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Integrated Resilience of the Built-Environment

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0. Introduction: Notion of resilience

1) In the 21st century, most of population on the globe live and work in cities, where uncertain future risks are increasing such as global warming, multiple natural disasters, income gap-widening, aging, health problems, political conflicts, terrorism, vulnerable infrastructure, etc.

2) In 1961, Jane Jacobs, a community activist, already published “The Death and Life of Great American Cities,” referring to the roots of similar risk issues of the city resilience.

3) “Resilience” is a term that emerged from the field of ecology in the 1970s to describe the capacity of a system to maintain or recover functionality in the event of disruption or disturbance. It is applicable to cities and buildings because they are complex systems that are constantly adapting to changing circumstances.

4) The notion of a “resilient city and building (built-environment)” becomes, therefore, conceptually relevant when chronic stresses or sudden shocks threaten widespread disruption or the collapse of physical or social systems.

5) “Integrated Resilience of the Built-Environment” describes, consequently, the capacity of those to function, so that the people living and working there, particularly the poor and vulnerable, survive and thrive no matter what stresses or shocks they encounter.

Such a goal towards human security must be the top priority that formulates the social responsibility of our profession worldwide.
1. Recent Proposal

“Meta-Sand Spiral City”, Cairo

Innovative resilience across time and scale

by

YASUI Architects & Engineers Inc. + IWAMURA Atelier Inc. JV
August 2016

“Meta-Sand Spiral City,” Cairo
From Cairo to the Site:
The site is located 38km away from and to the west-southwest of the city-center of Cairo, connected by the major road 27 July Axis and Al Fauaro-Al Wahat Road.

Main access to the site is given only through the northern residential areas, which is not favorable from the traffic point of view.

Although the southern buffer zone currently allows no access from Al Wahat Road, it is strongly advised to provide one to avoid any traffic inconvenience in the adjacent residential areas.

Also the southern buffer zone may be used for additional visitors parking place, as is the case of the Modern Science & Art University.

Local Consideration:
The northern residential areas, closely developed to the site, require a buffer line along the boundary.

The site plan, therefore, requires to keep a distance with buildings that embraces a courtyard, which creates tranquil and attractive urban asset with a well-tempered human environment for both the users and the neighbors.

Homage to the Pyramids:
Symbolizing the time evolution, the Observatory Tower allows to appreciate the Giza Pyramids, the jewel of Egypt, over the entire view of the Science City.

Site Planning:
The cell-like buildings are located at the center of site, surrounding a courtyard. They consist of four cells, connected with each other by spiral slopes in the courtyard. They are integrated into the site topography slightly rising toward the north and also partially connected with the landscaping.

Conceptual Coordinate across Time & Scale

Scale:
- Macro: Spiral Galaxy
- Micro: DNA Double Spiral

Time:
- Past: 2500 B.C.
- Future: 2500 A.D.
“Meta-Sand Spiral City”

The innovative incubator of scientific culture, integrating Nature, Civilization and Life, on the basis of “Meta-Sand” and “Spiral Evolution”

Site area: 125,000m², Built-up area: 32,000m², Total floor area: 114,500m²

Floor Plans

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Floor Plans

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Ⓒ YASUI Architects & Engineers Inc. + IWAMURA Atelier Inc. JV

Rooftop + Layout

Ⓒ YASUI Architects & Engineers Inc. + IWAMURA Atelier Inc. JV + Townscape Design Institute Inc.
Elevation (South)

Section (A-A')
Landscaping

1) Organically integrated landscaping through;
   Site specific topography and geography

2) Impressive surroundings along the site boundary by;
   Moats, mounds and rampart for security using similar material to the façade for harmony

3) Memorable approach & entrance by;
   Welcome water basin reflecting the unique façade and the stardust lighting

4) Region specific outer-gardens constituted of;
   Desert, Rock, The Nile, Oasis, Grass and etc.
   Roof-top garden on the Campus III linked to Grass Garden

5) Peaceful unique inner-garden as the courtyard characterized by;
   Lawn and pond at the middle surrounded by the three organic buildings and the tower
   Spiral pedestrian slopes connecting each floor

6) Natural irrigation water provision by means of;
   Air-water catcher devices taking advantage of the hourly fluctuation of temperature & humidity

7) Consideration for maintenance and security by;
   The maintenance road beside the mound and rampart along the site boundary

Interior images

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Innovative Structural Design

Main Structure
Main Structure is composed of RC 9m x 9m core system to support normal force, while random RC columns are set to support horizontal force to allow free and flexible space provision by means of:

1) Column-less space through long span PC beams
2) Full usage of the story height between the voided flat slabs

ECO void

<table>
<thead>
<tr>
<th>Core</th>
<th>Core</th>
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<tbody>
<tr>
<td>9m</td>
<td>9m</td>
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<tr>
<td>18m</td>
<td>9m</td>
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<tr>
<td>9m</td>
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RC Column (1m in diameter)

RC wall (thickness 1m)

Voided flat slab system:
Voids contribute to reducing the weight and can be used for utility piping & wiring

Cross section of a voided flat slab

Voided flat slab under construction

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Eco-Void System

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Meta-Sand Brick

is a state-of-the-art structural material that can be easily made by injecting CO₂ gas into SiO₂ and soaking in urethane liquid afterward.

SiO₂ is abundantly available in the adjacent desert and therefore very affordable.

(Courtesy of Prof. Norihide IMAGAWA)

Abacus of Meta-Sand Brick Elements

The elements of the Meta-Sand Façade represent a variety of molecules and compose diverse patterns according to the requirement of the related interior space.

This pattern characterizes the whole façade of the Meta-Sand Spiral.
Design for Resilience - 1:
Security System

Security

1) Security zoning
Comprehensive security system is an indispensable element to realize resilient operation of the Science City.
The security zoning is hereafter proposed to be divided into the Level I to VI according to the functional importance, and the security checkpoints are set in every zone.

2) Security level
The level of security is systematically established from I to VI covering the site, the buildings, general rooms and a special room respectively. Also, a personal authentication system through a chip card and fingerprint is introduced for security operation and management.

Design for Resilience - 2:
BCP System

BCP (Business Continuity Plan)

Disaster preparedness
Facing unexpected risks including natural disasters and/or terrorism, BCP is indispensable for both public and private business entities to support the stakeholders as well as the relevant company to survive beyond the prospective risks and dangers.
The figure on the right show an image of BCP framework simply customized in the Science City in case of the infrastructure shutdown.

Recovery during the aftermath
Simulation of recovery is the core of BCP in view of the survival with ever changing requirements during the aftermath. The Science City could be used as an evacuation venue for the employee, the visitors and the neighbors.
Nightscaping

According to the daily and seasonal change of natural lights, the Meta-Sand Spiral City is designed to appreciate the ecological lighting effects through the porous façade and the Tower.

“Meta-Sand Spiral City,” Cairo
2. Disasters

2.1 Occasional Disasters

Japan, like many other Asian counties, has been experiencing the frequent difficulties physically, environmentally, economically and socially, due to a variety of temporary & natural disasters including typhoons, floods, earthquakes, tsunamis, volcanic eruptions and the like.
27 Major Natural Disasters in Asia & Oceania since 1990
(as of August 30th, 2011)

28 Record of Major Natural Disasters in Japan since 2011

Note) EQ: Earthquake (only M=6.0 or more), E. Eruptions: Explosive Eruptions
The Great Japan East Earthquake & Tsunami

March 11, 2011

Casualties: (as of Mar. 10, 2016)

Deaths: 15,894p
Missing: 2,561p
Injured: 6,152p
Minami-Sanrikucho totally devastated by the 3.11 Tsunami

Before 3.11

After 3.11

Local disaster ⇒ Global disaster

Energy Transmission of the Tsunami triggered by 3.11 Earthquake

Arrival Time of the Tsunami to the Pacific Coasts after 3.11 Earthquake

(Source: 2011Sendai-NOAA-Energyhvpd9-05.jpg
NOAA: National Oceanic and Atmospheric Administration, US Department of Commerce)
Paper Partition System designed and provided by Shigeru BAN for human dignity at Ohtsuchi High-School’s gymnasium as an aftermath refuge, set up by the refugees themselves.

SHIGERU BAN ARCHITECTS
Voluntary Architects Network (VAN)

Before

After

© SHIGERU BAN ARCHITECTS

TOYO ITO
(Winner of 2013 Pritzker Prize and 2017 UIA Gold Medal)

& ASSOCIATES, ARCHITECTS
Initiatives of “Home-for-All” Networking

The 1st Home-for-All (Oct. 2011), built within a temporary housing site in Sendai.

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Kumamoto Earthquake

April 14~, 2016

Casualties:
(as of Apr. 28, 2016)
Deaths : 49p
Missing : 1p
Injured : 1,496p

Kumamoto Earthquake Apr. 14 ~, 2016

No Tsunami, but frequent severe aftershocks
Mt. Aso’s explosive eruptions

A series of explosive eruptions at Mt. Aso’s Nakadake Crater occurred at 21:52 on 7 October and 01:46 on 8 October, 2016, after a period of deformation was detected. The last similar eruption was recorded 36 years ago.

The volcanic ash fell as far as 320km away from the crater (see below the Aso City covered by ash).
Emergency Architects for disaster relief

sent by JIA nationwide to date for;
1) Aftermath investigations in general
2) Damage level diagnosis of the affected buildings
3) Consultation for the victims

Source: JIA Committee on Disasters, 2014

International Workshops about seismic-proof design


Organized and moderated by Kazuo IWAMURA, FJIA
2.2 Daily Disasters

In Japan, domestic accidental death toll amounts more than three times as much of traffic accident.

This should be called “Daily Disaster.”

The key architectural solution is providing a whole house with high thermal insulation to relax the Indoor Heat Shock in existing old houses.

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Annual death toll of domestic accidents in Japan (2011)

Total: 16,722p, of which 13,325p (79.7%) are seniors (>65)

- Drowning: 4,941p (seniors: 4,416p, 89.4%)
- Suffocation: 3,472p
- Fall: 2,414p
- Exposure to fire & smoke: 856p
- Poisoning: 414p
- Contact with heat: 129p
- Others: 843p

Death toll of drowning in bathtub has been rapidly increasing in existing old houses, while that of traffic accident became a half during 1995～2012.

The major cause of this accident is considered:

**Indoor Heat Shock,**

due to the intense temperature difference between

① living room (24℃),
② undressing room (14℃) and
③ bathtub (42℃),

which causes sudden change of blood pressure, and consequently stroke or cardiac failure.

High thermal insulation of the whole house is proved very effective to prevent such accidents.

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**Impact of Climate Change on Human Health**

- Injuries, fatalities, mental health impacts
- Asthma, cardiovascular disease
- Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus
- Forced migration, civil conflict, mental health impacts
- Water and Food Supply Impacts
- Water Quality Impacts
- Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms
- Malnutrition, diarrheal disease
- Extreme Heat
- Air Pollution
- Changes in Vector Ecology
- Increasing Allergens
- Respiratory allergies, asthma

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**Source:** [https://www.cdc.gov/climateandhealth/effects](https://www.cdc.gov/climateandhealth/effects)
3. Methodological Approach towards Resilient Built-Environment

3.1 Trigger

Iwamura et al. started developing so entitled “Environmentally Symbiotic Housing” as a national initiative of Japan in collaboration with governments, academia and industry in the year of 1990. The trigger was the Japanese cabinet’s project in view of coping with the Global Warming (1990). Since then as ever, Japan has experienced a number of tragic natural disasters.

Learning from those experiences, it should be recognized that the sustainability of housing and community be holistically elaborated along a cyclic sequence of time,

1) In ordinary time,
2) At the disaster and
3) In the aftermath.
3.2 Life Continuity Plan (LCP)

Given the above, it must be recognized that we are always confronted with disasters both “Occasional” and “Daily.” Taking this into consideration, how should we plan and design sustainable housing and community?

Related to this query, Business Continuity Plan (BCP) gives us a hint, which means as follows;

“When business is disrupted, it can cost money. Lost revenues plus extra expenses means reduced profits. Insurance does not cover all costs and cannot replace customers that defect to the competition. A business continuity plan to continue business is essential”.

The author proposed a similar initiative, replacing “Business” by “Life,” namely “Life Continuity Plan (LCP)” to take care of the holistic planning and design of resiliently sustainable housing and community.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Items</th>
<th>Housing Level</th>
<th>Community Level</th>
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<tbody>
<tr>
<td></td>
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<td>Detached</td>
<td>Collective</td>
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<tr>
<td>1. Ordinary Time</td>
<td>Physical Health</td>
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<td>Physical Security</td>
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<td>Mental Health</td>
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<td>Peace of mind</td>
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<td>Crime Prevention</td>
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<td>Maintenance</td>
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<td>Periodic Inspection</td>
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<td>2. At the Disaster</td>
<td>Place of Refuge</td>
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<td>Energy Sources</td>
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<td>Sewerage System</td>
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<td>Toilet</td>
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<td></td>
<td>Traffic</td>
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<tr>
<td>3. In the Aftermath</td>
<td>Place of Refuge</td>
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<td>Provisions</td>
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First, a basic frame has been developed to grasp at a glance overall relevant engagements in terms of the time-line and scale. The objects of measures are sorted horizontally according to the scale (from a detached-house, an apartment, a neighborhood, to a region), and vertically to the time-line (from ordinary time, at the disaster, and in the aftermath, which are always cyclically repeated).
4. Implemented Practice

Yakushima Symbiotic Housing
designed for passive & indigenous resilience

by
IWAMURA Atelier Inc.
2001-2006

Zones

Northern Zone (1, 2, 3, 4)
HDD: D_{18-18} >3,000

Intermediate Zone (5, 6)
HDD: D_{18-18} =1,500–3,000

Southern Zone (7, 8)
HDD: D_{18-18} <1,500
Yakushima Island Municipality

Location:
- Long. 130° 34’E
- Lat. 30° 25’N

Area: ca. 503km²

Population: 13,761 (as of 2005)

Nature of Yakushima: *World Natural Heritage*

- Jomon Cedar Tree: 7,000 years old
- Shiranui-utsugi Canyon
- Jomon-sugi Cedar
- Mt. Miyanoura (1,935m)
- Yakusugi Land
- Senpiro Waterfall
- Shiranui-utsugi Canyon
- Jomon-sugi Cedar
- Mt. Miyanoura (1,935m)
- Yakusugi Land
- Senpiro Waterfall

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Local climate

**TEMPERATURE**

Annual Mean Temperature: **19.14°C**

**PRECIPITATION**

Annual Mean Precipitation: **4,488 mm**

**HUMIDITY**

Annual Mean Humidity: **74.35%**

**HOURS OF SUNSHINE**

Annual Mean Hours of Sunshine: **1,627 hr**

Source: AMEDAS Data by the Meteorological Agency (1993~97)

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Existing vernacular settlement in Nagata on the western shore

©IWAMURA Atelier Inc.
Conceptual design guidelines

1. Live with the sun
   - Live with the sun
   - Live with water
   - Live with wind
   - Live with resources
   - Live with creatures
   - Live with local community
   - Live with the nature
   - Live safe

Yakushshima Symbiotic Housing

- Public Leasable Housing
  - 50 Dwelling Units
  - Public Facilities
  - Commons + Parking
- Site area: 19,750 m²
1) Provision of safe and long-life basis and housing, resisting typhoons, heavy rains, salt damage and termites
2) Creation of safe and beautiful town-and-land scape, respecting the original topography of the site as well as the local life-style
3) Provision of a greening base to be networked for the restoration of the local forests that disappeared through exploitation to date

4) Housing development using the indigenous resources of the Yakushima island
5) Provision of a variety of housing types based upon the simple and flexible timber structure
6) Consideration of the property maintenance through participatory initiatives of the residents

for Human Security and Resilient Sustainability
Common paths for the residents

For the neighborhood exchange as well as evacuation route at disasters

A Typical Cross Section

©IWAMURA Atelier Inc.
Indoor and outdoor relationship

- Traditional closed housing layout to protect each other against typhoon’s strong wind
- Open interior for providing flexibility and natural ventilation

A typical block (model)

Entrance hall

Interior solutions of passive design

©IWAMURA Atelier Inc.

As of October 2000
Central Square for provisional refuge

Neighborhood’s Meeting Hall as an indoor refuge
Occupants’ intervention

as of August 2004

Resident’s initiative to mitigate harsh day-light in summer

An indoor scene of post-occupancy in summer

New resilient village, learned from the heritage
Well known “Footprint” is metaphorically used to symbolize the negative impacts, while “Handprint” symbolizes positive and innovative management that contributes to the sustainable development.

Current Footprint approach is focused on the negative impacts to individual, organization or states.

On the other hand, Handprint means to identify, measure and evaluate the positive sustainable impacts including social and economic levels.

- Wasting resources
- Generate waste
- Emissions
- Social impacts
- Others

- Quality of life
- Recognition of sustainability
- Quality of eco-system
- Social benefits
- Others

Decrease Footprint  Increase Handprint
5. Conclusion

1) Japan, similar to other Asian countries, has been experiencing the frequent difficulties physically, environmentally, economically and socially, due to a variety of natural and occasional disasters including typhoons & earthquakes, as well as the daily indoor disasters.

2) Accordingly, short-, mid- and long term effective relief measures should be taken to cope with them, especially the relevant preparedness measures for predicted future disasters.

3) In this regard, a cyclical design process for the human security must be taken into consideration as the highest priority involving all the stakeholders beyond simply being “Green” or “Smart.”

4) To this end, our collective efforts through communal and local solidarity will be the very base towards; Integrated Resilience of the Built Environment for Human Security.
5) Consequently, it describes the capacity of those to function, so that the people living and working there, particularly the poor and vulnerable, survive and thrive no matter what stresses or shocks they encounter.

6) Such a goal towards human security must be the top priority that formulates the social responsibility of our profession worldwide;

Beyond Disasters
Through Solidarity
Towards Resilient Sustainability

Thanks for your attention.

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