inlet air through ceiling and exhausting warm room-outlet air through vents on the bottom of southward walls.
- Building rows fairly closed to each other to project morning and afternoon shadows on, respectively, eastward and westward facades; alternatively, trees rows can be planted between buildings.

Urban Design Criteria in hot-dry climate areas

- Trees and vegetation foreseen in a quantity higher than a threshold related to their potential for reducing heat island effect as well as absorbing carbon emissions.
- Pavement and external walls cladding materials characterised by low albedo (coefficient of short-wave thermal radiation) and low emissivity (coefficient of long-wave thermal radiation) to avoid outdoor overheating conditions.
- Outdoor elements and furniture laid out and designed to function as shading and warm wind barriers.
- Sprayed water, ponds, and fountains provided as evaporative cooling systems for outdoor spaces.

Building Design Criteria in hot-climate areas

Study by a LBNB’ team, Berkeley, 2003: comparison between indoor comfort conditions perceived and calculated, in sample buildings with centralised HVAC

Study by a LBNB’ team, Berkeley, 2003: comparison between indoor comfort conditions perceived and calculated, in sample buildings with natural ventilation
Accepted indoor comfort temperature variation range as a function of outdoor air temperature in naturally ventilated buildings (ASHRAE Standards – 2004)

STANDARDS CHANGE AFTER RESULTS OF A FIELD STUDY ON ADAPTIVE COMFORT

PANEL OF EXPERTS
New Fayoum City, Egypt, 25-27 September 2012

Dissipation by natural means of the heat stored in a room, and causing discomfort, due to uncontrolled solar radiation, convective exchange, and internal gains.

PASSIVE VENTILATIVE COOLING

OBJECTIVE

Dissipation by natural means of the heat stored in a room, and causing discomfort, due to uncontrolled solar radiation, convective exchange, and internal gains.

TECHNIQUES

- microclimate PVC
- geothermal PVC
- evaporative PVC

ARCHETYPES of m-PVC: wind catcher

ARCHETYPES of m-PVC: wind catchers

ARCHETYPES of m-PVC: wind-buoyancy-driven

ARCHETYPES of combined-PVC: wind-buoyancy-driven

Central guest room (qa’a) in Othman Katkhuda’s house, Cairo, Egypt, ca. 1350 A.D.

Persian Wind Towers (Badgir), Iran.
Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

Renaissance Palladian Villa “Trento” at Costoza (VI), Italy: longitudinal cross section

Natural underground ducts called “covoli”, with extension of artificial tunnels built by Ancient Romans for a calcareous quarry.

Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

ARCHETYPE of g-PVC

Renaissance Palladian Villa “Trento” at Costoza (VI), Italy, with natural underground ducts called “covoli”

Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

FUNCTIONAL SCHEME of e-PVC

Room evaporative hybrid ventilative cooling system.

Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

EXAMPLE of e-PVC

Downdraft evaporative hybrid ventilative cooling system, Negev, Israel.

Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

Examples of building design with m-PVC

Downdraft evaporative hybrid ventilative cooling system, Negev, Israel.

Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

Solar-chimney-driven m-PVC

Design of a residential building, Rome, Italy.

3-D representation of solar irradiation on the chimney wall

Designer: Arch. M. Irene Carallo, Rome, Italy.

Environmental Consultant: Prof. arch. M. Grosso.
Design of a residential building, Rome, Italy:
3-D representation of night m-radiation from the solar chimney wall.

Designer: Arch. M. Irene Cardillo, Rome, Italy.
Environmental Consultant: Prof. arch. M. Grosso.

Design of a residential building, Rome, Italy:
3-D representation of airflow during a summer night.

Designer: Arch. M. Irene Cardillo, Rome, Italy.
Environmental Consultant: Prof. arch. M. Grosso.

Design of a residential-tertiary compound, Cabiate, Como, Italy:
Perspective section with representation of CNV flows and results from an energy simulation for a terrace house with stack effect in a North-facing stairways cavity.

Designer: Arch. M. Irene Cardillo, Rome, Italy.
Environmental Consultant: Prof. arch. M. Grosso.

Design of a residential-tertiary compound, Cabiate, Como, Italy:
Perspective section with representation of CNV flows and results from an energy simulation for a multi-apartment building with North-facing dedicated stack cavity.

Designer: Arch. M. Irene Cardillo, Rome, Italy.
Environmental Consultant: Prof. arch. M. Grosso.

Design of a residential-tertiary compound, Cabiate, Como, Italy:
Perspective section with representation of CNV flows and results from an energy simulation for a multi-apartment building with stack effect in a South-facing stairways cavity.

Designer: Arch. M. Irene Cardillo, Rome, Italy.
Environmental Consultant: Prof. arch. M. Grosso.
Examples of buildings with PVC systems

Stack-driven m-PVC
Queen's Building, De Montfort University, Leicester, UK, Archh. Ford & Short: general view with the stack towers.

Stack-driven m-PVC
Queen's Building, De Montfort University, Leicester, UK, Archh. Ford & Short: cross section with a scheme of CNV flows and relevant airflow rates.

Junior high school building "L. Orsini", Imola, Italy:
Night cooling of thermal mass

Atrium glazed roof with the exhaust air stack vented clerestory
Panel of experts
New Fayoum City, Egypt, 25-27 September 2012

3D CFD simulation: temperature zones for a gradient of 10 °C between inside and outside after 5 minutes
after 35 minutes
after 1 hour

Junior high school building "L. Orsini", Imola, Italy:
Night cooling of thermal mass

Air-to-earth heat exchangers in the Junior high school building in Imola (Bologna), Italy

Geothermal PVC