Construction

Exploring Passive Design and Circular Economy Strategies in Tropical West Africa.

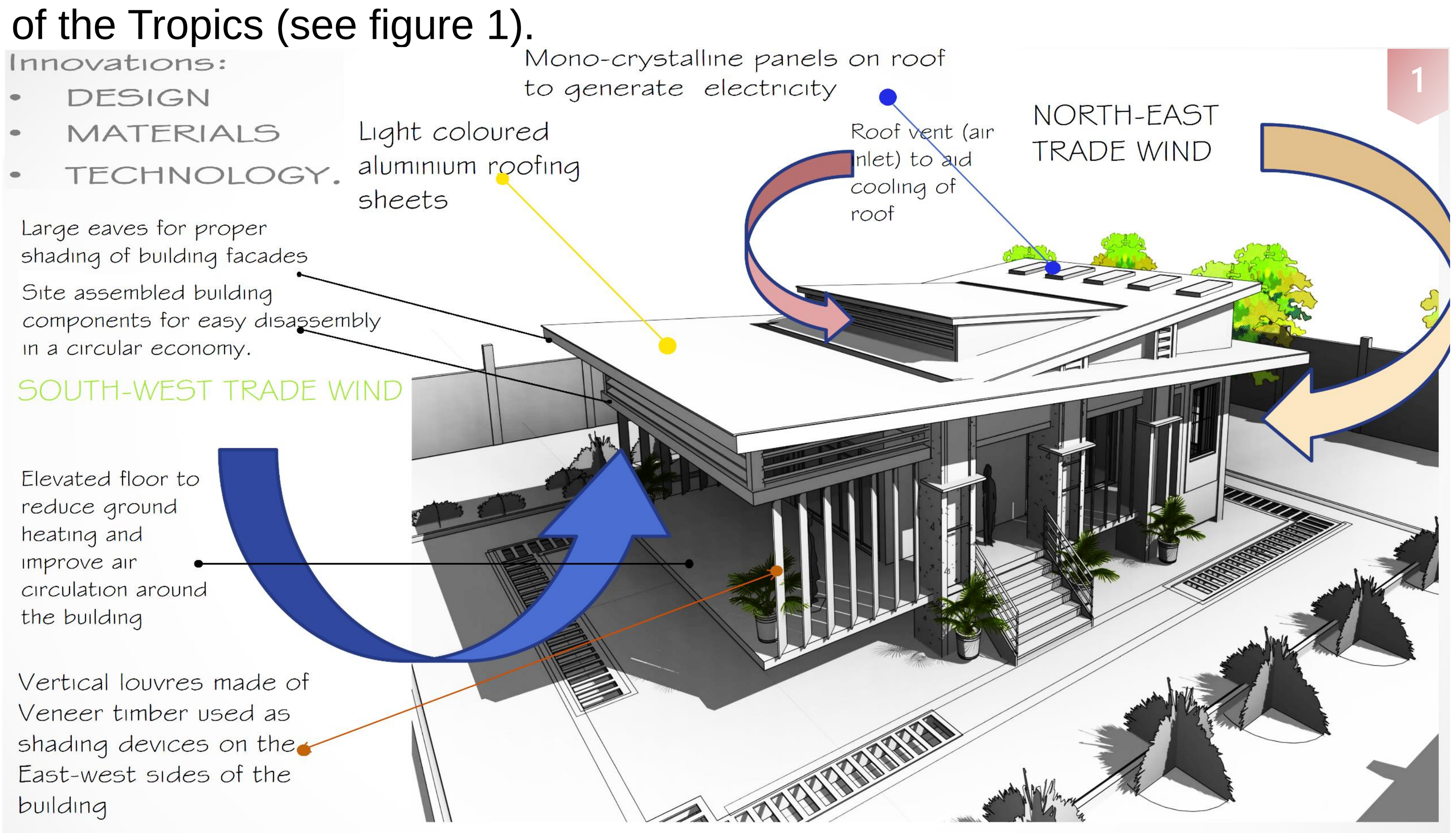
The Project

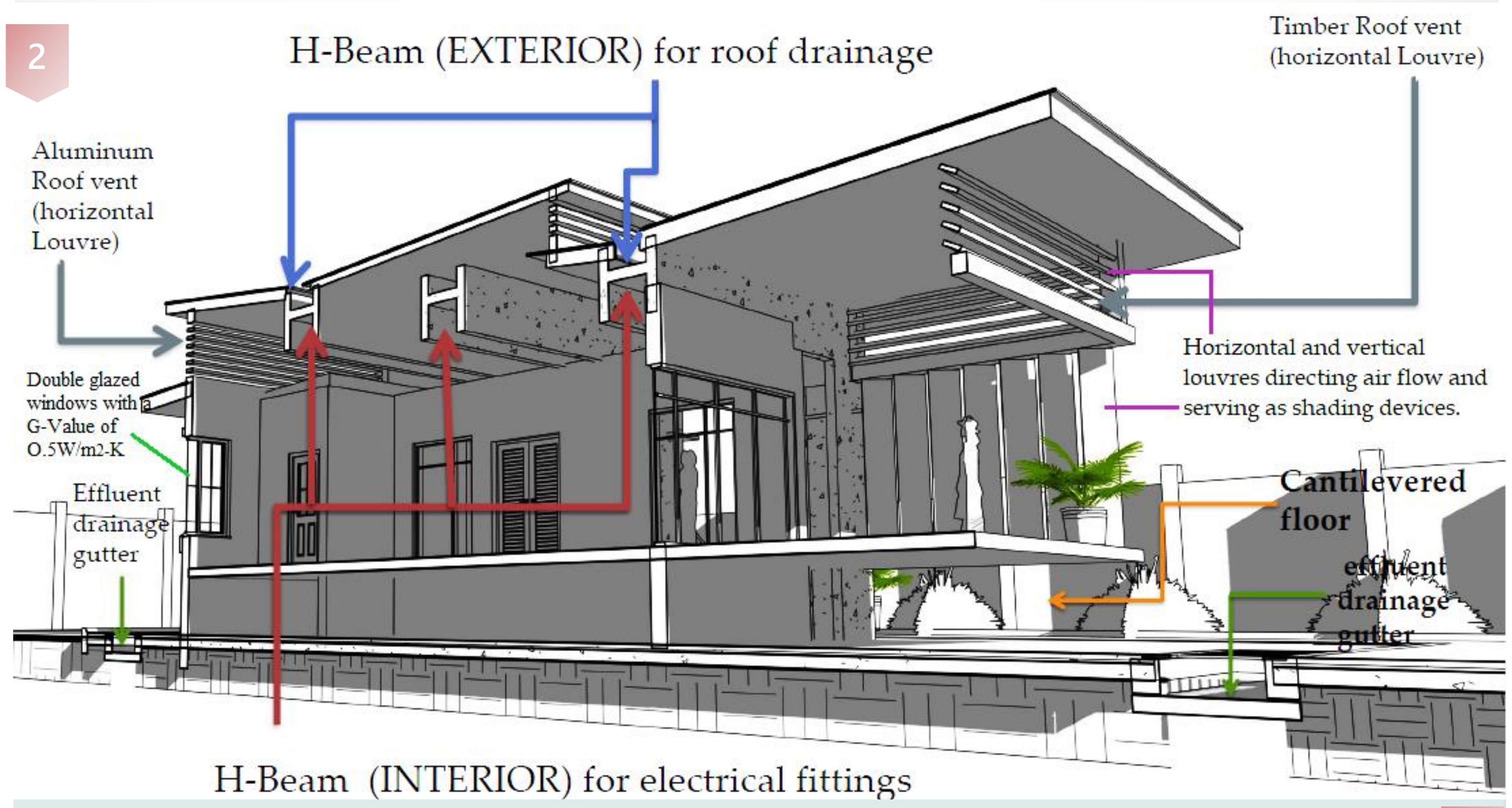
Based on research findings on Passive Design and Circular Economy principles, design strategies were put together for the construction of a practical project for the demonstration of passive design and circular economy interventions in Warri, Delta state, Nigeria in collaboration with Foundation for Partnership Initiatives in The Niger Delta (PIND)/Appropriate Technology Enabled Development (ATED) Centre, Ambrose Alli University and Utimits & Mira Associates. This research and project was vested on increasing the awareness on passive design strategies and circular economy principle especially in the tropical region of West Africa as Passive design and Circular economy principles offers sustainable strategies for energy and resource efficient buildings (Morgan and Mitchell, 2015).

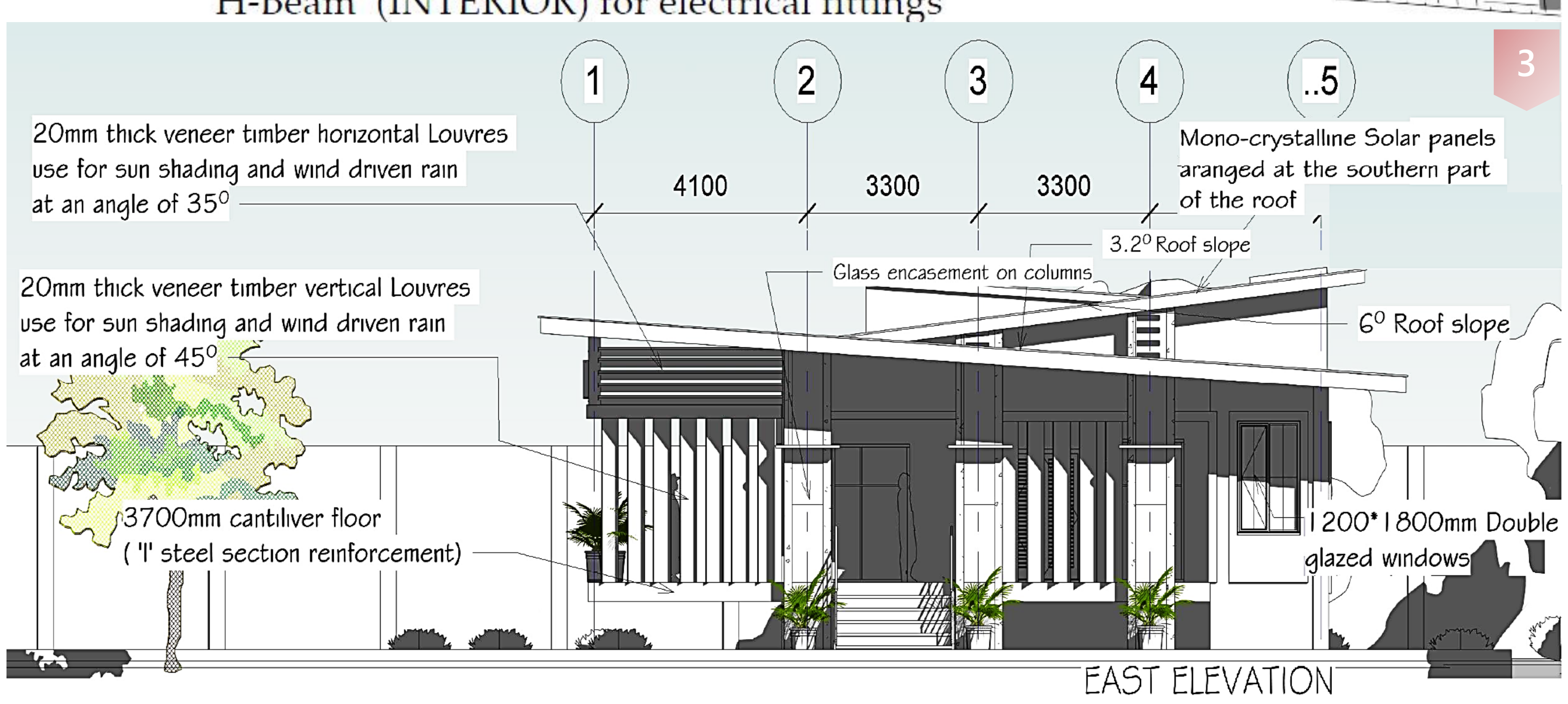
The demonstration project adopted basic passive design and circularity concepts to promote energy and resource efficiency principles in West Africa. This was intended to reduce the dependency on electricity in running buildings which is currently inadequate and unstable in the region whilst potentially increasing the reusability and recyclability of building materials since there is a great recession of construction materials (Rahman et al., 2017).

Design Strategies

The passive design strategies employed for the project included thermal mass, building orientation, daylighting, and natural ventilation which were combined with “design for disassembly” and “design for recycling” principles of circular economy with special consideration on the climatic configuration of the Tropics (see figure 1).







The building took advantage of the bioclimatic features of the site. Wind and sun studies were conducted to determine the positioning of air-intakes, shadings and vents on facades (see figures 2). This allowed airflow from the South vents into the building and exits through the North vents as seen in figure 1. Hence, achieving a well-ventilated roof.

The open floor plan is well ventilated at all sides, thus improving airflow in and out of the building. Simulation results from Revit Architecture software assisted in defining required shadings where needed and their required sizes, such as eaves, horizontal and vertical shadings as seen in figures 1, 2 and 3. To facilitate building services, H-beams made from reinforced concrete (see figure 2) were used both as structural components and service ducts which ran across the building to accommodate electrical components, battery cells for photovoltaic panels, and roof drains. Building specifications included the use of double glazed windows of 0.5 W/m²K (see figure 2), light coloured roof to reflect sunrays, compressed earth bricks with a U-value of 1.73 W/m²K for low thermal transmittance (see figure 7 and 10), large widows to maximize daylighting and natural ventilation while providing shades where necessary. One third of the building was fully cantilevered, while the rest were elevated to reduce heating, improve air circulation and cut down water capillary action (see figures 4,5).

The Construction

The materiality of the construction took into Circular Economy considerations. The principles of “design for disassembly” and “design for recycling” were applied where possible.

The building was mostly site assembled (figures 6 - 9), such as the steel frame stanchions bolted on foundation pads for easy dismounting (figure 5), laid bricks with no mortar for ease of reuse (figure 7), wooden floor bolted on steel frames, screwed-in roofing sheets and suspended ceiling members.

Conclusion

The West African tropical temperature was easily managed using passive design principles, thereby, attaining a thermal comfort range of 23-25 degree Celsius simply by natural ventilation and thermal mass. The project received good commendations from visitors as to the ease of construction and deconstruction strategies applied. It was discovered that the region have a wide range of material that can be employed in circular economy. 80 % of reusable and recyclable materials used for the construction were locally sourced. This study is essential because residential buildings amounts to most of the regions’ building stock. The human population in these regions are increasing and if more homes must be built, they need to be done in an energy and resource efficient manner considering the challenges of these regions such as unstable and inadequacy in electricity supply, unavailability of building material and the hot climate. A simulation with DesignBuilder software revealed that the building’s primary energy demand was under 120 kWh/(m²a) by achieving 48 kWh/(m²a) with a 46 % improvement in comparison with business as usual buildings in the area. The building as a demonstration project has gained popularity and currently serving as a reference for a resource and energy efficient building (see figure 10) built to basic Passive Design and Circular Economy Principles.

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