Koninklijk Instituut Van Ingenieurs

Engineering Society

Energy-efficient building design for a tropical climate: a field study on the Caribbean island Curaçao

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2. Key tropical building design principles
3. Energy use of air conditioners in Curaçao
4. Life-cycle of a building
5. Results
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7. Recommendations and limitations

1. Introduction

- Aim of the study
- Energy use in buildings
- Passive design strategies
- Direct and indirect effect on the environment
- Definition of passive design in the tropics

2. Key tropical building design principles (1)

- Building orientation
  - Prevailing winds
  - Minimize the effect of direct sunlight
  - Overhangs and other types of shading
  - Vegetation (figure 1)

Figure 1: A building designed with an overhang and vegetation (Hotel Floris Suite)

2. Key tropical building design principles (2)

- Natural ventilation
  - The advantages of natural ventilation
  - Encourage cross ventilation in buildings (figure 2)
  - Convective air movement or stack ventilation (figure 3)
  - Open blocks and elevated building (figure 4)

2. Key tropical building design principles (2)

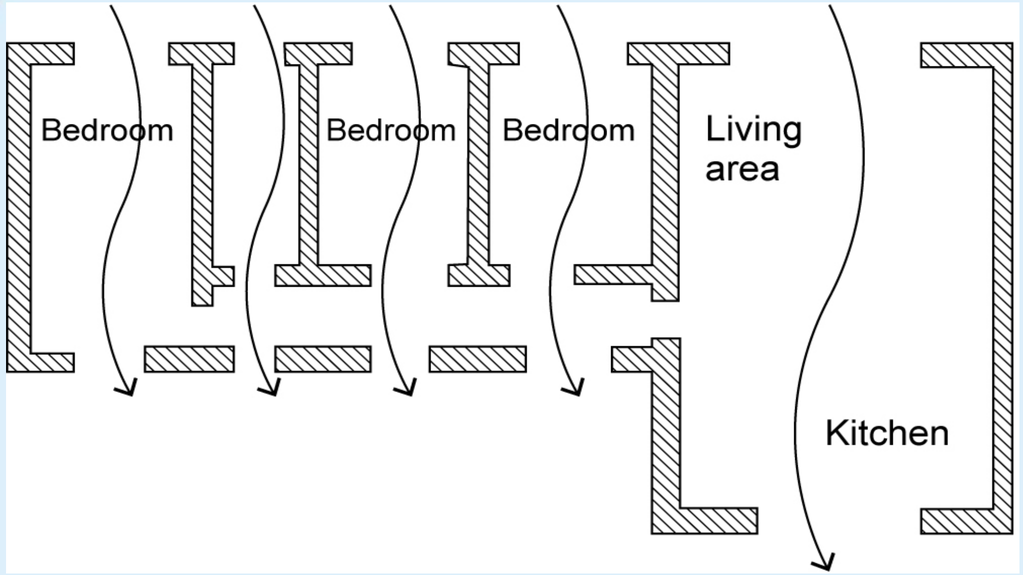

Figure 2: Natural ventilation in a house building design

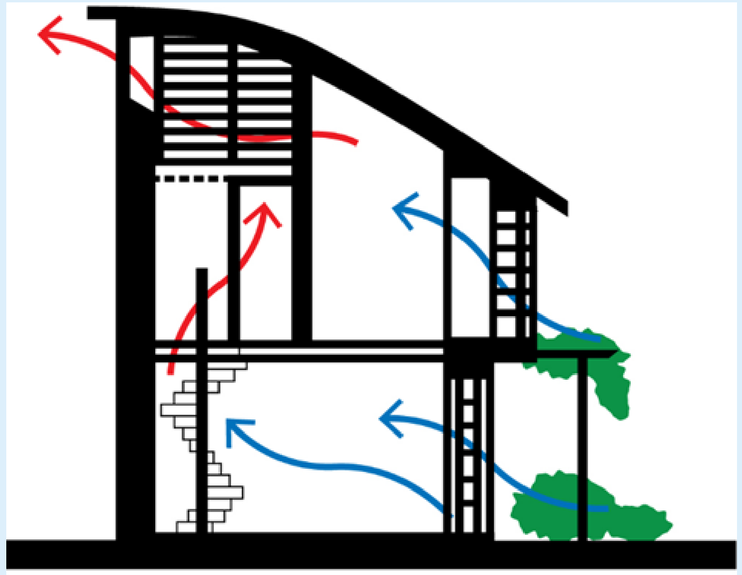

Figure 3: Convection air movement or stack ventilation

Figure 4: Open building blocks in an elevated house (Jan Thiel Curaçao)

2. Key tropical building design principles (3)

- Natural light
  - The extent of the natural light
  - Acquire natural light
- Windows
  - Exposed and shaded from direct sunlight
  - Minimize the heat input (figure 5)

Figure 5: A building with exterior louvers for windows and doors (Hotel Floris Suite)

2. Key tropical building design principles (4)

- Roof ventilation
  - Encourage natural ventilation
  - Use materials such as zinc and aluminum
  - Light colors
  - Slope roofs towards the prevailing wind
  - Insulation
  - Double roof shading technique (figure 6)
  - Green roof (living roof)
  - Ventilation openings (figure 7)

Figure 6: Double roof and shaded walls

Figure 7: Building of architect Tom Janga

2. Key tropical building design principles (5)

- Example of an energy-efficient dwelling in Curaçao

Figure 8: Energy-efficient dwelling at Rif St. Marie Curaçao by architect Jan de Bouvrie

2. Key tropical building design principles (6)

- Thermal mass Materials
  - Building materials with a high thermal mass
  - Lightweight materials with a low thermal mass
  - Prevent heat gain and heat storage
- External walls
  - Light colors
  - Overhangs
  - Vegetation
  - Interior shading
- Outdoor and Transition spaces
  - Cooling effect on the incoming air
  - Types of transition spaces

3. Energy use of air conditioner in Curaçao

- Low-income category households: 18.2%
- Middle-income category households: 26.3%
- High-income category households: 27.5%
- Hotels: 41%
- Office buildings: 54%
- Supermarkets: 27%

4. Lifecycle of a building

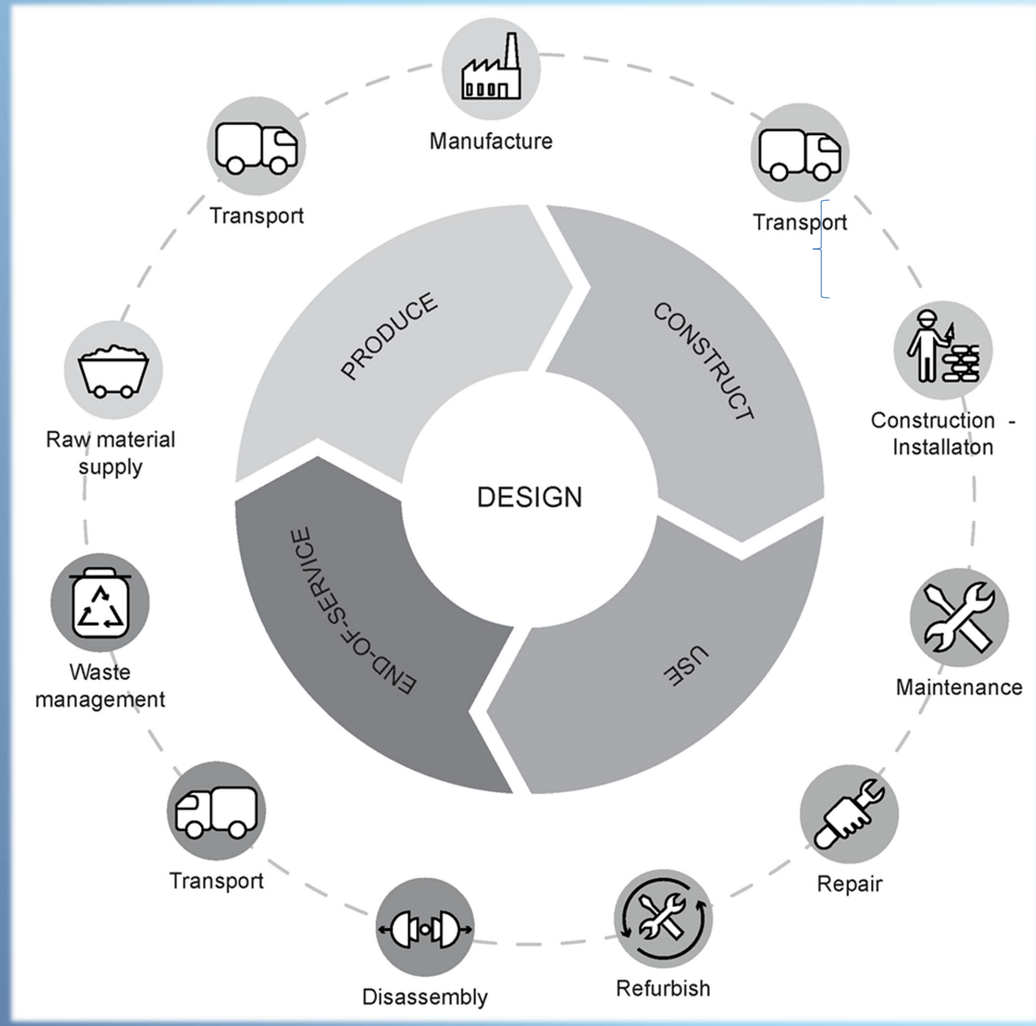

Figure 9: Life-cycle of a building

5. Results (1)

- Heat Transmission through the Roof (residential)
  - Fiber-reinforced roofing materials (eternit): 73.3%
  - Zinc/aluminum: 12.7%
  - Roof tiles: 5.7%
  - Concrete: 3.2%
  - Shingles: 0.6%

- Heat Transmission through the Roof (commercial)
  - Fiber-reinforced roofing materials (eternit): 26%
  - Zinc/aluminum: 2.3%
  - Roof tiles: 9%
  - Shingles: 5.1%
  - Unknown : 53%

5. Results (2)

- Roof color (residential)
  - Light color: 42%
  - Dark color: 58%

- Roof color (commercial)
  - Light color: 41%
  - Dark color: 59%

5. Results (3)

- Thermal Mass Materials (residential)
  - Concrete: 97.1%
  - Timber: 58%
  - Combination: 1%
- Thermal Mass Materials (commercial)
  - Concrete: 98.7%
  - Timber: 1.3%

5. Results (4)

- Wall color (residential)
  - Light: 61%
  - Dark: 39%

- Wall color (commercial)
  - Light: 46%
  - Dark: 54%

5. Results (5)

- Solar shading:
  - Residential: 93.3%
  - Commercial: 77.8%
- Transition spaces:
  - Residential: 91%
  - Commercial: 50.5%
- Single-story building:
  - Residential: 84%
  - Commercial: 72%

5. Results (6)

- Elevated buildings
  - Two residential buildings

- Double roof:
  - Eight commercial buildings

6. Findings

- Use low thermal-mass building materials to reduce heat gain.
- Facilitate natural ventilation as much as possible in all rooms of a building through an effective layout design.
- Shade the buildings and keep the heat of the sun away from the building.
- Use light colors for both the walls and the roofs of buildings.
- Install insulation in the walls and the roof of a building.
- Create roof spaces with adequate natural ventilation.
- Create outdoor and transition spaces.

7. Recommendations and limitations

- Targeted awareness campaigns.
- Introduction of passive building energy codes.
- Additional research is needed to verify the awareness and application of these passive building design principles.
- Quantify the effect of the application of each passive building design principles.
- Additional study is needed on insulation and building materials.

Thank you for your attention.