Vision of integrated sustainable building design

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Biography
1975 Born in Tokyo (36 years old)
1994-98 Tokyo Metropolitan Univ. (TMU)
1998-2005 Graduate School of TMU
2005 Dr. Eng.
2005-2010 Tokyo University of Science, RA
2010-2011 The University of Tokyo,
Project Assistant Prof.
2011- TMU, Assistant Prof.

Thesis
Building facility system
Air conditioning, Lighting
Window system
Urban climate / Heat island
Cool roof / facade
Water evaporation
Building science
Weather data
Optical property of building material
Ray tracing
Building design / Commissioning
Integrated building design
BEMS
BIM for design and Cx

Agenda
1. Background
Actual status of Tokyo and future of Asian cities
2. Glazed architecture
Facade engineering (mechanical, material,)
Numerical study
3. Urban climate
Cool roof / facade
Potential of water
4. Summary
Elements of Integrated Sustainable Building Design


Got through electric crisis by reduction of AC

Source: TEPCO
Mentality of Japanese citizen
Honesty, Diligence, Economy

Ishida Baigan (1685-1744)

Too Dark….

Too Hot….

Core temp. 1,500,000 K
Surface temp. 5,784 K

Solar radiation on the entire Earth surface (174PW) \(\times 10^{15}\)

\[= 10,000 \text{ times total human energy consumption (0.02PW)}\]

Solar heat balance of the earth

Solar heat balance of the city

Progress of heat island in Tokyo

Temperature distribution at 5 a.m. in the summer
Moriyama, Shousuke. Strategy and technology to heat island
**Temperature rise of Tokyo**

Year: 1880 to 2000

[Source: Japan Meteorological Agency]

**Number of heat illnesses in Tokyo**

(taken by ambulance)

Year: 1995 to 2005

[Source: Tokyo Fire Department]

**Ranking of urban populations (2005)**

- **Asian cities rank high**
- **There are 18 cities over 10 million.**
- **33 cities are expected to be over 10 million by 2025.**


**Estimated future CO2 emissions**

- **Scenario A1B: When economic growth is maintained**

[Source: IPCC 4th report]

**Breakdown of office building energy consumption**

- **Heating & cooling**
- **Lighting**
- **Office & other**
- **Hot water**

[Source: IPCC 4th report]
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Much of the sunlight on the city shines onto walls.

Glazed architecture:
- Hot and Cold?
- Waste energy?

"Oil Shock" caused by wars in the Middle East (1970s)

"Reduce Windows!"

Example 1: Air Flow Window

Air is carried and exhaust by mechanical ventilation

Outer Glass

Blind

Air Layer

Inner Glass

Section of window

<table>
<thead>
<tr>
<th>Air Flow Window Effect</th>
</tr>
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<tbody>
<tr>
<td>Air Speed (CMH)</td>
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<tr>
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<tr>
<td>60</td>
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<td>70</td>
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</tbody>
</table>

Example of temperature variations:
- 45°C
- 35°C
- 30°C
- 25°C
Example 2: Exterior Shading

Mechanical automatic controlled louver shades direct solar radiation.

Example 3: Themotropic glass

- TT glass is a sealed unit in which a polymer gel is sandwiched between two panes of glass.
- The gel undergoes a sol-gel phase transition at a characteristic temperature, allowing the glass to autonomously shade solar radiation while retaining maximum natural light.

Comparison of internal and external louver

Visible Infrared

Automatic controlled blind system

- Shading direct sunlight
- Introducing daylight
- Ensuring view

Fluctuation of colour temperature of sunlight around sunset

Example 3: Themotropic glass

Section of TT glass
パッシブ建材の応用：自律応答ガラス

Example 4: Window film

破壊の可能性か？

ブラインド併用西窓面の熱画像

Spectral transmissivity of Nano film
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**Spectral solar irradiance on the ground**

Near Infrared
(780~2500nm)
45%

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**Luminous efficiency of daylight**

\[
\text{Sky sunlight} \quad 120 \text{lm/W} \\
\text{Direct sunlight} \quad 100 \text{lm/W} \\
\text{Fluorescent lamp} \quad 80 \text{lm/W}
\]

Combination of AFW and Low-E glass maximize to 160lm/W

**Utilization of Daylight**

Daylighting contribute to both electric energy and heat load.

Lighting control system is simple and moderate in price.

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**計算建物の断面図**

**開口率の影響：一次エネルギー**
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10. 各種屋根表面温度測定

雨水型スクエアターフの表面温度のほかにも、各屋根構成材料表面温度を測定する。

- 測定計器: 熱電対、ロガー

ドムターフ 人工芝 + 断熱材
スラブ面 高反射塗料 人工芝のみ

熱画像の時刻変動 7/21 6:30-14:00

57

芝生ユニットS

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Diagram of the grass unit

5. 貯水量測定

雨水型スクエアターフ内の雨水貯水量の変動を測定する。含水率計を水位計の代わりに用いて水位を測定する。

- 測定計器: 含水率計 (型式: ECH2O, 製造会社 Decagon Devices, Inc.)

6. 土壌含水率(長期)

土壌に含まれる水分量を測定する。土壌中に含水率計を埋設しデータロガーで測定を行う。

芝生ユニットの水分特性
日射量と蒸散潜熱量の経時変化（水位変動から算出）

日射量と蒸散潜熱量の日積算 2004.7/21

Solar Irradiance
Latant Heat Flux
59.0%

Singapore
Newton house

Tree Lodge @ Singapore
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OASIS21 @ Nagoya

Section diagram of OASIS21

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With water

2003 8/3 14:00
Without water

水盤より約9℃高い
水盤ガラス面45.3℃

2003 8/2 14:00

Sectional diagram of glazed roof with water pond

ヒートアイランドの緩和効果

Time fluctuation of heat flux (7/31-8/3,9/26-29,1/28-31)
Spectral transmissivity and reflectivity of grazed water roof

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What and how do we integrate?

- Building and City
- Design and Verification
- Architecture and System
- Heat and Light
- Science and Engineering
- For Human