The Hub of Hope: Realising an Evacuation Hub at Pula Village, Philippines (Practitioner paper)

Sharon Lee, HY Lee and KY Chan
Arup HK, Level 5 Festival Walk, 80 Tat Chee Avenue, Kowloon Tong, Hong Kong

sharon-hy.lee@arup.com; zoe.lee@arup.com; kennis.chan@arup.com

Abstract. A group of Arupians formed a collaboration with Hong Kong-based NGO in contributing to the less privileged East Asia community at Pula Village, Philippines. There is an urgent need for a safe space during the severe typhoons throughout the year. The village currently do not have access to clean water and proper sanitation facilities. The Hub of Hope is birthed in response to those needs. Apart from meeting the basic physiological needs by providing a shelter, safe drinking water and proper sanitation facilities to improve hygiene and cleanliness, the Hub is the village’s central space for social happenings. Hosting activities such as weddings, schooling and medical treatment. It is an incubator promoting health, well-being and self-actualisation, contributing to SDG Goal 3 and 6. Human-centric approach to research and design was taken to best suit the local culture, ways of life and demographic. With site survey on geological and existing housing conditions; interviews with villagers; analysis and research on local construction methodology and locally sourced building materials. The Hub adopt a modular design using local materials and maximising the use of local skills and traditional crafts. Passive designs were adopted, using CFD analysis to maximise natural ventilation performance, shading and fenestration to optimise solar heat gain and daylighting performance. Off-grid renewable energy system is also integrated into the Hub for resilience purposes. As the design can be easily replicated by the villagers, the Hub opens the opportunity for villagers to use the same method in building for themselves resilient homes against adverse weather of the region. Creating a self-sustainable solution for the community in line with SDG Goal 11. Eventually, the Hub can serve solely as a community centre. This Hub of Hope is a catalyst, opening opportunities to improve the quality of life and inspiring hope for the community.

1. Context
As part of Arup’s core value in shaping a better world, a group of Arupians from Hong Kong, Manila, Taiwan offices have formed a collaboration with Hong Kong-based NGO The Bridge of Different Nations (thereinafter referred to as “BDN”) in designing an Evacuation Hub (thereinafter referred to as “The Hub”) for the remote Mangyan village named Pula located in Mt. Halcon at Oriental Mindoro region of Philippines.

The Mangyan villages are located in a region exposed to an average of 20 typhoons per year where devastating damages are done to the villages. Rivers are likely to burst their banks and the houses built by the villagers are prone to collapse. Currently, the Mangyan villagers hide in holes they dug in the mountain or in the make-shift shelters which are bamboo leaves propped up by bamboo.
BDN are in contact with 8 Mangyan villages where they have aided one of them in building a basic brick evacuation hub after typhoon Nona in 2015. BDN hopes to continue preserving lives of the villagers by constructing one evacuation hub per each of the remaining 7 villages.

The Arup team aims to design an evacuation hub that adopts passive design for comfort, uses local materials, clean energy and sanitary fitments. Sanitary fitments are something that they do not have at the moment, it is part of BDN’s intention to teach them how to use toilets for better hygiene and well-being. The building’s design allows for easy adaption of the same construction techniques by the villagers in building safer homes for themselves. The Hub will be used for evacuation purposes during the typhoons and a community center during non-typhoon days. Eventually The Hub is to function solely as a community center as villagers progressively adopt the same building techniques for constructing their own sturdy homes.

Pula – the Mangyan village chosen for this project has a population of around 270. The site chosen is a flat plain of around 1,000m² at a safe distance from the floodplain.

2. Site Visit
As Pula Village is located at a remote area where not much site information is available, a site visit is essential in verifying site conditions, topography, understanding the logistics, identification of site area, and obtaining first-hand information about the villager’s cultural background, lifestyle and understanding their needs and expectations of The Hub. The main categories of information required from the site visit are stipulated below.

2.1. Material Palette. As part of the aim to achieve a self-sustainable design easily adoptable by the locals, the construction material of The Hub should be easily available to the villagers within a close proximity. Visits to the construction material stores in the closest city – Calapan were made to identify widely available materials. The materials and construction methods used for the local single-storey houses are noted as reference to the labour skills and construction technology available.

2.1.1. Site data collection. Laser measuring tools were used to obtain dimensions, tree heights, topography and for surveying existing village houses. Site information was obtained to form an accurate model for simulations during design stage for passive design verification.

2.1.2. Interview with the locals. Human-centric approach to the research was taken so The Hub can be designed to best suit the local culture, ways of life and demographic. This is essential for improving the locals’ quality of life especially in terms of health and well-being.

Through the interview, the brief was established. The Hub is to be of evacuation purpose during typhoons and other calamities. On other days, as wished by the villagers, it will function as a meeting space, wedding venue, study space, religious activities venue and humanitarian relief space such as medical treatments.

3. Design
The site is located in a tropical region with an average of 20 typhoons per year, annual rainfall of 965 – 4,064 mm and humidity of 71-85% [1]. The major design challenge is for The Hub to support daily activities and comfort within this given environment for the 270 villagers. The Hub aims to maximize the use of naturally available resources from the environment to achieve a sustainable and easy to maintain design. Passive design in the area of ventilation, rain protection, natural daylighting and thermal comfort have been studied to form the basis of The Hub’s design. As the village’s location is remote lacking stable supply of electricity, considerations have also been given to the provision of clean energy by inclusion of PV panels and fuel blocks generated from the toilets in improving the villagers’ quality of life. This paper will focus on the passive design aspects of The Hub.
3.1. Priorities and Objectives of Passive Designs

Passive design elements are prioritized and input into the hub according to the significance of contribution to SDG Goal 3 – Good Health and Well-being. Based on the design objectives, the target performance of those passive designs is determined accordingly. Computational Fluid Dynamics (CFD) and solar analysis are used to verify the design and provide wind environmental pattern and daylighting distribution details.

### Table 1 Priority and Target Performance of Passive Design Strategies

| Priorities of Passive Designs | Design Objectives                                                                 | Target Performance                                      |
|------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------|
| 1. Natural Ventilation       | Indoor air quality; Maintain healthy CO₂ level (indoor air quality)              | Min. 2.4 Air change per hour (ACH) for 270 people [2]    |
| 2. Rain Protection           | Resilience environment for protecting the villagers                              | 90% rain protection under normal wind condition          |
| 3. Natural Daylighting        | Allow handcrafting and supporting daily life activities                          | Illuminance: 300 lux for handcrafting needs Min. 50 lux for transition area |
| 4. Solar Heat Control         | Provide thermal comfort                                                          | Thermal Sensation Index (TSI): TSI: 3 – 5 for comfort Min. TSI: 2 – 6 for acceptable thermal sensation |
3.2. Natural Resources Availability & Design Scenarios
The village is located at foot of the hill at the Northern portion of Oriental Mindoro in Philippines (13°20'N, 121°02'E), to the South of Manila. The annual prevailing wind entering the site from the E direction, with an estimated incoming wind speed of 2.5 – 4m/s is expected at the site. The annual average dry-bulb temperature is 27.5°C, with an annual average solar irradiance of 334W/m².

Due to the relatively openness to the surroundings, the hub has a pleasant outdoor wind environment with sufficient wind and daylighting availability. Solar heat control is required, as are no shadings from the surrounding.

Different scenarios are considered for the passive design strategies of The Hub, i.e. good weather (normal case scenario) condition and typhoon condition (worst case scenario). This is to ensure safety and quality of built environment for the 270 people when operating as an evacuation hub.

3.3. Passive Design Strategies

3.3.1. Natural Ventilation. With the relatively large building footprint of 15 m (W)×20 m (L), and vertical openings of 1.89m along the periphery of The Hub, cross ventilation will not occur in the space. An effective ventilated area of approximately 180m² is expected at the perimeter zone of The Hub only. Therefore, passive design strategies are implemented in order to ventilate the inner core zone of The Hub.

3.3.2. Corner Set-back Design. To facilitate the ventilation at the northern portion of The Hub, a corner set-back is designed to introduce more annual E prevailing wind penetration from the high pressure zone at upwind location along the corridor to the low pressure zone at the downwind location.

![Figure 2 Plan of The Hub, showing the corner set-back design to introduce more annual E prevailing wind](image)

This design helps to divert ventilation movement at the northern portion of The Hub inside.
3.3.3. Secondary Roof & Permeable Flooring Design. To further enhance ventilation performance, especially during typhoon condition, in which the side openings are closed, an additional secondary roof and permeable flooring design are incorporated. The Hub being of 6m in height creates a temperature difference between the occupant and ceiling level. The hot and humid air rises to the top and leave The Hub through the vertical openings between the primary and secondary roof, i.e. stack effect. The secondary roof, made of translucent polycarbonate, absorbs solar irradiance, resulting in a steeper temperate gradient along the occupant level to the ceiling to further drives this air movement. The secondary roof with a pitch angle of 35° creates a pressure difference along the secondary roof canopy [3], this drives the incoming wind to penetrate through and the hot exhaust air is vented out from the inner core of the hub [4] [5]. This secondary roof and its vertical opening also limits the rain penetration into the hub. As hot exhaust air is vented out, cool fresh air enters the hub though the porous staircase and permeable bamboo flooring strips. Beside removing the heat, this ventilation pattern also drives indoor air pollutants up and away from the occupant level resulting in better air quality.

3.3.4. Rain Protection. The secondary roof and its vertical opening limits rain penetration into The Hub while maintaining ventilation performance. The large primary roof canopy that extends from The Hub to the periphery corridor also provides rain protection.

The standardized falling speed of raindrops is estimated to be 9 – 13m/s and the average wind speed of the site is around 2 – 4m/s as mentioned before [6]. In order to provide sufficient rain protection to occupant, the angle of elevation to the edge of cover is estimated to be 23.9° according the equation below.

\[
\tan(\text{angle of elevation}) = \frac{\text{horizontal wind speed (m/s)}}{\text{falling raindrop speed (m/s)}}
\]
Therefore, the eaves of the primary roof canopy with an angle of 40-degree elevation is provided for rain protection along the corridor.

3.3.5. Natural Daylighting and Solar Heat Control. Due to the large span of the primary roof, providing sufficient daylight into The Hub’s core space is a challenge. Meanwhile, balancing between natural daylighting and solar heat control is also the focus in passive design to creating a thermally and visually comfortable area for the occupants.

Translucent gable wall from the sides allows indirect daylight while limiting the direct solar radiation entering The Hub. Typically, daylight penetration from the north side only is preferred for buildings in northern hemisphere to reduce direct sunlight from the South. However, considering the site location is close to the equator with larger solar azimuth angle as shown in the sun path before, direct sunlight from the South is not significant. Translucent gable walls facing Southeast and Northwest is designed to maximize daylight penetration into internal space whilst blocking direct sunlight from the East, West and the top.

Daylight distribution gutter is designed at the roof of periphery zone for The Hub. In order to light up the core of The Hub and maintaining the lifestyle of the villagers, the idea of solar bottle bulb was adopted in addition to the translucent second roof [7]. Solar bottle bulb is simply a water bottle filled with water. By mounting it on the roof, the water bottle can collect and diffuse daylighting effectively into the indoor space due to the high reflective index of water. This idea is incorporated with the rain water harvesting system of the hub where the gutter becomes a daylight distributor. The rain gutter connects those rain collection spots – the water bottles which penetrate throughout the roof which in effect is alike to a light bulb system connected by a circuit.

3.4. Building Material
All materials are to be found locally for easy future maintenance and easy adaptation of design.
3.4.1. Roofing Material. The main roof acts as a braced rigid diaphragm with GMS panels for the roof sheathing so that when the typhoon blows over the structure, it spreads the wind load to the timber frame formed by rafters and columns. The columns in each frame resist this wind load by an effective push-pull action. The GMS roof is topped by a coconut leaves weaved layer commonly found locally acting as an insulation, waterproofing and anti-drumming layer. Stainless Steel mesh is put on top of the coconut leaves as a strapping device to hold up the layer against strong wind. The secondary roof uses transparent polycarbonate sheets to act as a skylight, allowing daylighting into the core space of The Hub. There are also PV panels attached to the secondary roof for generation of clean energy for lighting during night time.

3.4.2. Flooring Material. Bamboo is widely available in the village with a fast growth rate. Therefore, it is chosen for the flooring material where villages can harvest the material themselves for building their own homes or for maintenance of The Hub.

3.4.3. Wall and Structural Material. The Hub is built with timber structure with steel braced frame design according to the National Structural Code of the Philippines to withstand the wind loads equivalent to typhoon level in the region. Bamboo openable panels are used for the multifunctional space wall. Hollow blocks which are also widely available at the nearby city – Calapan is used for the back of house space: toilets, storage and kitchen.

4. Implementation and adoptability of design
The material used for The Hub are all sourced locally. In this design, we have introduced the bamboo raised floor, openable partitions, water bottle light bulbs, structural braced frame design to withstand the typhoons, diaphragm roof and organic toilet where the waste can be used as fuel blocks. In the construction process, the villagers will be involved so that they can learn the skills of building those features which in turn they can use to build their own homes.

5. Conclusion
Through the research of vernacular architecture in the East Asia region of similar climate, gathering of century long wisdom in passive design, The Hub has been designed in a way that is self- sustainable, easily maintained and operated by the locals. The design objectives for natural ventilation, rain protection, natural daylighting and thermal comfort were addressed using passive design strategies. With this humble beginning at Pula Village, it is hoped that those passive design ideas can be used by the villagers in building their own homes of comfort and in building for the wider community.

6. References
[1] GOVPH PAGASA, "Climate of Philippines," [Online]. Available: http://bagong.pagasa.dost.gov.ph/information/climate-philippines. [Accessed 8 January 2020].
[2] ASHRAE, "Ventilation for Acceptable Indoor Air Quality ANSI/ASHRAE Aaddendum d to ANSI/ASHRAE Standard 62.1-2016," 2018.
[3] S. A. G. Ben Richard Hughes, "A numerical investigation into the effect of Windvent louvre external angle on passive stack ventilation performance," Building and Environment, vol. 45, pp. 1025-1036, 2010.
[4] Q. R. e. al., "A literature review on the improvement strategies of passive design for the roofing system of the modern house in a hot and humid climate region," Frontiers of Architectural Research, vol. 5, pp. 126-133, 2016.
[5] K. S. K. e. al., "Climatic desing of the traditional Malay house to meet the requirements of modern living," in *The 38th International Conference of Architectural Science Association*, Tasmania, 2004.

[6] K. V. B. e. al., "Terminal velocity and shape of cloud and precipitation drops," *Journal of the Atmospheric Sciences*, pp. 851-864, 1976.

[7] G. Zobel, "Bottle light inventor proud to be poor," BBC News, [Online]. Available: https://www.bbc.com/news/magazine-23536914. [Accessed 8 January 2020].

**Acknowledgements**

Would like to take this opportunity to thank the project team – special mention to Simon Cheung, Raymund Vega, Raymond Chiu, Travis Chan, Edmond Asis, Benilda Fonseca, JC Valencia, Harry Sze, Alaadin Ucol, Ivan Li and Christopher Fung for their hard work in making this project possible. Special thanks to Alice Chow for being inspirational with her works with Médecins Sans Frontières. Also for all of her support, guidance and encouragement along the way, without whom this project would not have been birthed.