Asia-Pacific Housing Forum

Powering collaboration for housing impact

Window to appropriate construction technologies

“Appropriate” Housing Construction Technology: Friend or Foe?

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Lecturer | Humanitarian Engineering
Director of Research Training
School of Civil Engineering

THE UNIVERSITY OF SYDNEY

Humanitarian FRONTIERS LAB

What comes to mind when I say *“housing construction technology”?*

Image Credit: ICON


Image Credit: USAID

Construction technology refers to the collection of innovative tools, machinery, modifications, software, etc. used during the construction phase of a project that enables advancement in field construction methods.

Construction Industry Institute

Philippines – Recovery after Typhoon Haiyan

Philippines – Recovery after Typhoon Haiyan

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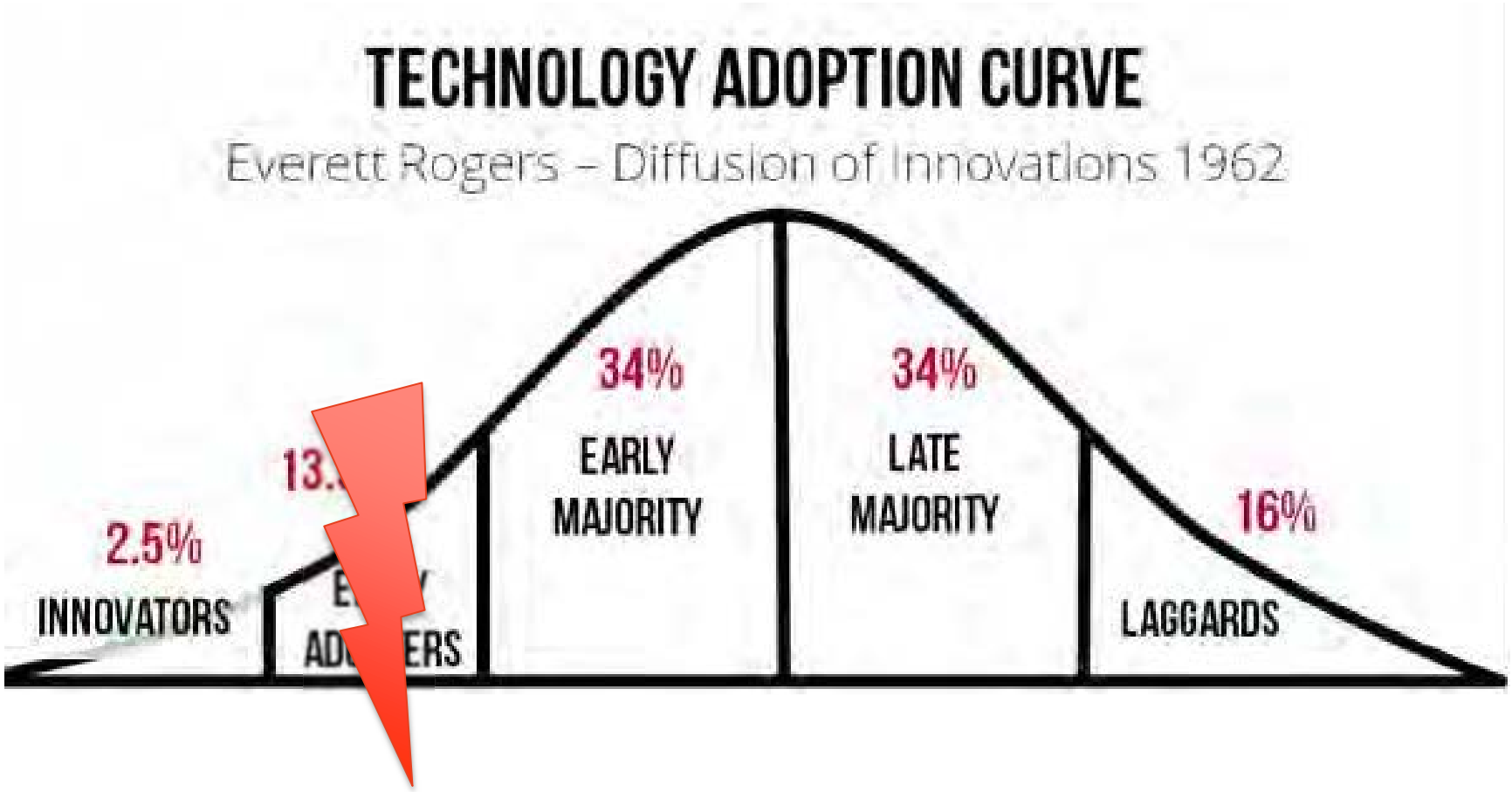
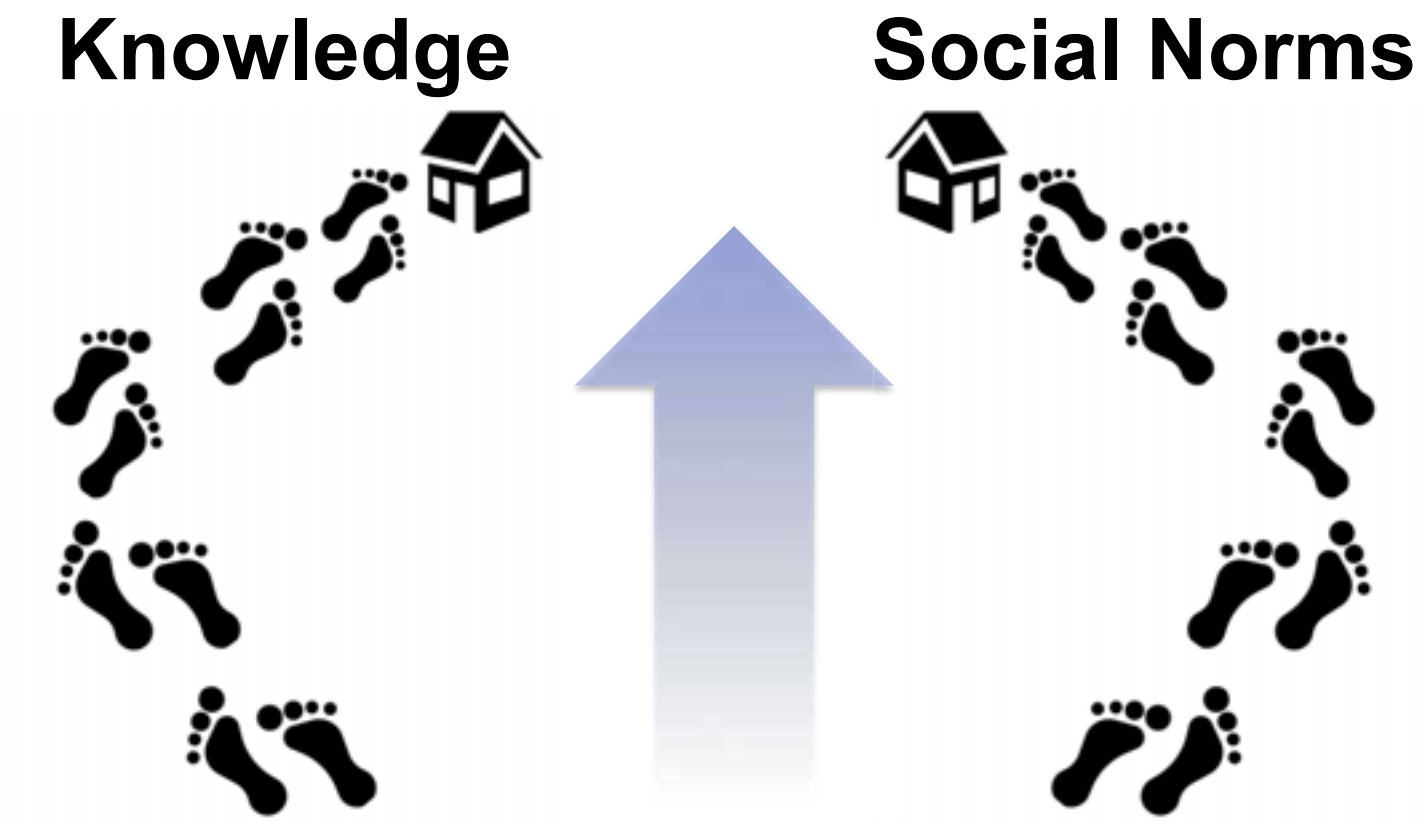
Philippines – Recovery after Typhoon Haiyan

We don’t need new technologies; we need to <u>disseminate and scale</u> the ones we already have.


TECHNOLOGY ADOPTION CURVE
Everett Rogers – Diffusion of Innovations 1962
2.5%
INNOVATORS
13.
34%
EARLY
MAJORITY
34%
LATE
MAJORITY
16%
LAGGARDS
The Chasm

How do we Increase Construction Technology Uptake?



Opdyke, A., Javernick-Will, A., and Koschmann, M. (2018) "Household Construction Knowledge Acquisition in Humanitarian Shelter Projects." *International Journal of Disaster Risk Reduction.* 28, 131-139. doi: 10.1016/j.ijdrr.2018.02.038

Nepal – Recovery after 2015 Gorkha Earthquake

***97%** of those who received technical assistance applied safer construction techniques*
(n=1,457)

Photo Credit: Eefje Hendriks

Social Norms as a Driver of Diffusion

"First, I was able to watch the group that built the bigger houses, and I learned a lot of techniques from the builders.
So, when it was time for our house, smaller compared to the first, I was vocal in airing my observation based on my previous experience. Every now and then I make suggestions on how to construct a specific portion. One time I called them out when I saw that they didn't install the posts properly because I've seen how it was seamlessly set up by the builders from the bigger house."

Concluding Thoughts

- We can't overlook **prerequisites** (e.g. land tenure) when using innovative construction technology

- **Select technologies that give agency to households**, not take it away

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Questions?

Plastic 2 Build


PET bottles scrap


SABA
Single use Plastic sachets


HDPE Plastic Waste

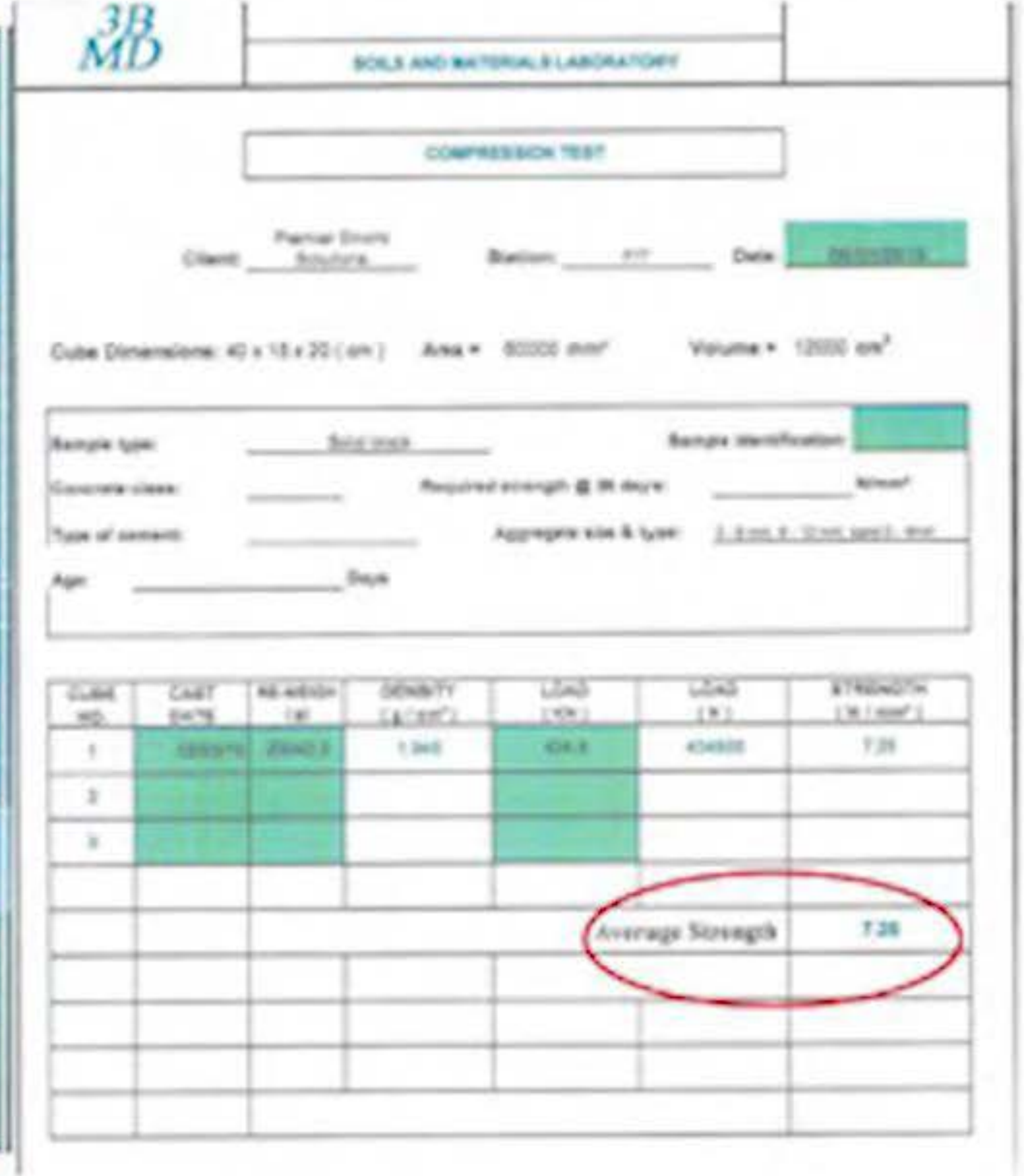

Film Plastic Waste


Shredded PET
River Sand
Blend
Quarry Granite stone


Pre-Cast
Pillars & Beams
No Cement
Roof Slab
No Cement


Hollow
No Cement
Solid

Compression Test



SOILS AND MATERIALS LABORATORY

COMPRESSION TEST

Client: [illegible] Station: [illegible] Date: [illegible]

Cube Dimensions: 40 x 15 x 20 (cm) Area = [illegible] Volume = [illegible]

Sample type: [illegible] Sample identification:

Concrete class: Required strength @ 28 days: N/mm²

Type of cement: Aggregate size & type: [illegible]

Age: Days

CUBE NO.	CAST DATE	RE-WEIGH (g)	DENSITY (g/cm³)	LOAD (KN)	LOAD (N)	STRENGTH (N/mm²)
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2						
3						
					Average Strength	[illegible]

Cement Block
Same size 4-5

Fire Resistant delay

10 Tons of Plastic Waste
in a 60 m^2 *2 bed Villa*

Expectations from Government:

To create an Enabling Environment

i. ***Space: Provision of space for the recycling and value add activity***
ii. ***Fiscal: Import Duty Free for Equipment and Spares, Tax Holidays and exemption from GST for trading in products from recycling.***
iii. ***Discount: Due to the high Electricity Costs of operations offer a discount price per Kwhr***
iv. ***Market Creation for OFF TAKE:***
a. ***Stipulate in Contracts for building of schools, Low Cost housing, Road Construction and upgrading of current Slums that at least 30% of materials utilized to be from recycled plastics.***
b. ***Embark on a Project for affordable low-cost housing village that would also have solar power, innovative faecal sludge treatment and water installations. (Eco-Village)***
i. ***Access to Finance…Financiers would only have an appetite if there is an OFF-TAKE Agreement guaranteeing a revenue stream. Institutions such as NASSIT can be encouraged to either take equity in a PPP arrangement or engage in a scheme where a developer will build affordable housing utilizing recycled materials and the houses can be either rented or sold in a rent to buy agreement.***

Benefits

1. Job Creation: Direct 100 PAX — Recycling Plant/ Buy Back Center/Drivers
   Indirect 500-800 PAX — Agents/ Collectors/Builders/Contractors

2. Wealth Creation potential over **200,000 PAX** as they can get money from Plastic waste that was previously thrown away

3. Drastically Reduce Plastic Pollution, less Plastic to Dumpsite, meeting **Transform Freetown 40 % Recycling Target.**

4. Products from Activity with **100% local Raw Materials** Blocks/Roof Tiles/Pavement Tiles that could make **low cost Housing Projects affordable.**

5. **Reduce Foreign Exchange** requirements, as using less Cement for building.

6. Can be replicated all over the World. Currently talking to a Company extracting Plastics from the rivers of Manilla in the Philippines and Econas Malaysia.

BUILDING BEYOND TODAY

Asia Pacific Housing Forum
18 September 2019

Base | Initiated by HILTI The Foundation.

ABOUT BASE

Base is a foundation that provides alternative building technologies to enable a network of partners that provide comfortable, affordable, resilient, eco-friendly houses with social impact.

Base | Initiated by HILTI The Foundation.

The Philippines and some of its challenges

POVERTY

4.2M poor families

25.2M or **25%** of Filipinos living under $1/day

NATURAL DISASTERS

TYPHOONS

20 average number of typhoons per year

315kph wind speed of Haiyan in 2013

EARTHQUAKES

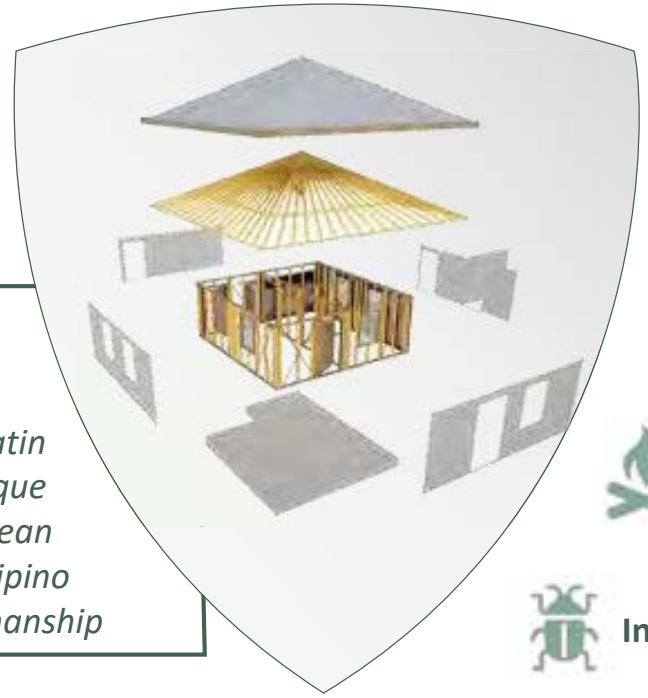
222 people killed and
796 injured during the Bohol and Cebu Earthquake in 2013

Base | Initiated by The Foundation.

THE CEMENT-BAMBOO FRAME TECHNOLOGY

Accredited by the Accreditation of Innovative Technologies for Housing (AITECH)

Combination of Latin American Bahareque Technology, European Engineering and Filipino Tradition and Craftsmanship



Typhoon Resistant

Earthquake Resistant

Fire Resistant

Insect Resistant

Base | Initiated by The Foundation.

Research and Design

Material

Connection

System

All the different components are tested according to existing standards. House designs are designed accordingly and consistent with the National Structural Code of the country.

Base | Initiated by Hilti The Foundation.

FULL SCALE TYPHOON TEST BEFORE AND AFTER GLENDA

Since 2013, the model houses have resisted 11 typhoons and 1 earthquake.

CEMENT-BAMBOO FRAME TECHNOLOGY

is accredited by the

Accreditation of Innovative Technologies for Housing (AITECH)

Republic of the Philippines
Office of the President
HOUSING AND URBAN DEVELOPMENT COORDINATING COUNCIL

THE ACCREDITATION OF INNOVATIVE TECHNOLOGIES FOR HOUSING (AITECH) COMMITTEE

ACCREDITATION CERTIFICATE No. 2016 - 016

CEMENT-BAMBOO FRAME TECHNOLOGY

BASE BAHAY INCORPORATED

MARIA LEONORA G. ROBREDO
Chairperson

Base

Initiated by Habitat for Humanity The Foundation.

DISASTER RESILIENT

From Destruction to reliable Construction

Base | Initiated by Hilti The Foundation.

ELEVATES THE QUALITY OF LIVING

From Poor to Secure

Base

Initiated by Hilti The Foundation.

COMFORTABLE AND ADDRESSES NEEDS AND WANTS

to accessibility and possibility

Base

Initiated by Hilti The Foundation.

BASE INNOVATION CENTER*

Testing of new Species, components, and connections

Closer monitoring of testing

Immediate access to research and testing equipment

Collaboration with Universities and research institutes

*Opens 4Q of 2019

Base | Initiated by HILTI The Foundation.

TREATMENT FACILITIES

Strict quality control and monitoring process to ensure Construction grade Bamboo poles

Batangas

Murcia

Dumaguete

Bukidnon

Cement Bamboo Frame Technology

A System that creates a value chain that encourages individuals and communities to GROW, BUILD and TRANSFORM

"I have been able to augment my income and provide for my family while learning new skills in Bamboo treatment"
Berto, Murcia Farmer

"I lost everything. But I didn't lose hope. When Base started in Samar, I decided to ask if there was any work for a woman in construction"
Michelle , Haiyan survivor

"Now it is easier for me to get to school and pursue my dream of becoming a teacher"
Rouela, ATI Tribe Iloilo

Base | Initiated by Hilti The Foundation.

SUSTAINABILITY

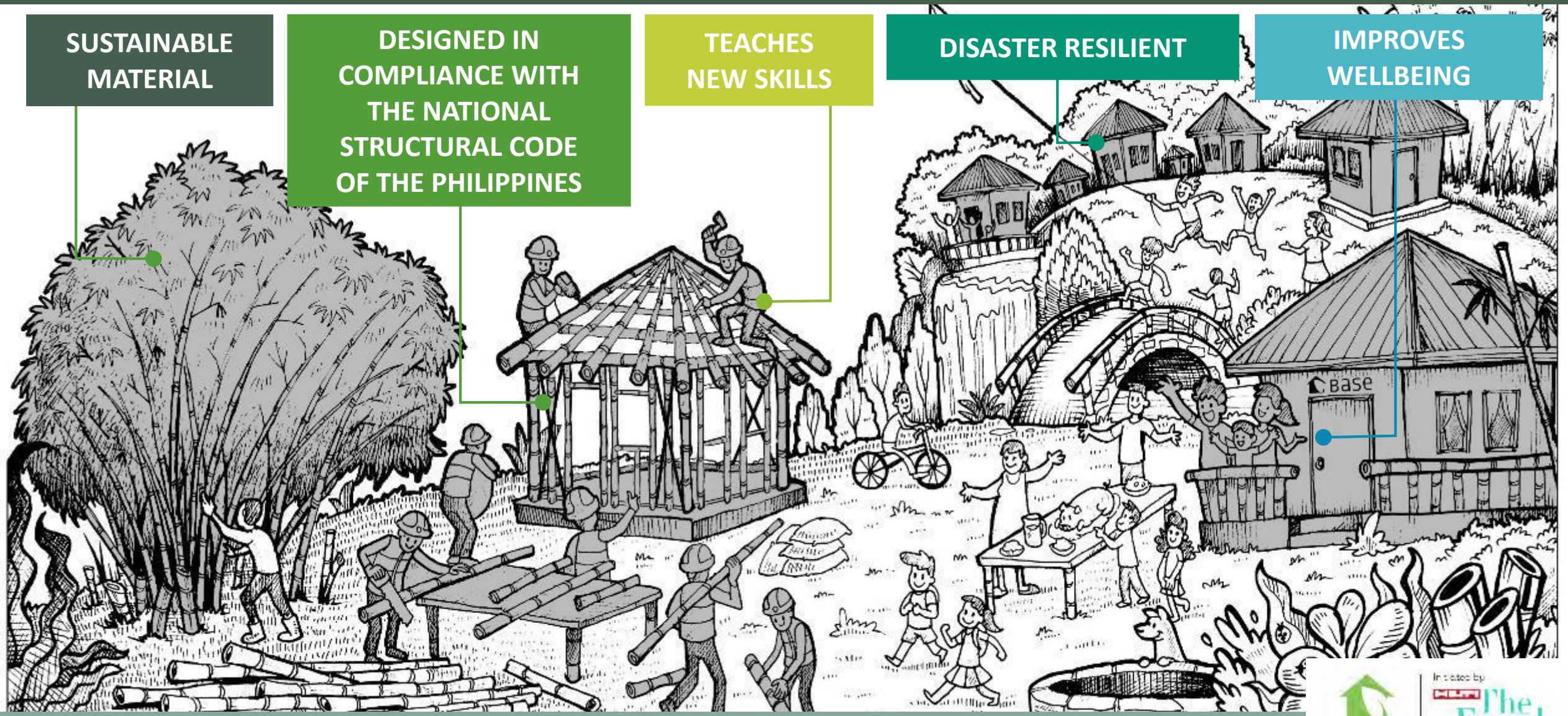
SUSTAINABLE MATERIAL

DESIGNED IN COMPLIANCE WITH THE NATIONAL STRUCTURAL CODE OF THE PHILIPPINES

TEACHES NEW SKILLS

DISASTER RESILIENT

IMPROVES WELLBEING



Base

Initiated by

The Foundation.

IMPACT 2024

HILTI The Foundation.

Habitat for Humanity®

Base

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MARAMING SALAMAT!

THANK YOU!

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Window to Appropriate Construction Technologies

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School of Architecture + Design
King Mongkut's University of Technology Thonburi
September 18, 2019

Image: Supakrit S.


Heritage and Vernacular
-Adaptive reuse
-Implementation in its own ways
New Urban Agenda
-Rating tools
-Equality, Inclusive
-Smart and Transparent
-Waste
-Air Quality
Resilience
-Flood
-Earthquake
-Landslide
-Disaster Recovery
-Water Scarcity
Energy Efficiency / Sustainability / Innovation 4.0
arcasia
Country issues
ARCASIA COMMITTEE ON GREEN AND SUSTAINABLE ARCHITECTURE (ACGSA)

Future Resilient Urban Planning + Architecture:

Thai Central Flood Plain

Sustainability for
Social Values, Economic Values,
Aesthetic Values, Historic Values,
Health + Well-Being

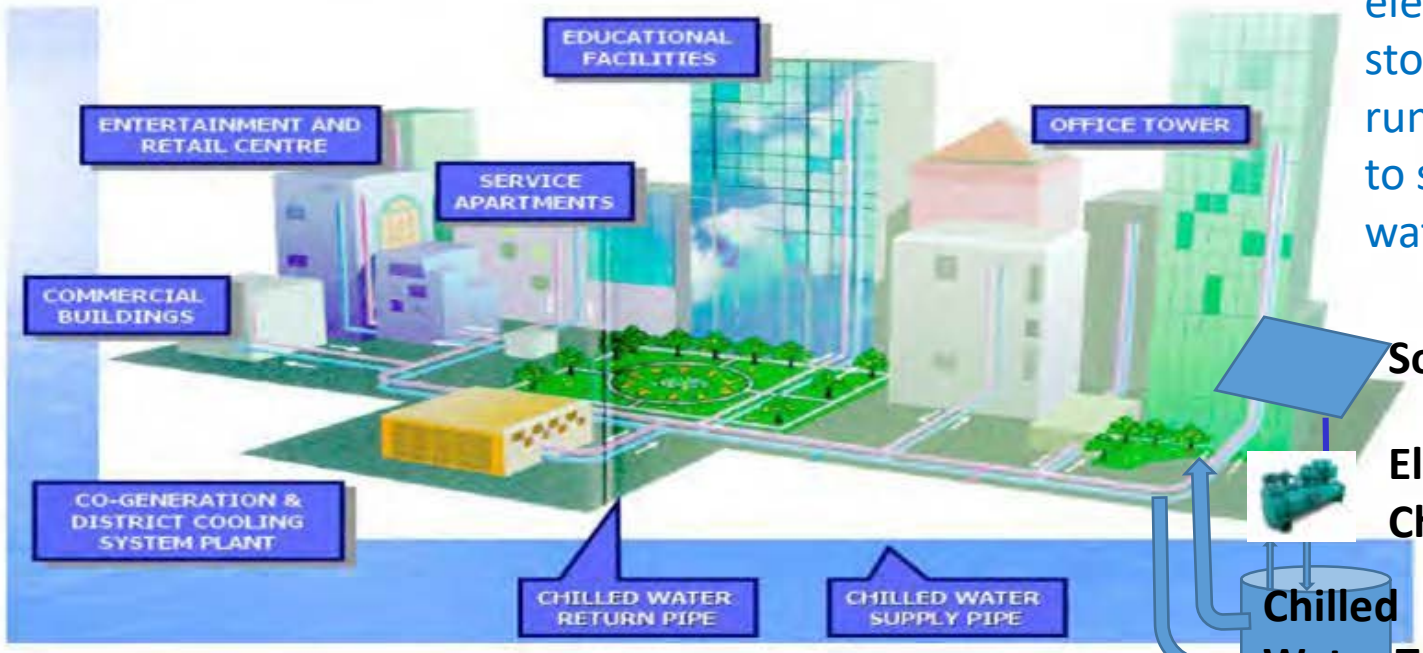
Urban:
-Bring back old wisdom in urban planning / Architecture—adaptability
-Adaptive use for flood, design for self-sufficient for several days, porous city
-Shared facilities such as co-working, parking, waste water treatment and service systems such as PV , District cooling

Design + Construction:
-Computer Simulation
-Passive design strategies
-BIM-Digital Fabrication, Modular, Prefab, movable, compact
-Responsive design, AI

Materials:
-Low CO_2 , VOC emission materials, reuse, recycle, upcycle, EE envelope
-Waterproof / moisture proof materials
-Ease of maintenance, less cleaning, repairing

District Cooling – *Mixed used project*

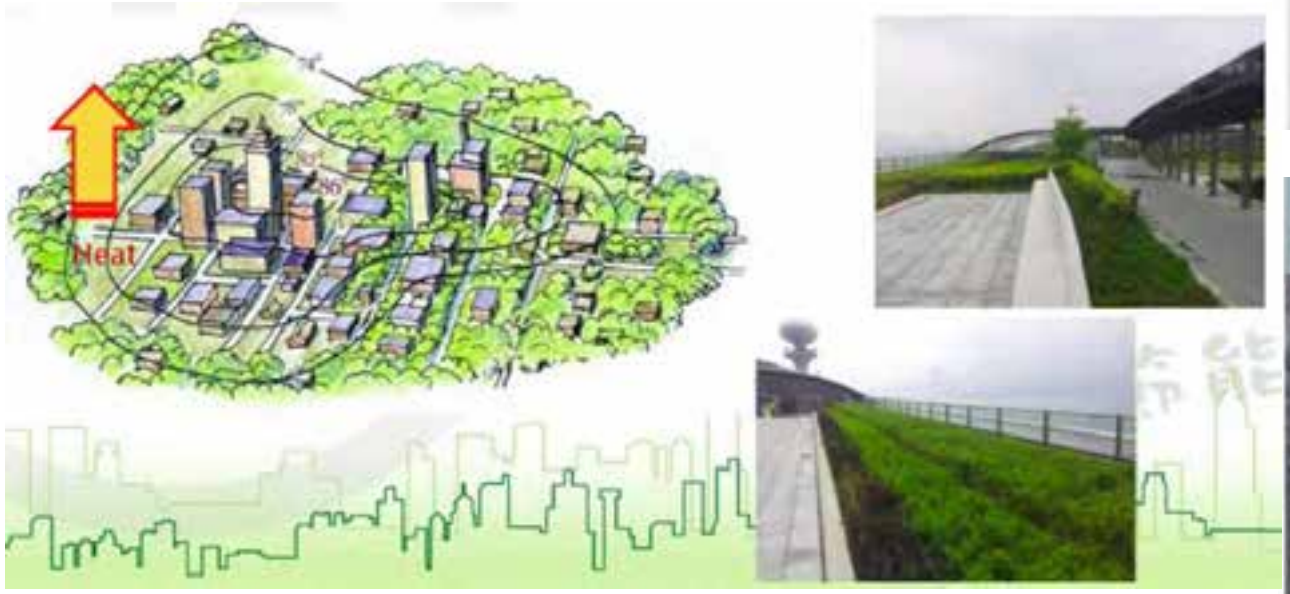
- District cooling means the centralized production and distribution of cooling energy. Chilled water is delivered via an underground insulated pipeline to office, industrial and residential buildings to cool the indoor air of the buildings within a district.



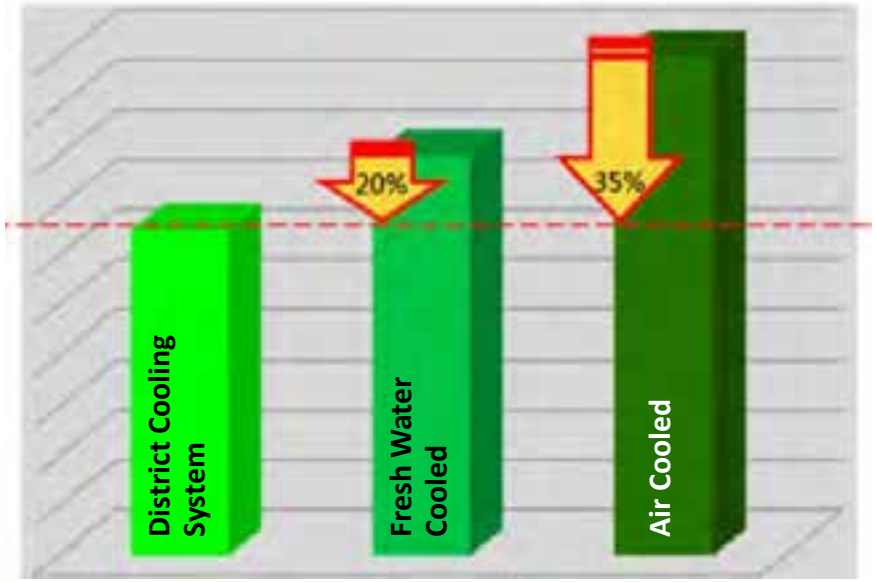
Excess solar electricity can be stored or used to run electric chiller to store chilled water

District Cooling – *Benefits*

Annual energy saving of up to 85 million kWh or equivalent to the reduction of 59,500 tones CO_2 emission upon full development.



Enhance building/ architectural design/function, better planned maintenance, reduce heat island effect, etc.



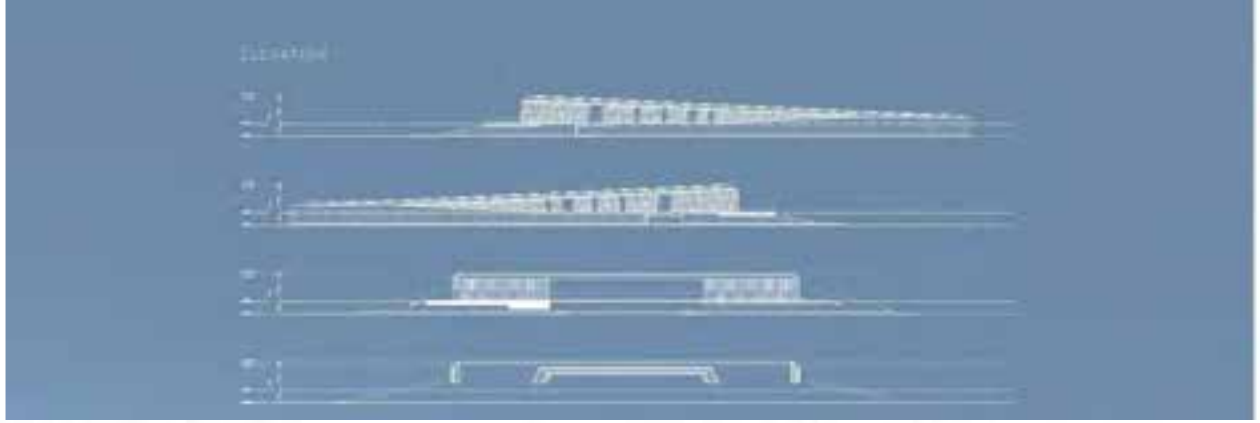
More adoptable than individual system to varying demand for air-conditioning

Noise, vibration and heat arising form individual plant could be reduced.

Chulalongkorn University Centenary Park

Project Location	Wang Mai, Pathum Wan,Bangkok, Thailand
Architect	N7A Architects Co.Ltd.
Landscape Architect	LANDPROCESS Co.Ltd.
Completion Date	2017
Building Type	Public Buildings
Owner's Name	Property Management of Chulalongkorn University
Construction Area	15,559 sq.m.
Construction Cost	300 million baht

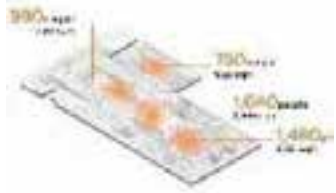
ASA ARCHITECTURAL DESIGN AWARDS 2018 –Silver



URBAN GREEN CONNECTIVITY

GREEN ROOF

SMALL GROUP

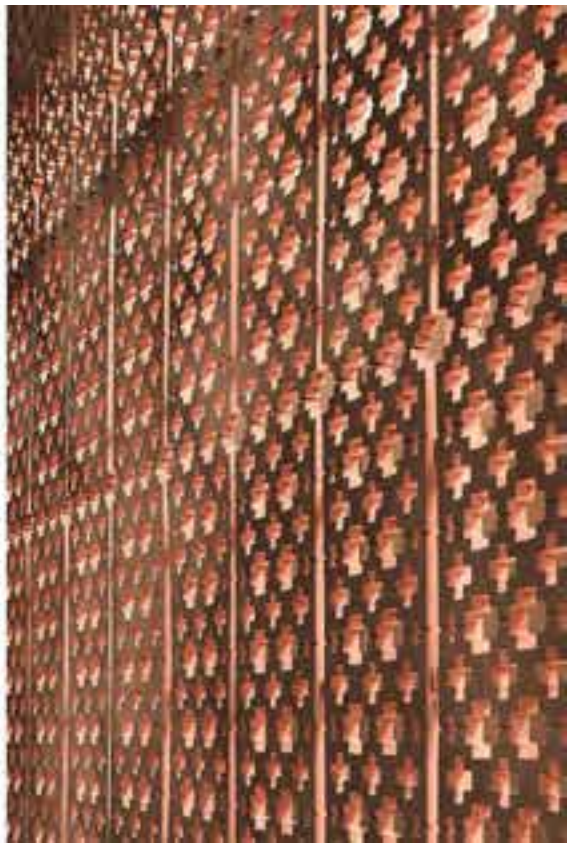


MEDIUM GROUP

LARGE GROUP

CONSTRUCTED WETLAND

DETENTION LAWN



Adaptive House: Baan Chaan, Solar Decathlon Europe 2014:
Public Choice Award 2nd Place

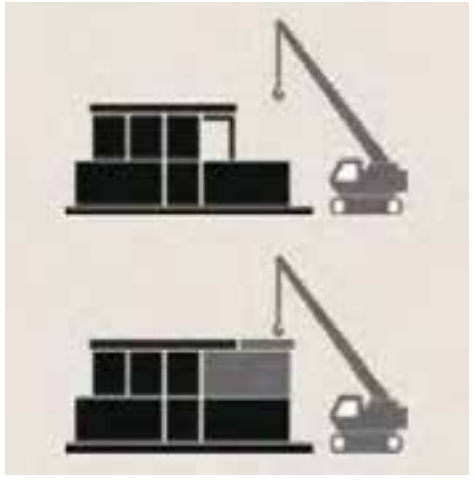
100 m2 modular house
5kW PV
Energy Plus building
Special designed sewage system
Water proof materials/insulation
Light + flexible furniture

Concept

Baan Chaan house was designed to be a net-positive energy house in a tropical hot and humid climate.
The house aims to provide the inhabitants with good living comfort and to ascertain simultaneously the optimal energy balance that can be achieved. Following figures show the configuration and floor plans of the house.

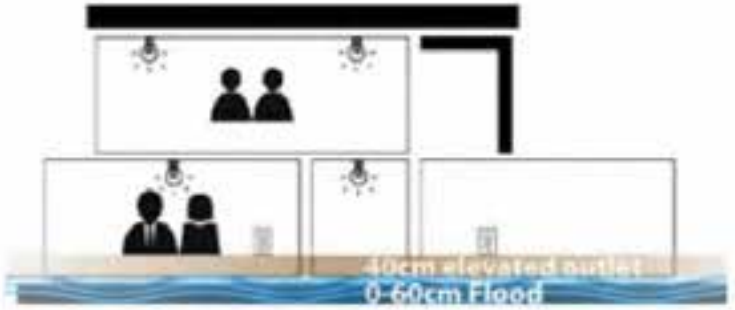
Design for Flood

The house can withstand flooding up to 60 cm high due to the lifted platform design. Once the flood reaches a height of 100 cm, electricity on the ground floor will be cut off for safety. In this worse case scenario, the second floor is still operable as an evacuation space with electricity and water. Interior and exterior materials were selected for ease in maintenance and reusability.

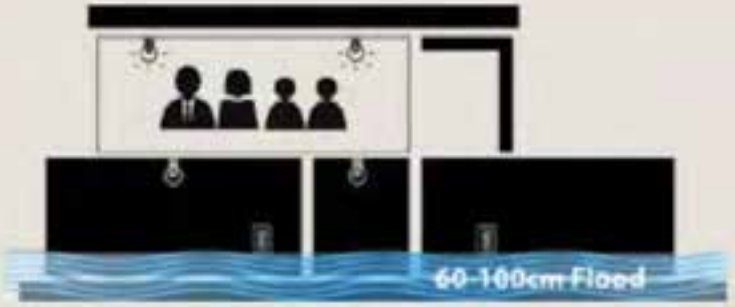


Architectural Concepts

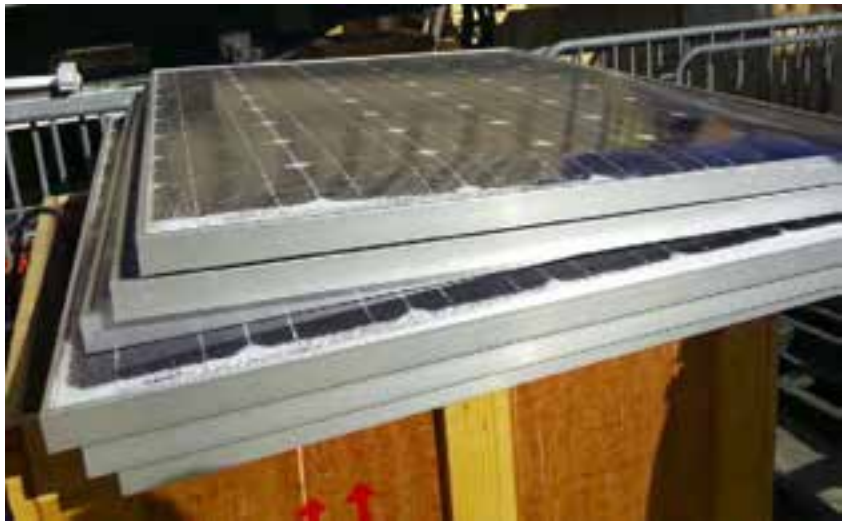
The KMUTT prototype house or "Baan Chaan" (My house / Terrace House) is designed and re-configured from traditional Thai vernacular architecture. The terrace, as a main house element, increases the awareness of nature and reduces energy loads for active design systems commonly practiced today. On occasions that climate conditions exceed the tolerable heat and humidity levels that natural ventilation alone cannot cope, air conditioner will be used as a supplement.

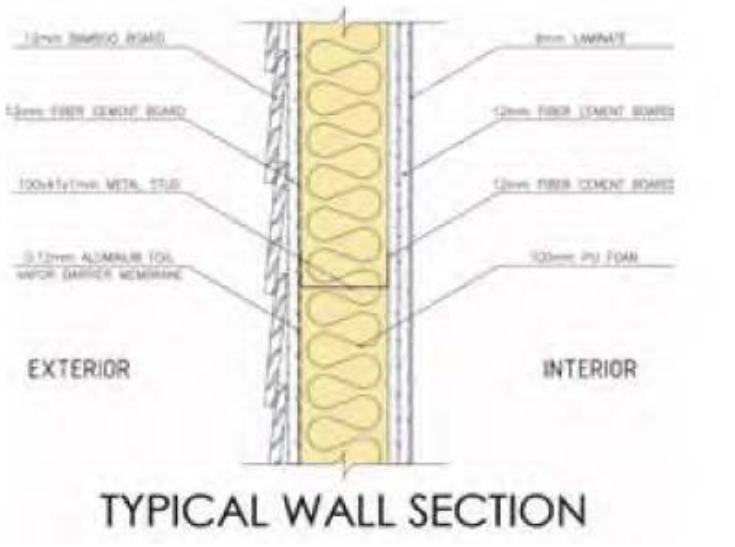


• At 60 cm flood level, the house can still operate with a raised ground floor of 60 cm



• At 100cm flood level, users have to evacuate to the second floor with provided electricity and sanitary.



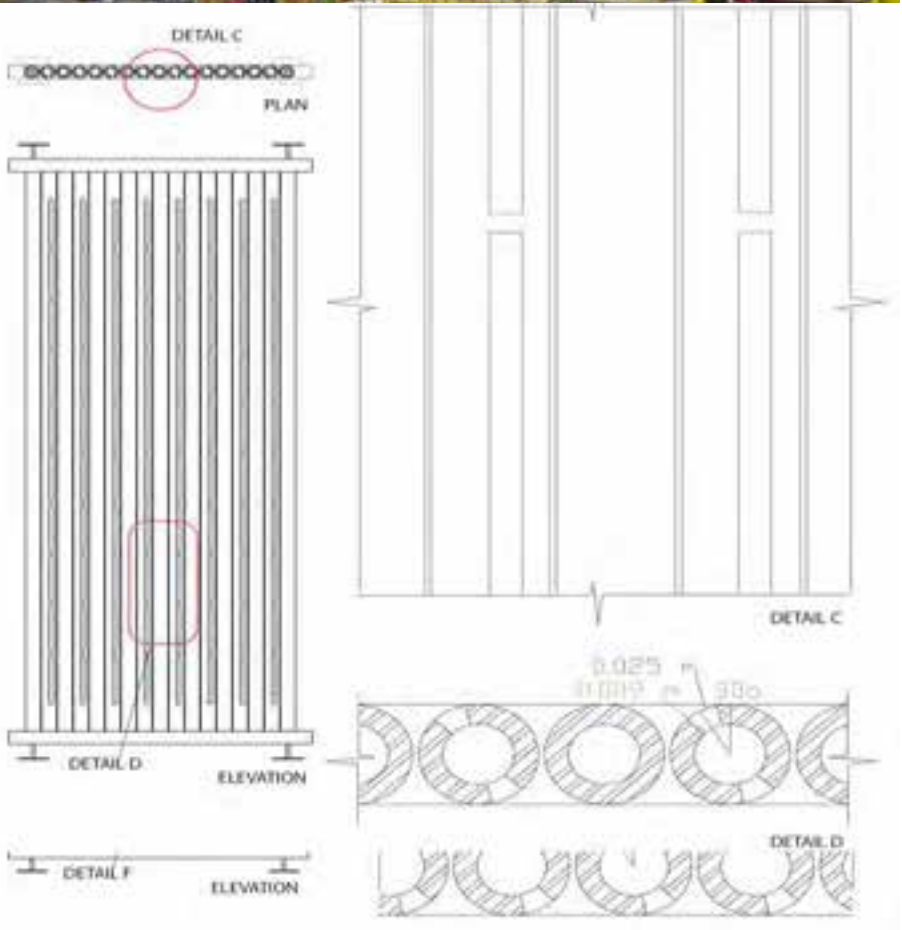


TYPICAL WALL SECTION

Fah Lai

Sliding windows

Optimized bamboo angle as a shading device



Bamboo Flooring

Adjustable PV array

Energy balance of Baan Chaan house (Thailand)

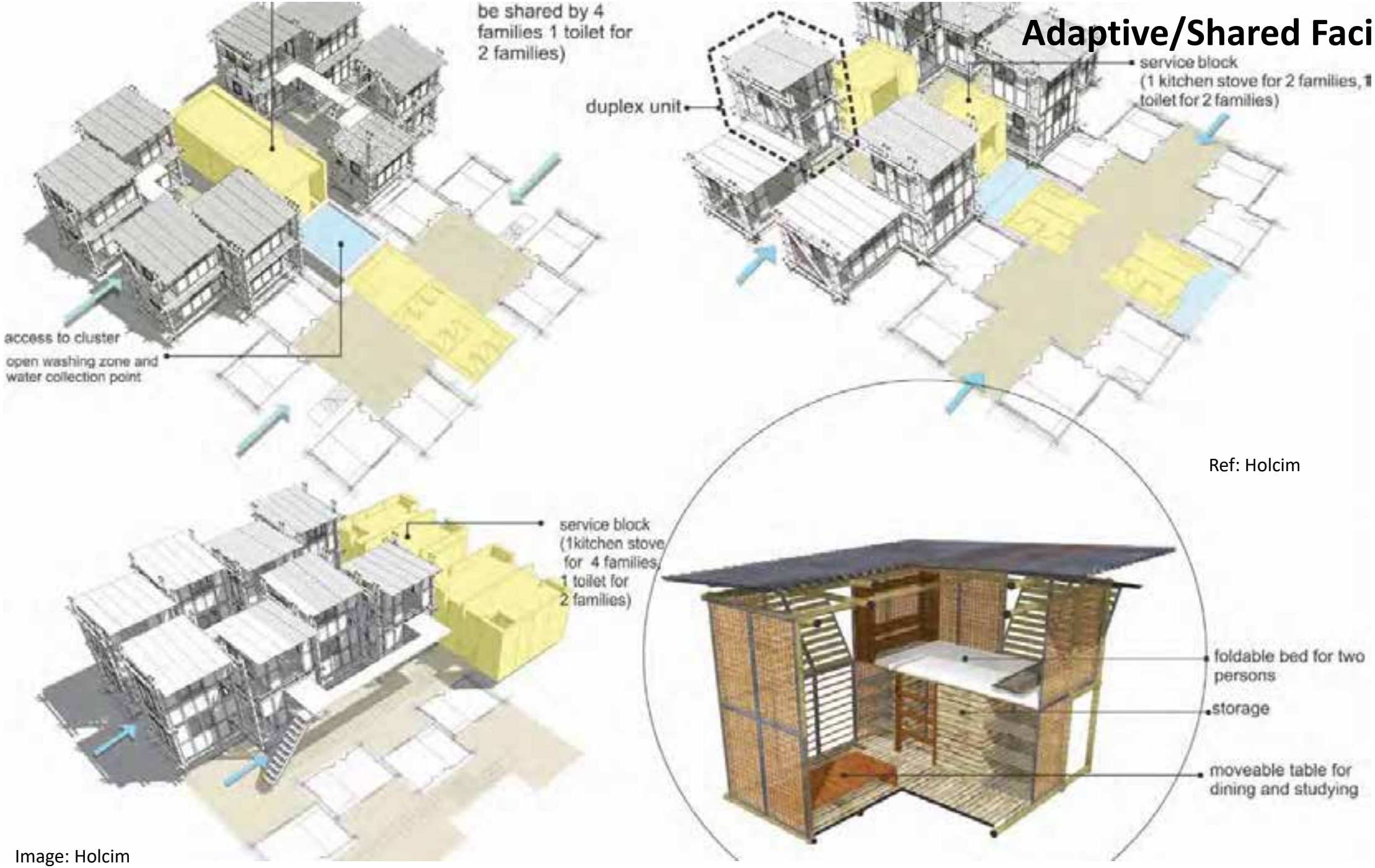
Month	Electricity from PV (kWh)	Tilted angle (degree)	Electrical energy consumption (kWh)						Surplus elec.
			Cool	Vent	Light	Equip	Hot water	Total	
Jan	618.4	30.0	182.4	12.4	75.0	190.3	21.9	482.1	136.3
Feb	557.0	30.0	191.5	11.2	67.8	171.9	14.9	457.3	99.7
Mar	666.0	15.0	275.8	12.4	75.0	190.3	9.9	563.5	102.5
Apr	622.6	-	306.3	12.0	72.6	184.2	14.2	589.3	33.3
May	602.4	-	302.9	12.4	75.0	190.3	17.4	598.1	4.3
Jun	538.4	-	305.3	12.0	72.6	184.2	24.4	598.5	-60.1
Jul	555.1	-	271.4	12.4	75.0	190.3	23.1	572.3	-17.2
Aug	535.9	-	248.9	12.4	75.0	190.3	26.2	552.8	-16.9
Sep	467.9	-	243.9	12.0	72.6	184.2	28.5	541.2	-73.3
Oct	496.7	15.0	252.4	12.4	75.0	190.3	28.3	558.5	-61.8
Nov	568.7	30.0	203.7	12.0	72.6	184.2	20.1	492.6	76.1
Dec	674.2	30.0	141.9	12.4	75.0	190.3	13.3	433.0	241.2
Annual	**6,903.3**		**2,926.4**	**146.0**	**883.3**	**2,241.1**	**242.3**	**6,439.1**	**464.2**






Automated CO2 Detection Ventilation Fan
Light indicator and alert
on energy + air quality

Adaptive/Shared Facilities

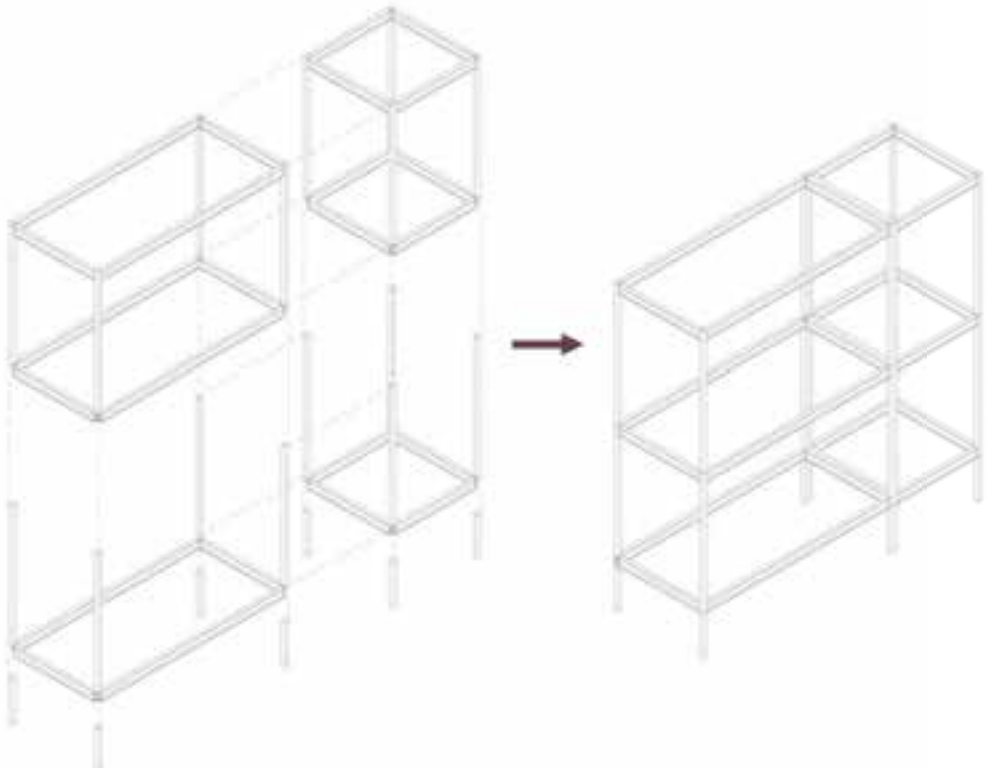


Ref: Holcim

Image: Holcim

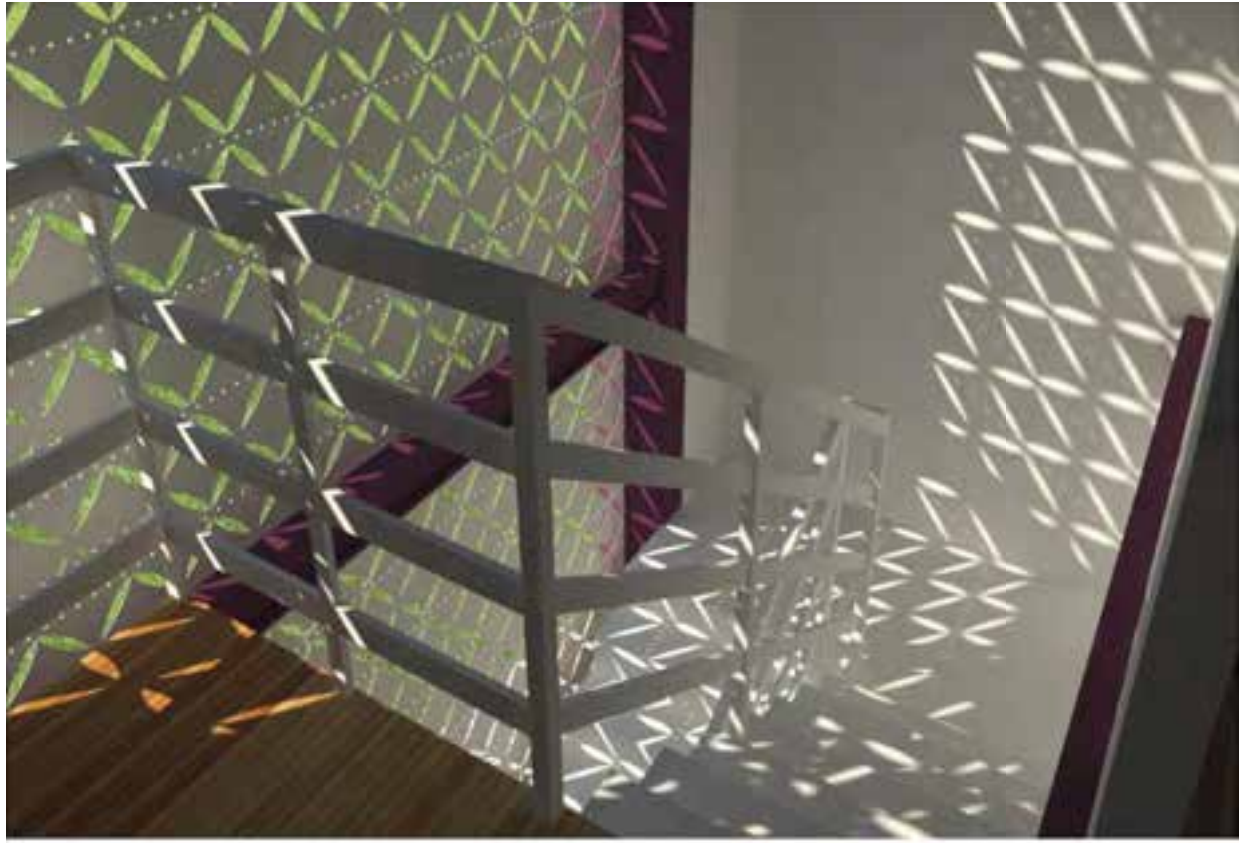

Border Police School, Taak province, Thailand

CONSTRUCTION PROCESSES



300 m2 modular construction and method
10kW PV
Energy plus school
Rain water harvesting, Ground water filter
Natural light
Recycled material content

Old wisdom with BIPV integrated shade for self-sufficient, visual and thermal comfort



PAPARKAYOR TEXTURE

คอนเอเจอะ (ลายต่อลูก

Green Concrete: Fly Ash, Silica Fume, Slag, RA

- Cost effective and environmentally friendly
- Reduces mining of river sand
- Reduces carbon emissions generated from manufacturing cement and crushing aggregates
- Helps to conserves natural resources
- Helps to reduces landfill.

"The fine particles of these products (FA, SF) tends to fill in the voids that exists between the aggregates and the cement matrix. Technically, when these products react with cement and water they form additional calcium silicate gel that tends to densify the pores structure thereby retarding the movement of water ***thus improving both the mechanical and durability properties of concrete****."*

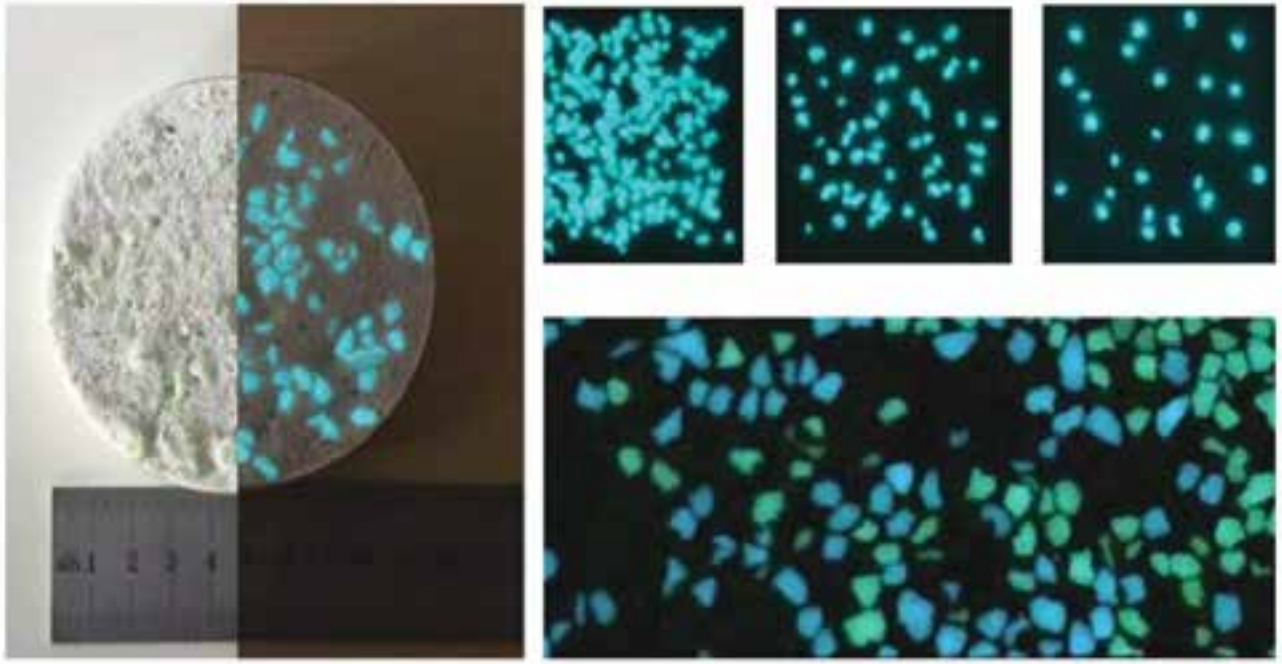
"FA reacts with the calcium hydroxide to form calcium silica hydrate. FA densifies the concrete making it ***more water proof and dense****. Since FA concrete is* ***less permeable****, it makes the concrete* ***more durable.*** *The same respondent suggested that strength performance higher than cement can be achieved when using SF and slag."*

"FA, SF and slag were finer than cement which help to improve the durability properties of concrete. Moreover, concrete prepared from these by-product waste tends to be ***acid resistance****."*

Ref: Khushal Ratna Karsan and Ali Ghaffarian Hoseini, 2015

Alternative Materials

Photoluminescent

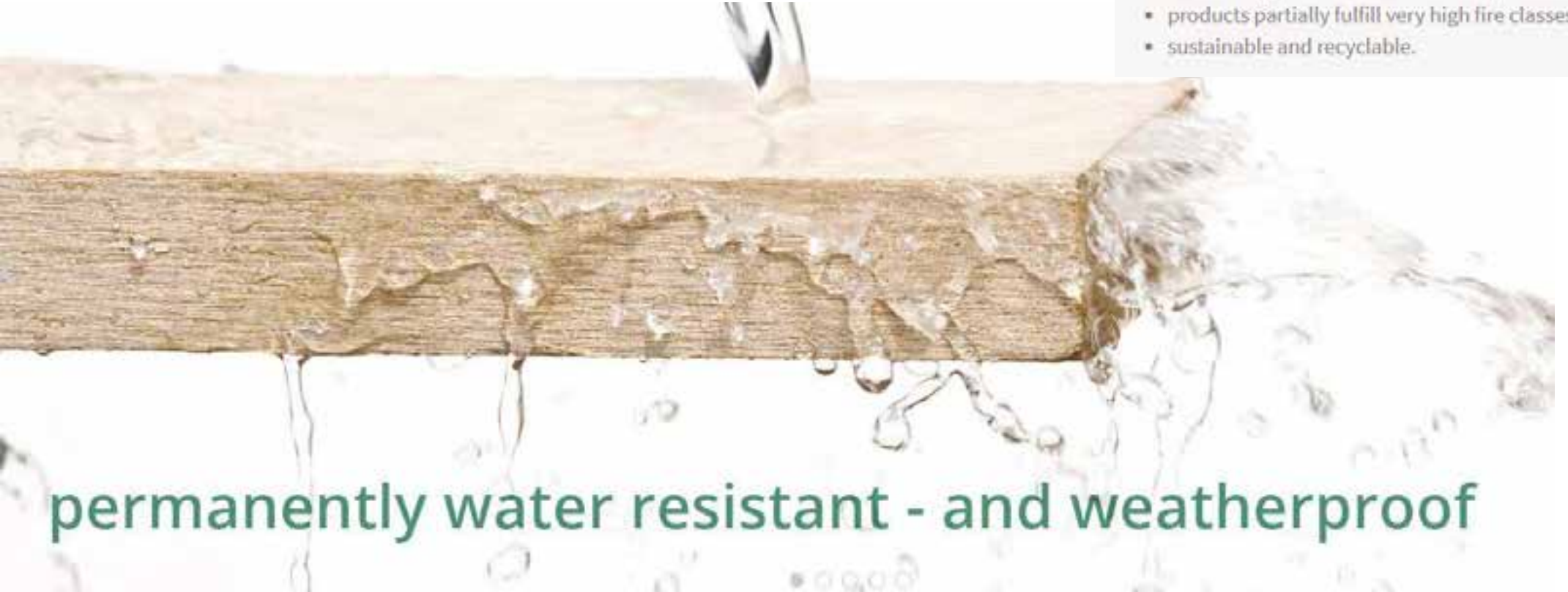


Fluorescent Aggregate

60% Rice Husk
22% Common Salt
18% Mineral Oil

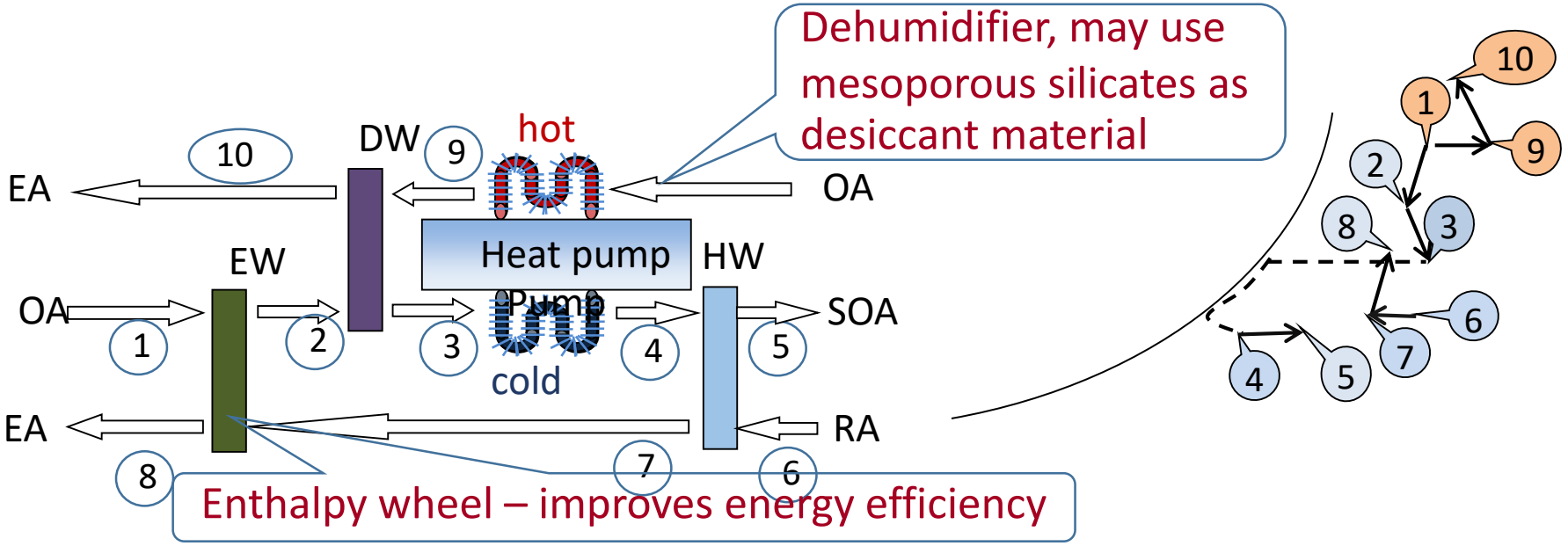
Resysta properties at a glance:

- durably water and weather resistant (no swell and can be installed in water)
- resistant against salt and chlorinated water
- durably UV-resistant (no fading)
- skid-resistant (ideal for pool decks and terraces)
- no cracks and splinters (no more splintering)
- resistant against fungal and mold decay
- resistant against termites and other parasites
- products partially fulfill very high fire classes (IMO certification)
- sustainable and recyclable.



permanently water resistant - and weatherproof

Dedicated Outside Air System (DOAS)



Radiant Cooling

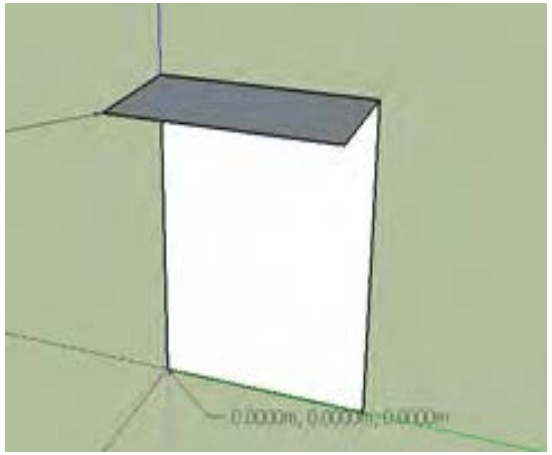
- Designed temperature of supplied cool water 18°C.
- Efficiency of water chiller increases 2 folds.

Source: Surapong C.

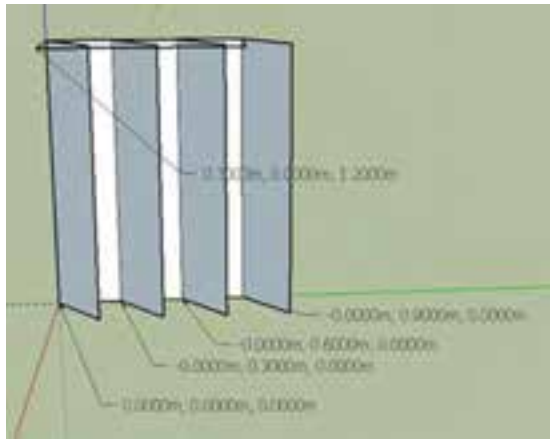
Building Envelope

Thailand distinguishes beam shading coefficient from diffuse shading coefficient and uses the methodology to shade sun radiation to reduce cooling load and promote design for daylighting using daylight from sky.

E/W oriented windows

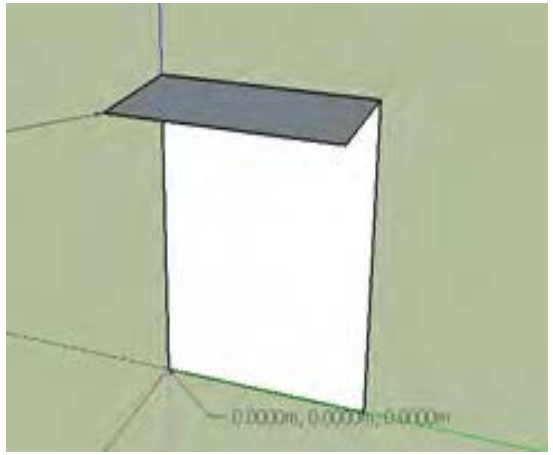


Shading Coefficient
0.694 Total
0.248 Beam
0.446 Diffuse

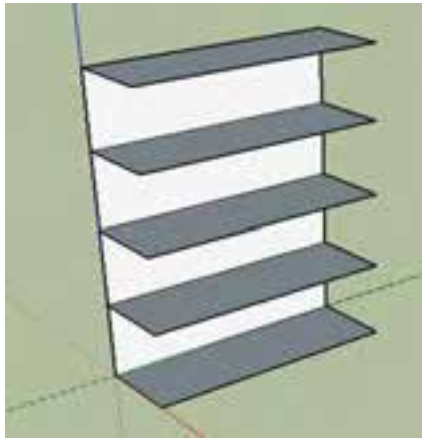


Shading Coefficient
0.194 Total
0.043 Beam
0.151 Diffuse

N/S oriented windows



Shading Coefficient
0.653 Total
0.255 Beam
0.398 Diffuse



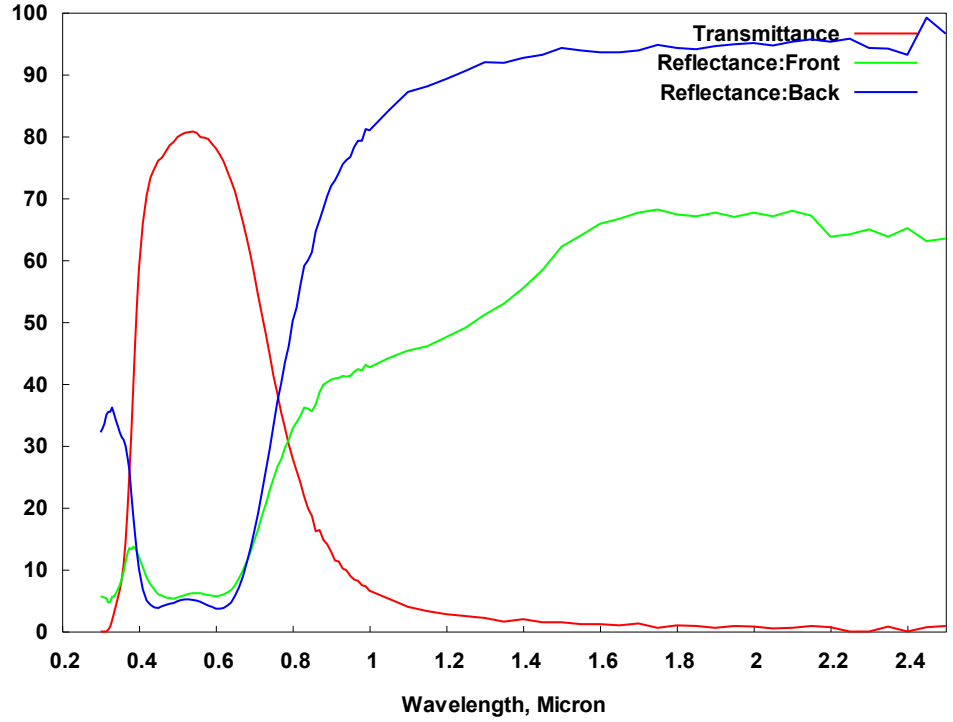
Shading Coefficient
0.265 Total
0.061 Beam
0.204 Diffuse

Can be adjustable shade
Can be optimized shade
Can be electrochromic glass

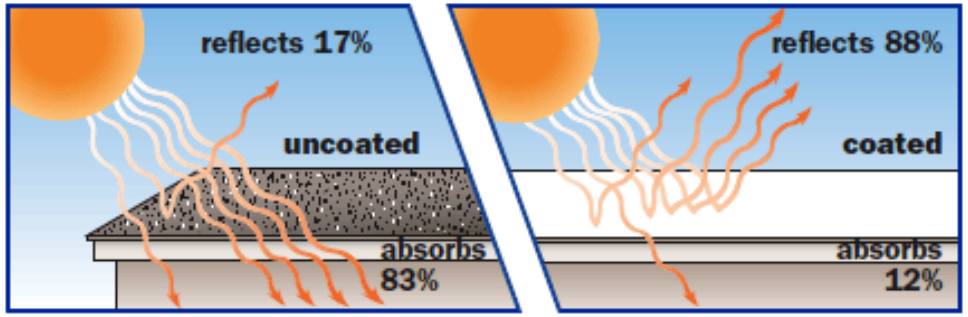
Source: Surapong C.

Building Envelope

- Solar gain through glass is ~ 5 times higher than conduction gain through wall.
- Spectrally selective glass has low SHGC to reduce solar gain but high visible transmittance.



- Light color/solar reflective roofs and walls reduce conduction gain, very effective for roof.
- Thermally reflective roof insulation is cost-effective



- High thermal mass is not cost-effective for all types of buildings.
- For buildings used at night, high thermal mass increases cooling load.
- Insulation on interior surfaces improves thermal performance of walls.
- Insulation on exterior surfaces of buildings used at night increases cooling load.

Source: Surapong C.

Future Resilient Urban Planning + Architecture:

Thai Central Flood Plain

Sustainability for
Social Values, Economic Values,
Aesthetic Values, Historic Values,
Health + Well-Being

Urban:
-Bring back old wisdom in urban planning / Architecture—adaptability
-Adaptive use for flood, design for self-sufficient for several days, porous city
-Shared facilities such as co-working, parking, waste water treatment and service systems such as PV , District cooling

Design + Construction:
-Computer Simulation
-Passive design strategies
-BIM-Digital Fabrication, Modular, Prefab, movable, compact
-Responsive design, AI

Materials:
-Low CO_2 , VOC emission materials, reuse, recycle, upcycle, EE envelope
-Waterproof / moisture proof materials
-Ease of maintenance, less cleaning, repairing

Thank you

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