*Proceedings of the IASS Annual Symposium 2025*
"The living past as a source of innovation"
27 October– 31 October 2025, México City, México>
<Juan Gerardo Oliva, Juan Ignacio del Cueto, Elisa Drago (eds.)

# New Hope Village – The Timber Blanket

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## Abstract

This paper presents the "timber blanket," a novel tensile roof system developed for a community hall in New Hope Village, Tanzania, a philanthropic development supporting underprivileged young women. This work has been informed by community outreach and visits by the design team. The "timber blanket" is created with a lattice of softwood timber and steel cables, forming a flexible and lightweight tensile surface. A globally rigid system is created using an anti-clastic surface geometry supported on a central steel truss and edge frames. Advanced computational methods, including form-finding and parametric finite element analysis (FEA), were employed to optimise the geometry. The system can be constructed locally by craftspeople and the community and has the potential to be used in similar locations, where light-weight large span roof structures are desired. The novel Timber Blanket shows the potential of biogenic materials in cable-net like tensile structure in resource-constrained settings.

**Keywords**: Tensile timber, net structures, biomaterials, concept design, form-finding, optimisation, sustainable design

# 1 Introduction

One Heart Village near Dar Es Salaam, Tanzania, aims to establish a permanent, safe home for up to 250 vulnerable girls and young women so they can escape poverty and abuse. Set for completion in 2027, the new development is zoned into housing, play, gathering, education, health, sport, and farming areas across the site. Sensitive and sustainable design makes the buildings and the entire village feel genuinely connected to the location, community and culture.

The project was born out of a conversation between philanthropist Simon Costa OA and a local woman (who due to safety issues cannot be named) close to the cause who envisaged housing up to 250 at-risk girls and young women, empowering them to live self-sufficiently off the land. Inspired by this altruism and vision, Simon approached Hassell in 2020 to design a concept, which has evolved and become reality through the not-for-profit One Heart Foundation, and a collaboration with engineers Eckersley O'Callaghan, architects ClarkeHopkinsClarke along with Tanzanian firm ALAMA Architecture.

One Heart Foundation is an Australian not-for-profit organisation that was established in 2007 and works in Kenya, Uganda and Tanzania. One Heart's primary focus is to change the future of vulnerable and abused children living in poverty in East Africa, and in turn see whole communities transformed through education, leadership, and empowerment.

This paper focusses on the design of the community hall of Hope Village. In particular on the development of the roof of the hall, which is a novel tensile structural system, the timber blanket, that leverages local biogenic materials. The roof will cover the settlement's community centre building which will host collective/social activities and therefore the need for lager spaces. The design focuses on creating an efficient large-span tensile structure using computational methods to form-find the overall geometry. The roof is to be fabricated using locally available resources and built by the community.

Part of the team visited the community to identify the availability, species and dimensions of local structural timber. This informed the system's development through iterative design processes, including form-finding techniques, parametric finite element analysis (FEA), and validation using industry-standard FEA software.

The resulting system integrates a lattice of softwood timber elements and steel cables, forming a lightweight, flexible "timber blanket" capable of bending about both axes. This tensile blanket is supported by a central steel ridge truss and peripheral support elements to generate a semi-rigid anticlastic surface. The design achieves an elegant balance between structural efficiency and material sustainability, resembling a finely crafted textile, which can be built from locally available stock by the community.

# 2 Background

## 2.1 The Community

Approximately 30 acres of land have been acquired as the foundation for a new masterplan that will provide homes, schools, and community facilities for young women and girls. The masterplan includes the design of 10 residential buildings, each accommodating 240 girls and young women, arranged across distinct quarters of the site. Once complete, One Heart Village will offer safe and supportive housing, a high school, an early learning centre, a sports and soccer field, and a community centre at the heart of the site.

All buildings are designed to be sustainable and self-sufficient, incorporating features such as natural ventilation, solar panels, and water retention systems. Locally sourced materials are used throughout the development, celebrating regional craftsmanship and building traditions.

The community hall plays a central role in the masterplan. It is a shared space open to both the residents of One Heart Village and the wider local community. It serves as a place for communal meals, spiritual gatherings, celebrations, and acts as a welcoming threshold into the One Heart Precinct.

### 2.2 Available Materials

It was seen as essential that the design team visited the site, connected with the local community and local contractors and fabricators before the concept design of the community hall started. Edouard Cabay from IAAC spent 10 days in Tanzania, which included: visits to the site and surroundings in Kibanha, visits to local fabrication facilities, understanding the local architecture, and understanding the availability of materials and their sourcing and costing.

In this rural context, local dwellings are made using basic materials and traditional construction techniques. Older homes are typically built with locally available materials such as earth and non-engineered wood (branches and fibres) for the walls, and simple timber profiles for the roofs, covered with corrugated steel sheets. Newer homes tend to use concrete blocks for walls and steel for doors and windows. Due to the relatively mild climate, buildings are usually not insulated; instead, they are well-ventilated to avoid heat retention from solar radiation.

Timber is widely available in Tanzania. Large timber sections are expensive and mainly designated for export, while smaller, less valuable sections are widely available in large quantities. The commonly used timber is known locally as "Cypress" (*Cupressus lusitanica*), a softwood sourced from the Iringa region of Tanzania. It is sold in treated sections of 2x2, 2x4, and 2x6 inches, and in lengths up to 18 feet (priced at 1,500 Tanzanian shillings per foot). Local timber workshops are widespread—every village typically has one. These workshops are modestly equipped, often with just a few mechanized tools like band saws, but they employ large teams of carpenters and have access to various hand tools. Although most timber is exported, the main structural elements fabricated locally are trusses spanning 4 to 7 meters.

Earthen construction is also practiced locally. Due to climatic considerations, earth walls tend to be thin (4 to 8 cm), forming hybrid structures made from locally available branches woven into screens, which are then coated with earth. For construction purposes, the earth needs a clay content of approximately 10% to 20%. The New Hope Village site has soil with a lower clay content, but suitable clay can be sourced within a 20 km radius.

### 2.3 Community Hall Architectural Design

The community hall occupies a central position within the masterplan and serves as the focal point of Hope Village. It is envisaged as the primary location for interaction between the local population and the residents of the village. The brief for the community hall was intentionally left open-ended by the client to allow for flexibility in its use. The space was required to support a variety of communal functions, including shared meals, social gatherings, events, and religious services. As such, it was essential that the design accommodate a high degree of spatial adaptability, leading to the decision to minimise the number of internal columns to create an open, multifunctional environment.

The community hall is the largest building by footprint within the masterplan and serves the most outward-facing functions. It was therefore deemed appropriate for this building to exhibit a distinctive architectural character, enabling it to serve as the emblematic centrepiece of the development and a landmark within the surrounding landscape.

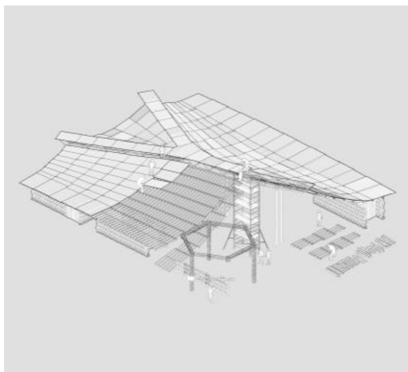
Figure 1: External architectural render

Among the structural typologies considered, tensile structures were explored due to their potential for generating visually iconic forms and for spanning large distances without intermediate supports. However, it was recognised that fabric-based tensile systems were not suitable for this context due to challenges in local fabrication and long-term maintenance. Consequently, the design team investigated the possibility of replicating the formal qualities of tensile structures using small-section timber elements readily available in the local area.

Given the anticipated multifunctionality of the hall, the brief required substantial storage space to accommodate chairs, tables, and a portable stage. In addition, to support catering operations, an industrial-grade kitchen was specified. The brief also included provision for a bakery intended to serve both the village community and residents of Hope Village.

The design strategy acknowledged the differing spatial requirements across the programme. While the main hall necessitated generous height and long structural spans, the ancillary spaces such as the kitchen and bakery did not. To address this, a central structural spine was introduced. Toward the front of the building, this spine bifurcates into two separate branches, creating lower ceiling heights appropriate for the kitchen and bakery. In contrast, the main hall retains a singular, elevated spine, supporting the larger volume. Storage areas were positioned along the sides of the building, where the roof is at its lowest point. These spaces are optimally located to support the activities of the main hall and an opportunity for structure.

(a) Internal architectural render



(b) Construction diagram

Figure 2: Concept typologies and precedent projects

### 2.4 Structural Constraints and Opportunities

The roof must not only provide effective shelter from both rain and sun but also help to define an open, welcoming space for the local community.

To encourage natural airflow and passive cooling, the perimeter of the structure remains open and naturally ventilated, which introduces additional challenges in managing uplift and suction wind loads acting on the interior.

In considering local material resources, it's important to note that much of Tanzania's high-quality timber is exported, limiting access to larger, specialist or laminated sections. Our design solution needs to achieve this long span using standard, readily available member dimensions.

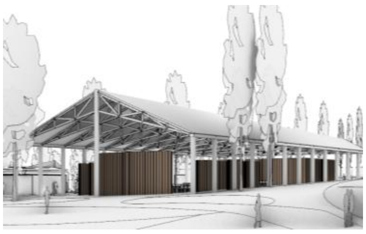
With construction in the rural setting, ease of assembly is also crucial; connections should be fixable by hand, and manipulation of the timber members themselves must be possible using hand-operated tools. Due to the desired height of the roof, the erection may require limited use of construction machinery, but the sequencing must be considered.

Beyond the initial construction, the building must remain resilient in the face of extreme weather. Structural redundancy is to be integrated within the scheme, ensuring that the loss of a small number of members during a severe storm would not lead to a total collapse. The hall should be straightforward to maintain, allowing repairs to be carried out without placing the entire structure at risk.

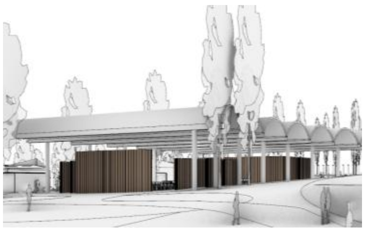
Together, these constraints provide a unique opportunity to provide a novel design, practical construction assembly and maintainable solution that addresses the structure as method creating the heart of the village.

## 3 Precedent Projects

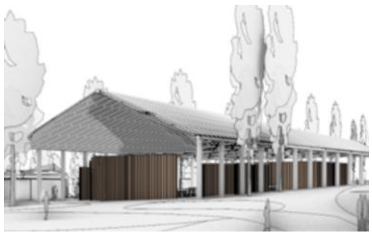
Precedent structural typologies and example projects were explored to find a suitable system that could match the architectural ambition and could be constructed with the given environmental constraints. Four typologies were explored: timber trusses, vaulted roofs, reciprocal structures and tensile systems. Figure 3, shows concept images and relevant precedents for each system.



(a.1) Truss concept



(b.1) Vault concept



(c.1) Reciprocal concept

(a.2) Simanjiro, Tanzania

(b.2) Intermediate House, Paraguay

(c.2) Mutter Fourage, Germany

Figure 3: Concept typologies and precedent projects

Based on a review of the existing precedents a decision matrix was created to inform the design of the new community hall. The tensile system was selected based on the improved structural efficiency, reduced structural depth and the novelty. Projects with tensile structures involving timber were reviewed in greater detail to identify relevant geometries, stability systems and details which can be used to inform the design of the hall. Two key precedents were found and used as inspiration, the Woodland Canopy in Dorset UK and the Grandview Heights Aquatic Centre, Canada. The Woodland Canopy used relatively small elements, with a ruled surface to create double curvature, to help provide rigidity of the system. This project also uses a scaled metal roof sheeting fitted to the curved surface. The aquatic centre used an alternative system with a simplified catenary shape, using glulam elements in tension to take the gravity loads and using the section depth and continuous connections to create bending capacity to resist transient load conditions.


(a) Cable net structure

(b) Woodland Canopy, Dorset UK

(c) Grandview heights aquatic centre, Canada

Figure 4: Tensile Timber Concepts and Projects

## 4 The Timber Blanket Concept

Exploring the precedent projects while considering the available materials a cable net-structure was identified as the most suitable. The system used by the woodland Canopy relies on relatively long straight members, with minimum number of intermediate connections, given the scale of the community hall and local supply chain timbers of this length would not be procurable. The Grandview system is also reliant on long glulam sections and moment connections within the span. The glulam would have to come from Europe. In comparison a cable net structure can be made from small elements and only requires simple pin connections between elements. Together these factors would allow more local elements to be used on the structure.

Development of the Timber Blanket started from the mechanical properties required for a cable net structure, the project supply constraints and the desire to have the roof partly constructed by the community. The tensile system requires high levels of flexibility about both the in-plane axis of the membrane and a high tensile capacity. Starting from short rigid timber elements we developed a system where the timbers are threaded onto steel cables in alternating layers with bead-like timber spacers creating a fabric like material sheet, we've named the Timber Blanket.

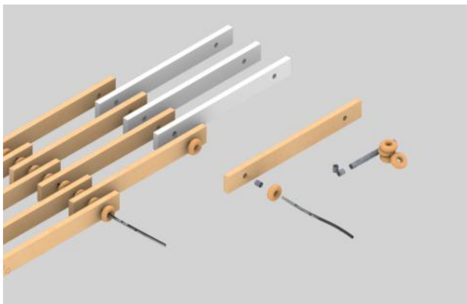
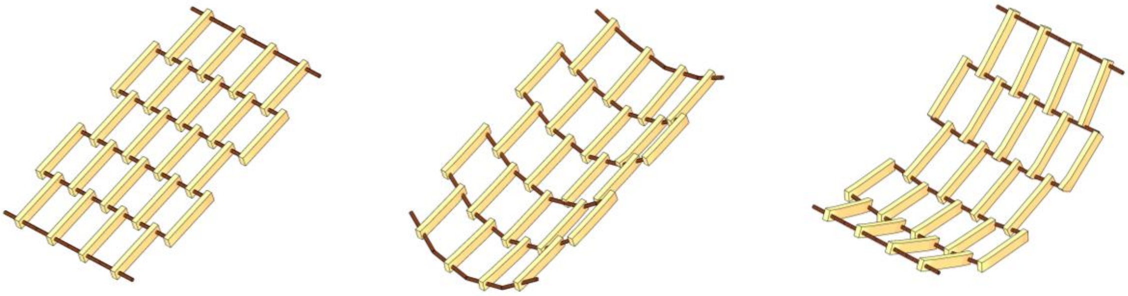


Figure 5: The Timber Blanket concept diagram

The Timber blanket utilises steel cables in one direction to provide flexibility and high tensile capacity, with the rounded timber spacers allowing rotation between the timber elements. About the other axis the simple pin like connection at the end of each timber allows for rotation. Combined these effects allow the blanket to behave as a cable net-like membrane.



(a) Timber blanket (b) Flexibility provided through cables bending (c) Flexibility through pinned timber connections

Figure 6: Creating a flexible membrane with rigid elements

To create a rigid global system to prevent uplift due to wind or asymmetric loading an anticlastic surface is created between the curved central truss and the linear edge support steel frame. This is enhanced with two types of additional ties. The first set of ties span between each side blanket near the truss evenly spaced along the building. The second tie lines are from the lower quarter of the blanket to the foundations. The cross ties between the sides, allows tension to be shared between each side as dynamic wind loads are applied. The vertical ties to the base provide a secondary tensioning point intended to help resist uplift.

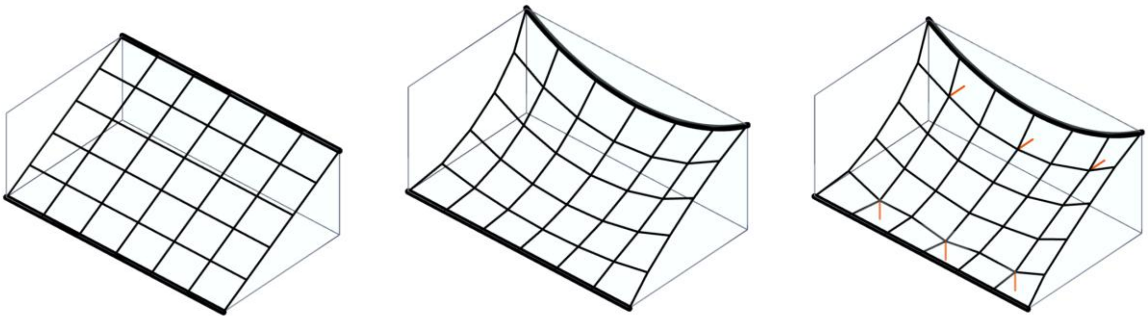


Figure 7: Creating an anticlastic surface with the timber blanket to form a globally rigid system

The whole building frame is shown in Figure 8. The timber blanket is suspended between the central steel ridge truss and edge steel frame. The Timber Blanket is clad with corrugated tin panels which are fixed to the blanket with cross battens. The panelisation of the roofing material is to be optimised to minimise the number of panel types and to reduce complexity of individual elements. The internal partitions are formed with 3D printed clay walls developed by the Institute of Advanced Architecture Catalonia (IAAC) allowing natural ventilation through the use of locally available soils.

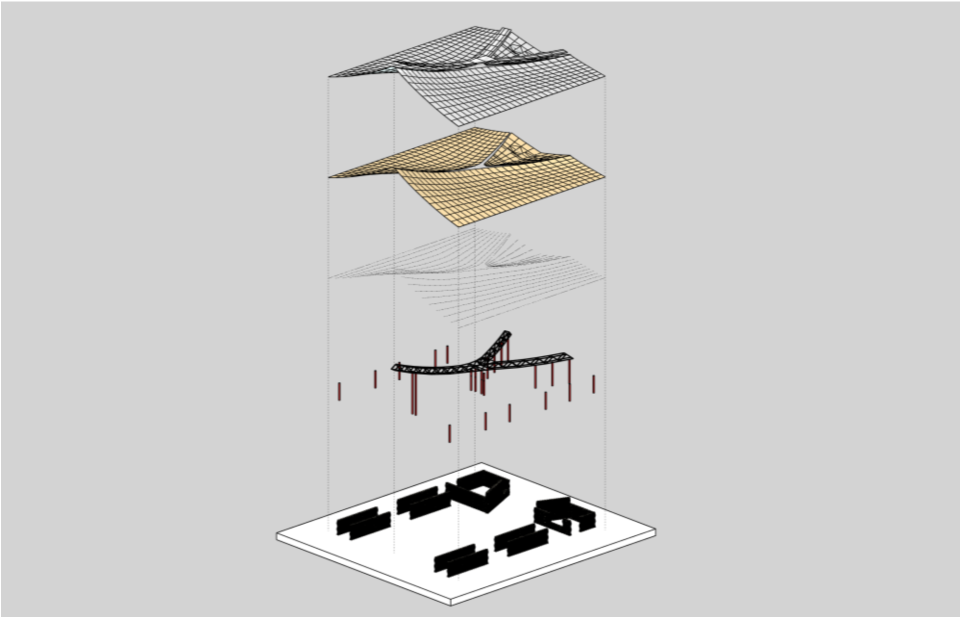


Figure 8: Exploded axonometric view of the structural elements

A key consideration throughout the conceptual design of the timber blanket was the constructability of the system. A key goal was to utilise local craftsmen and have the community involved in the process. This was a driver of the blanket system that primarily uses small sections that are easily fabricated and moved. The Timber Blanket itself can be assembled in strips on the ground and raised onto the central truss using a pulley system, before being stitched together and then tensioned. The assembly and erection process for the blanket is summarised in Figure 9.

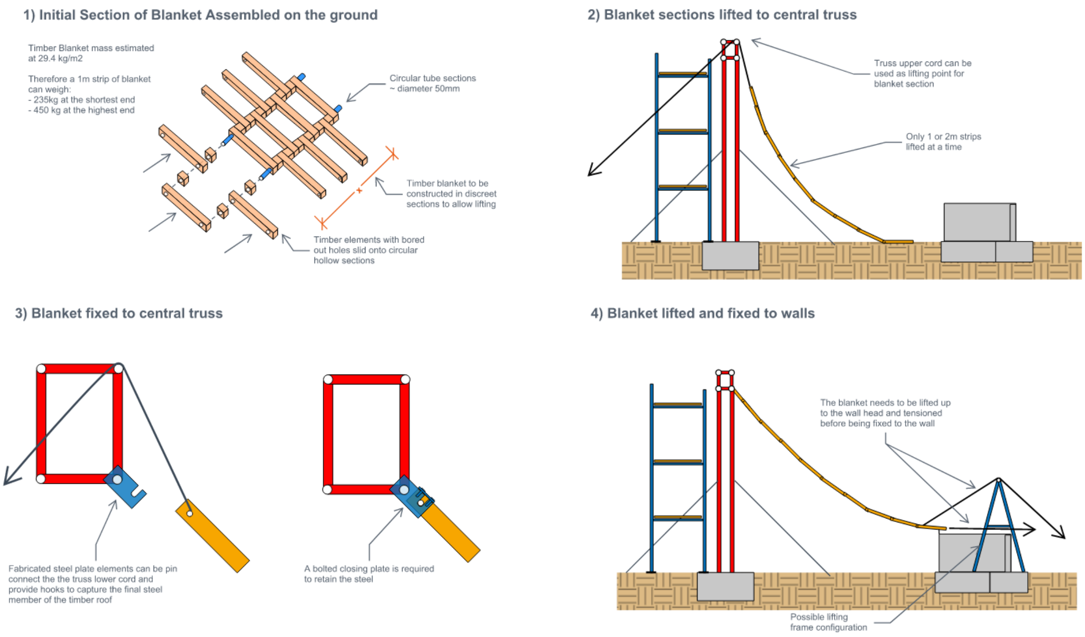



Figure 9: Construction sequence diagram (Temp image for layout)

Further consideration has been given to the durability and repairability of the system. Given the context of the project and restricted budget a simplified member replacement and repair strategy was developed. This is considered in two parts. First, due to the close spacing of timber elements there is substantial redundancy in the system, individual elements can be damaged or lost without affecting the global stability of the roof. This allows individual elements to be replaced by loosening the blanket, cutting free the damage item, and replacing it with a slotted timber piece and cover plate as shown in Figure 10, before re-tightening the system. The reduced strength of the replaced element is compensated for by the high level of redundancy. In the case of a cluster of damaged and replaced elements a larger repair will be required, which will include lowering one of the blanked segments for reconstruction.

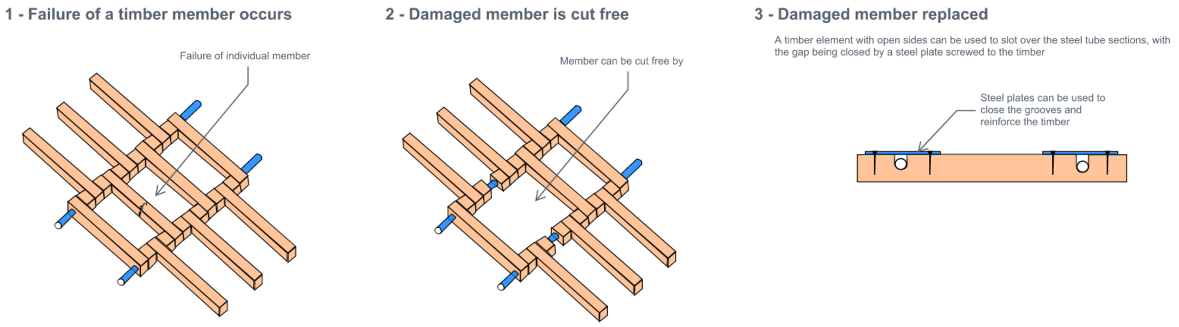



Figure 10: Element replacement diagram

## 5 Design and Optimisation Process

A digital design focussed workflow has been developed to complete the design of the new community hall. A digital first approach has been adopted to allow for fast iteration of the design while accommodating the complex geometry and the use of optimisation algorithms. Iterating the design quickly is essential as the internal forces can be reduced significantly with minor geometry changes [2,3].

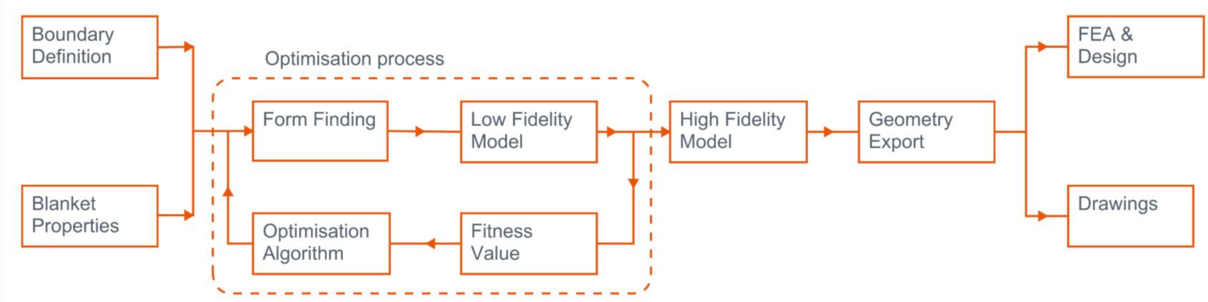
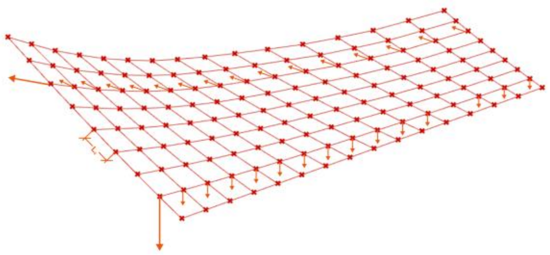


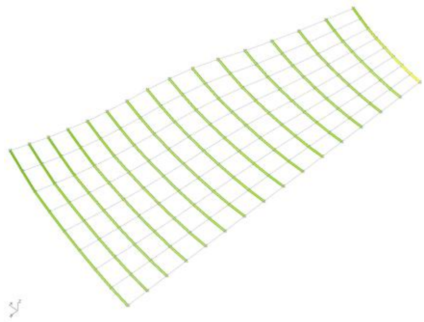

Figure 11: Digital design workflow

The detailed design of the roof starts with a geometry optimisation process aimed at reducing the internal forces in the blanket, movement due to wind and ensuring there are no areas where water can pond on the roof. A parametric mesh model is generated using grasshopper and then relaxed into a catenary geometry using the physics engine Kangaroo2. The relaxed mesh is used to define a low-fidelity Finite Element Analysis (FEA) model in Karamba, using the iterative second-order solver to accommodate changes in the geometry due to temporary load cases. The FEA model includes accurate material properties, sections, support conditions, tensioners and wind uplift. The tension in the timber elements, movement due to wind and minimum slope of the roof are used to define a fitness value used as optimisation goal for the genetic optimisation algorithm Galapagos. Inputs that can be altered include:

the ridge height and curvature, the timber element length and spacing, the sag of the blanket and the applied tension.



(a) Form finding mesh for optimisation



(b) Low-fidelity model to assess results of optimisation

Figure 12: Physics and FEA models used in the design

After the optimisation process is complete the top results are checked with a high-fidelity parametric FEA model and second-order solver. This model is used to check the roof's movement under additional wind cases, impact of the real blanket spacing, utilization of the timber elements and for any local effects around the tensioning cables fixing points. These checks lead to a decision on which of the optimised geometries best fits the architectural intent while working structurally.

Next the support structure is defined, as the stiffness of these elements will have a large impact on the blanket's behaviour [4]. The steel support structure is added to the geometry which is pushed to an industry standard FEA software (RFEM) for final verification of the structure.

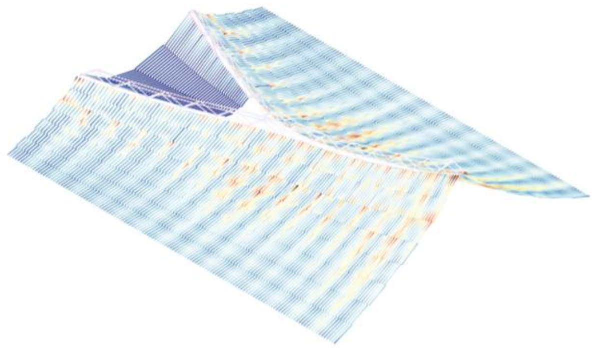


Figure 13: High fidelity parametric FEA model of the roof used in the design

The connections between the cable and the timber elements are shown below. A steel insert (part of a CHS section) is inserted into the timber to ensure a large contact area is achieved between the cable and timber and prevent local crushing. The maximum connection loads are checked to EC5 [1].

The final stage in the digital workflow is the production of fabrication drawings. Due to the large number of timber elements with varying lengths, detailed information is required as with coordination of element sizes with the typical material feedstock locally available. Sourcing cables and hardware – tension and hardware required isn't any more than pavilion style architecture.

### 5.1 Model Testing

A physical 1:50 model was created to test the buildability, structural theory and digital design to fabrication workflow developed. Some simplifications to the geometry were required to accommodate the scale change such as increasing the timber width, elimination of the side cables, increasing the cable size and reducing the number of timber bands in the blanket.

Using the edge length output from the optimisation workflow we nested the segments end on end replicating true construction methodology. Each segment was individually labelled in horizontal bands and threaded together using steel cables and secured to the 'steel' framing elements.

A qualitative result was the observable, jewellery-like quality of the structural system. The timber beads which acted as spacers worked effectively to maintain the distance between the tensile timber sections. The structure successfully spanned across the model incurring tensile loads on the perimeter columns as expected within the structural analysis. Findings include the possibility that there too are too many similar edge lengths of timber and that a grouping system to reduce the number of unique pieces could be developed within the workflow would benefit the constructability of the building.

Figure 14: 1:50 Structural Model

An effect of changing geometry on the roof due to increased tension in the ties was observed and the rigidity that it in turn provided was evident by the lifting of the blanket.

Holes intending to allow a fully pinned connection will always be larger than the cables diameters themselves and it was observed that a foreseeable sag in the blanket was caused by the accumulation of this additional diameter in comparison with the digital model.

Risks considered when building the model also include the complexity of the proposed steelwork, the possibility of water pooling and sag should be reviewed in the next stage

## 6 3D Printed Walls

While not the focus of this paper, the internal partitions are intended to be formed using innovative 3D printed clay walls developed and test by the Institute of Advanced Architecture Catalonia (IAAC) [5]. The technique allows for complex shapes to be fabricated using local clay extracted from the existing site allowing natural ventilation from the exterior, an image of a test print is shown in Figure 14.

Figure 15: Test print of the clay walls completed by IAAC

## 7 Next Steps

To date the schematic design of the community hall has been completed, remaining construction level design elements to fully realise the project include: façade design and penalisation, detailed construction design and fabrication drawings, foundation design and final development of the 3D printed walls. Along with design, full scale testing of the tensile timber connections with the local timber is required to verify the design. Other than design the project is still fundraising for construction. Upon successful validation and fund-raising, construction of the community hall in the New Hope Village will commence, demonstrating the feasibility of sustainable tensile architecture in resource-constrained settings.

## 8 Conclusions

The New Hope Village Community Hall represents a bold and thoughtful response to the unique challenges of building in resource-constrained settings. Through a collaborative, community-driven process, the design team has developed an, efficient, and locally constructible tensile roof system, the Timber Blanket, that embraces the use of biogenic materials in a novel structural method.

By adopting a workflow which combines computational form-finding and optimisation, the project successfully balances structural efficiency, constructability, and architectural intent. The use of locally sourced softwood timbers threaded onto steel cables and a carefully designed support structure, resulted in a flexible yet robust anticlastic surface capable of spanning large areas with minimal material.

The project's development has demonstrated the technical feasibility of this novel tensile system and its adaptability for future applications in similar communities. Its straightforward assembly process, capacity for local fabrication, and inherent redundancy ensure it remains practical, maintainable, and repairable in a remote and challenging context.

## Acknowledgements

The work on the community hall has been enabled by Simon Costa OA, One Heart Foundation and the New Hope Village community. Engineering and architecture services have been provided pro bono by Eckersley O'Callaghan, Hassell Studios, ClarkeHopkinsClarke along with Tanzanian firm ALAMA Architecture. The development and supply of the 3D printed clay walls has been done by the Institute of Advanced Architecture Catalonia (IAAC).

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