research booklet
case studies

Explore Lab graduation studio 2023/24 Q3



Feiko Nooyens | 4714822

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This booklet was made as part of my project for the Explore Lab graduation studio 23/24 Q3 at the faculty of Architecture, Urbanism, and the Built Environment at Delft University of Technology. Other than most studios, Explore Lab offers students the opportunity to propose their own framework regarding the research and design focus. As a result, each Explore Lab student's project becomes a unique manifestation of their personal interest. This approach perfectly matched my desire to reverse the traditional direction of working through the different scales of architecture, namely from the large (urban scale) to the small (detail scale). Consequently, this project has become an exploration of designing from the small material scale to the larger scales, while including many of the immateral factors that architecture touches upon.

contents

introduction

The modern culture of construction relies heavily on non-renewable and imported materials. In the face of rising global temperatures, irreversable pollution and the depletion of finite resources, we as the perpetrators need to change our ways in order to establish a healthy relationship with the planet that houses us. Construction accounts for large portions of global emissions and waste generation, so improving this sector will contribute considerably to a better environment. Bio-based and locally harvested materials are just two concepts worth investigating when searching for more sustainable design solutions. Literature is vast, but learning from ideas put into practice blatantly exposes faults and opportunities, as well as a dependency on the limitations of reality.

In this investigation, the use of materials in their respective projects is put into context. Their feasibility is reviewed, showing how structures that may seem environmentally responisble often still hide rather unsustainable dependencies. But we cannot blame them; innovation in the field of architecture and construction as a whole is restricted by mind bogglingly complex factors, sometimes even on a global scale. Progress is slow, but thanks to daring pioneers, designers and developers alike can be inspired to continue the transformation of our building culture.

structural context

Each case study features a 'structural context' section where the focus elements of the structure are briefly noted. These elements are what make the project of interest for the case study. Some information is given regarding material origin, application, and role in the structure as a whole. None of the case projects are built using exclusively bio-based or hyper-local materials, which illustrates our ongoing dependency on non-renewable resources and a globalised economy. The materials that are discussed, however, function to inspire and catalyse innovation for more sustainable design solutions.

design/material

Each case study also features a 'design/material' section after its conclusion. Here, speculations about the impact of the chosen material on the design process are discussed, alongside the case-specific take-aways regarding this interaction. From the experimental nature of this project rises the question of how to design based primarily on material, before context or user. Part of this research is trying to answer this question for myself.

case selection and method of analysis

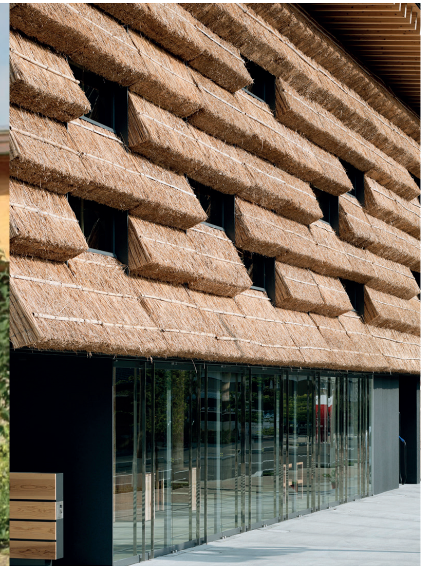
The projects featured in this case study we originally selected based on tectonic expression. The intention was to find the relation between the aesthetics of the structure and their use of bio-based or local materials. The goal of this case study is to put into context the use of these materials, and to subsequently attempt to derive some insights on how the use of material influenced the design process. Therefore, the three projects with the most notable use of material have been selected to further carry out the case study.
The case studies will result in documentation by manner of extracting information about each material analysed using the six basic interrogative words: where, what, how, why, when, and who. The combination of the findings on every discernible material in the analysed fragment shows the intricacy of the structure, the source of the material, where it is applied, as well as the expertise needed to build the structure. These 'material chain overviews' will be the product of each different case study, which will then be compared to each other. The goal is to rather systematically obtain information about each case's material sourcing, application, and complexity, in order to compare findings and obtain a holistic view of the structure, not just one that is fixated on a single aspect. However, each case will have a designated 'focus material,' which is the material that distinguishes its respective case from the others.

Flat House
Practice Architecture
Cambridgeshire
United Kingdom
2019

Sands End
Mae Architects
London
United Kingdom
2020

BKRK Bakery
BC Architects
Bokrijk
Belgium
2015

OTOProjects
Assemble Architecture
London
United Kingdom
2013



Yusuhara Marche
Kengo Kuma & Associates
Yusuhara
Japan
2010

material chain overview

Where
For each listed material, a presumption about its origin is made, alongside an estimation of the distance travelled from this origin. The origin describes the place from where the material in its finalised state was transported from. Obviously, the material chain is much longer, especially for heavily processed materials like metals or petrol-based products.
For the purposes of this case study, however, the focus materials have received the furthest origin tracing. It should be noted that these material origins also contain speculation, as even for the architect and contractor, this information is unfortunately often very limited.

What
The "what" provides the conventional information about the material used, as is nearly always found right beside the detail in question. It is the second column on purpose; the source comes before the product.

How
An axonometry is made for each case, based on available publications of details, photos, and other media. Though not precisely accurate, it provides context to the focus material.
This axonometry also forms the basis of the 1:20 model, which is made to accompany the MCO, in order to offer a clearer understanding of the spatial workings of the fragment, as well as the chronological order in which materials need to be applied (see 'When').

Why
Inspired by Frank Duffy and Steward Brand's concept of Shearing Layers, the materials will be categorised according to their function in the case fragment.

'Structure' contains the materials used for the construction and stability of the building.

'Climatisation' contains the materials used for insulating and sealing the building.

'Weatherproofing' contains the materials used for protecting the building from the elements, such as rain, sunlight, and other weather phenomena.

'Finishing' contains the materials which form the added surface the user will interact with.

When
Precisely when a material is applied is difficult to specify, as every technical design demands a unique chronological order. However, comprehending this order is essential for the designer, as it is a direct translation of ideas to real world limitations. In this column, a distinction is made between the basic parts of a building, namely the foundation, walls, floor, and roof. The order from top to bottom is accompanied with the initial of the category of the 'Why' column, showing how these categories often follow a certain chronological logic.

Who
A two-part score (a/b) is given to each material as an estimation of the expertise required to a) process and b) apply said material. For both scores, a scale of 1 to 3 is used:
1: any able bodied person should be able to produce/apply this material, with no prior knowledge, just demonstration;
2: any able bodied person should be able to produce/apply this material with considerable training and demonstration;
3: only experts with extensive experience and training are able to produce/apply this material, often due to the requirement of heavy machinery and/or extreme extreme production conditions.

Flat House

introduction

project name:	Flat House
architect:	Practice Architects
location:	Cambridgeshire, United Kingdom
date:	2019

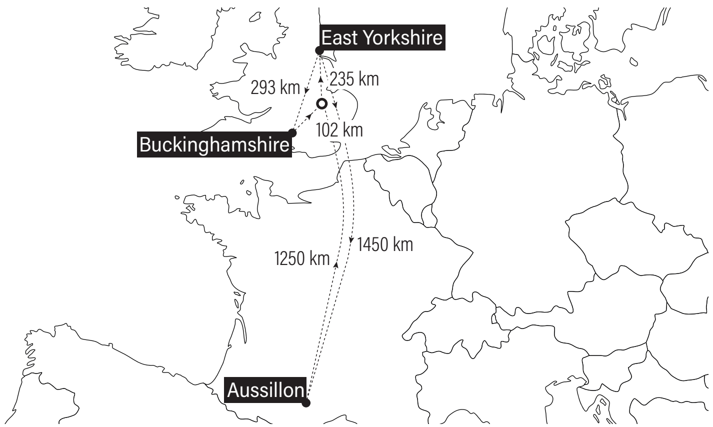
Flat House is a single family home designed by architecture and research firm Practice Architecture. Built using 8 hectares of hemp grown on site, it is an experimental project exploring new possibilities of bio-based architecture. This radically low embodied carbon structure is the firm's prototype for developing the prefab construction system for eventual large-scale production. Flat House was commissioned by Steve Barron, owner of Margent Farm, an R&D facility focusing on hemp as a source of biomass in a low impact circular economy.

key words: hemp, embodied carbon, bio-based, off-grid

structural context
focus material: hemp

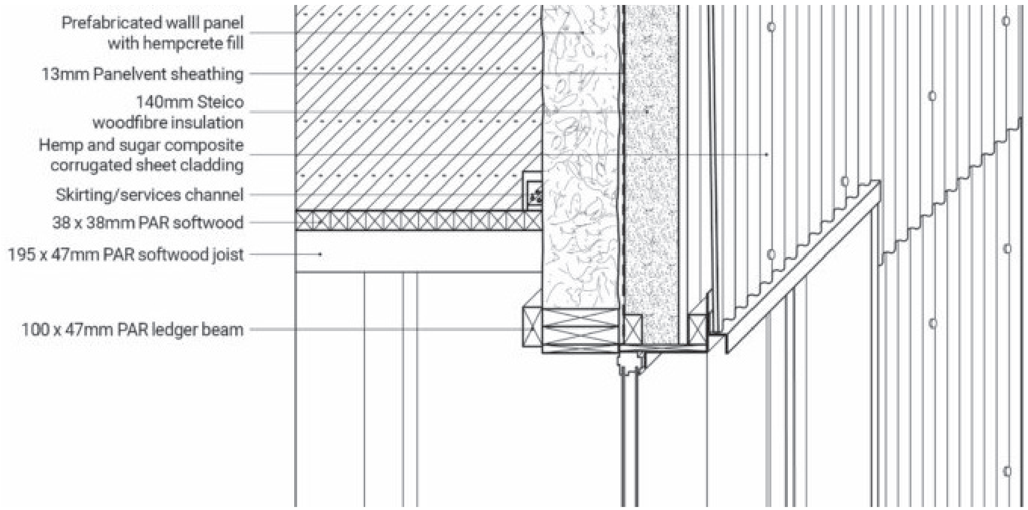
Timber cassettes filled with hempcrete are prefabricated and transported to the site, where they are carefully put in place, leaving very little margin for displacement. In order to produce the hempcrete, the hemp is harvested, shipped to Yorkshire, separated into seed, fibre, and shiv: the chopped woody core which is the essential ingredient for hempcrete. The shiv is then sent to Buckinghamshire, where it is mixed with lime and cast into the cassettes. The fibres are shipped to France (likely to the Toulouse region), and pressed into corrugated sheets with sugar resin as a binding and waterproofing agent.

Ironically, the hemp fibre that was grown on-site was transported roughly 2700 km to be processed for construction. This is due to a lack of facilities able to process a still experimental building material. Ideally, such facilities will become commonplace if we are to prioritise bio-based materials over petrol- and mining-based ones.



interior hempcrete

exterior hemp fibre corrugated sheets



scale 1:20 (original scale unknown)

1

2

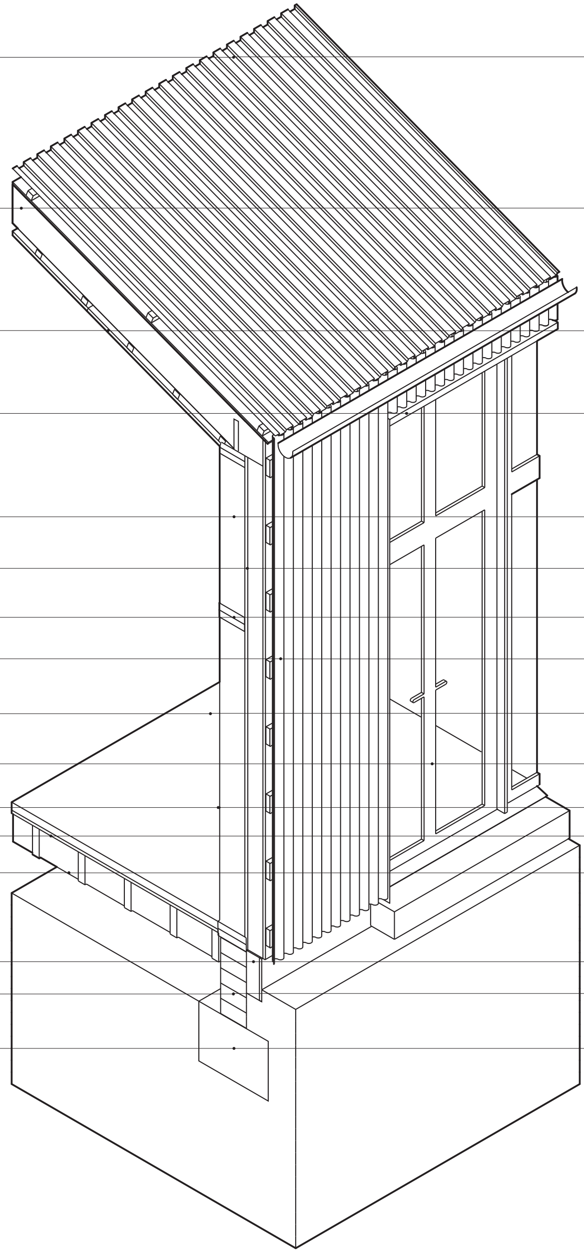
3

4

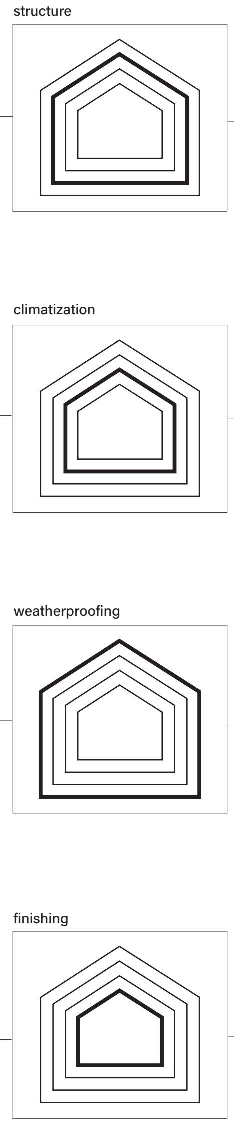
material chain overview

where source / km traveled *German origin presumed* *Ruhr area*	what material
likely from Germany 670+ km	corrugated metal sheets
likely from Czarnków, Poland 1,450+ km	Steico wood fibre insulation
likely imported n.a.	wood fibre cement panels
likely imported n.a.	aluminium sills
hemp grown on site processed: Yorkshire, UK (235 km) cast: Buckinghamshire, UK (293 km) 630 km	hempcrete in timber cassettes
possibly from Kent, UK 159 km	Panelvent sheathing board
UK (wherever discernable) <880 km (one way)	timber (pine)
hemp grown on site cessed: France, likely Toulouse region 990 km (one way)	hemp fibre and sugar resin corrugated panels
possibly from UK n.a.	anhydrite screed (latex finish)
likely imported n.a.	aluminium casement window/door frames
possibly from UK n.a.	lime wash
likely from Germany 670+ km	OSB subfloor
likely from Germany 670+ km	steel mesh
likely from Klášterec, Czechia 2,044 km	Foamglass insulation
possibly UK n.a.	blockwork dwarf wall
likely UK n.a.	concrete

how
2200x2200 mm axo



why
function / shearing layer



when application order		who skill levels (production / applicatio
foundation		
S	concrete foundation	3 / 2
S	blockwork dwarf wall	3 / 2
C	Foamglass insulation	3 / 2
W/F	(aluminium ?)	3 / 3
wall		
S	timber frame	3 / 2
S	hempcrete in timber cassettes	3 / 2
C	aluminium casement window/door frames	3 / 3
S	Panelvent sheathing boards	3 / 2
C	Steico wood fibre insulation	3 / 2
S	timber battens	3 / 2
W	hemp fibre and sugar resin corrugated sheets	3 / 2
F	lime wash	3 / 1
floor		
S	timber floor joists	3 / 2
S	steel mesh	3 / 2
C	Steico wood fibre insulation	3 / 2
S	OSB subfloor	3 / 2
F	anhydrite screed (latex finish)	3 / 3
roof		
S	timber rafters	3 / 2
S	timber underpurlins	3 / 2
C	Steico wood fibre insulation	3 / 2
S	(OSB ?)	3 / 2
S	timber battens	3 / 2
W	metal corrugated sheets	3 / 2

elaboration

Where

As mentioned before, the hemp was grown on site but had to be shipped throughout the U.K. and partly to France, presumably in the Toulouse region where needle-punched fibre mats are produced, the penultimate form of the fibres before being pressed into corrugated sheets.

Most steel imported into the U.K. comes from Germany; the Ruhr area is Germany's largest manufacturing site for steel. Steico (part of Kingspan Group) has factories in Poland. Foamglas (part of Owens Corning) has factories in Czechia.

What

Bio-based materials are accompanied by industrial, emission heavy materials such as steel and aluminium. Precisely why is not clear; the architect could have decided on using wooden window frames for example, which would have added to the low-carbon nature of the bio-based materials. Possible reasons for selecting more environmentally impactful materials could be aesthetical considerations or financial limitations.

How

Prefabricated cassettes filled with hempcrete are shipped to the site and assembled on a small-footprint foundation of concrete and brickwork. The floating ground floor is made from timber with insulation in between the joists which is kept in place with a steel mesh.

The roof is also made from timber and insulated after installment. The outer walls receive a 140 mm layer of insulation (R_c=3,8), as the hempcrete also acts as an insulator. On a latticework of timber, facade materials are attached.

Why

Hemp plays multiple functional roles in this construction: it is the stabilisator for the timber casettes, which are the primary structural features; it has insulating and thermally massive qualities; and lastly, it is the exposed texture as experienced internally, where it absorbs sound

Externally, hemp covers the building's facade, protecting it from the elements. This shows the crop's versatile potential for construction, provided it is complemented by other materials such as lime (internally) and resin (externally).

When

The cassettes are assembled and filled in a factory, allowing them to dry indoors, which in turn allows for year-round production. Meanwhile, the foundations are built on the site. When the panels are ready for installment, they are shipped to the site and assembled.

The roof is constructed and insulated in situ. Presumably, the window and door frames are put in now. Ceiling panels are attached to the underside of the roof, and the walls are covered in a thin layer of lime wash internally, and insulated externally. A timber lattice is built around the structure, and on it the corrugated hemp sheets are attached on the facade, and a metal sheets cover the roof.

Who

Every single material scores 3 for production. Materials such as metal and concrete have a long production chain, involving a lot of expertise from varying parties. The bio-based materials' production chain is shorter, yet not necessarily less complicated in terms of skill involved. The cassettes have been meticulously planned and sized, requiring great precision. The processing of the hemp is no less complex, as operating specific machinery and is needed.

For application, most materials score 2, as they require very little cutting due to the use of standard measurements, and attachment is usually as simple as screwing them down. The panels, however, need to be lifted by crane, and placed precisely, as they apparently required some 'persuasion' to be put into place, even when carried out by professionals.

conclusions

Flat House is a model for innovation using bio-based materials as it manages to incorporate a single, rarely used crop in two vastly different ways. However, the project can be considered too far ahead of its time, as a lack of processing facilities resulted in the material having to travel large distances before it could be used. In order to make hyper-local structures work, sufficient facilities need to be available within a relatively short reach. As bio-based solutions become more commonplace, so should their respective processing sites.

design/material

Despite the misleading connection between the site and the hemp grown for construction, Flat House offers an interesting perspective on the possibilities bio-based materials provide. Hemp, being a fast growing crop (much faster than trees for lumbering), is used for insulation, rigidity, and exterior cladding. The project beautifully showcases the crop's versatility, not only its technical capabilities, but also its aesthetical quality. By radically limiting themselves to hemp as the main building material, Practice Architects have truly had to exploit and embrace all the possibilities hemp provides.

Usually, building with hempcrete is time consuming. Practice Architecture chose to develop a prefab system for this project specifically, but they claim to further investigate its potential for wider use. The system proved "incredibly easy to manufacture and very cost-effective," adding to the potential such systems could have for replacing current construction methods.

model

OTOProjects

introduction

project name:	OTOProjects
architect:	Assemble Studio
location:	London, United Kingdom
date:	2013

OTOProjects is a small scale performance and workshop space built by 60 volunteers in Dalston, London. It was designed by Assemble Studio, a collective specialising partly in self-buildability. The design relies on rubble found on-site as a structural and finishing material, inspiring new perspectives on upcycling and hyper-locality. It was built over the course of one summer for experimental music venue Café OTO.

key words: self-built, hyper-local, upcycling, experimental

structural context
focus material: rubble

Rice bags are filled with rubble already present on-site. They are then compressed and stacked in an overlapping, brick-like pattern, a single bag wide. Outward buttresses are adjoined perpendicularly in the same manner.

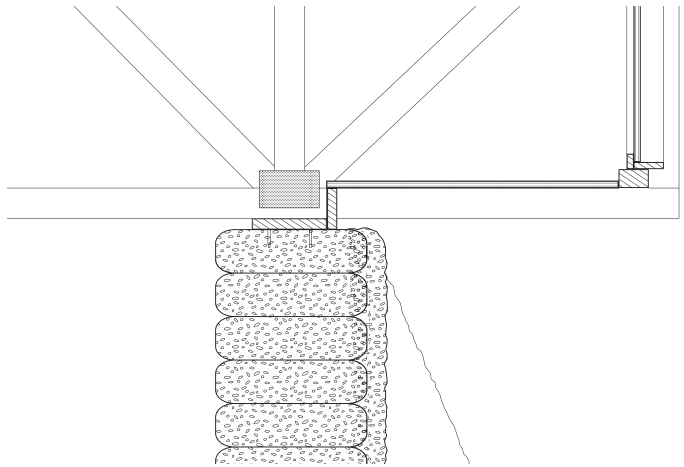
A timber board tops off the stack, on which rest the prefabricated trusses. The trusses were assembled on site and lifted into place and connected to eachother, after which the structure is clad in plywood. Corrugated metal sheets comprise the roof.

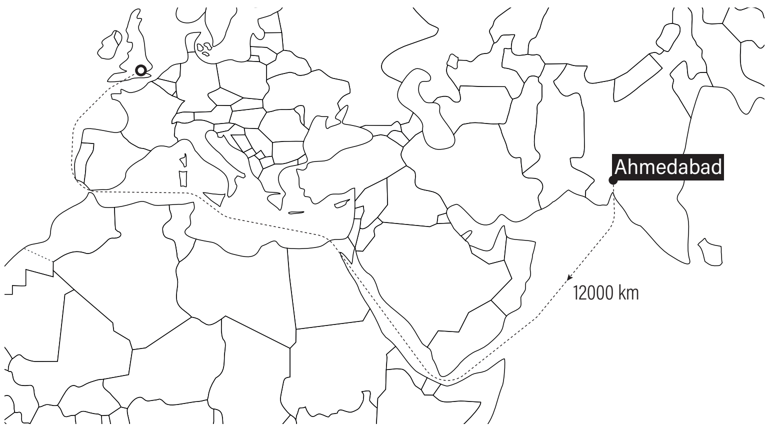
The exterior of the wall is covered with the team's own 'rubble-dash' render, also using the rubble found on-site. It is reinforced using chicken wire.

Over the course of its lifetime, OTOProjects saw additions made by its users when needed, such as using expanding foam to close gaps in colder, windier weather, or more permanent cladding for the roof structure, as being able to open the sides was no longer deemed necessary.

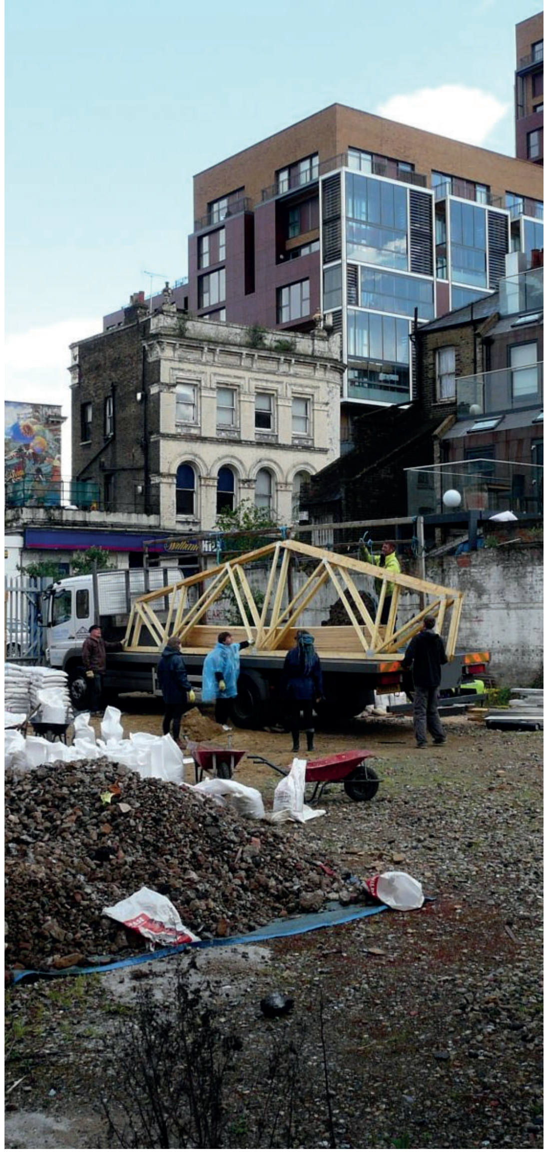
interior rice bags and timber structure

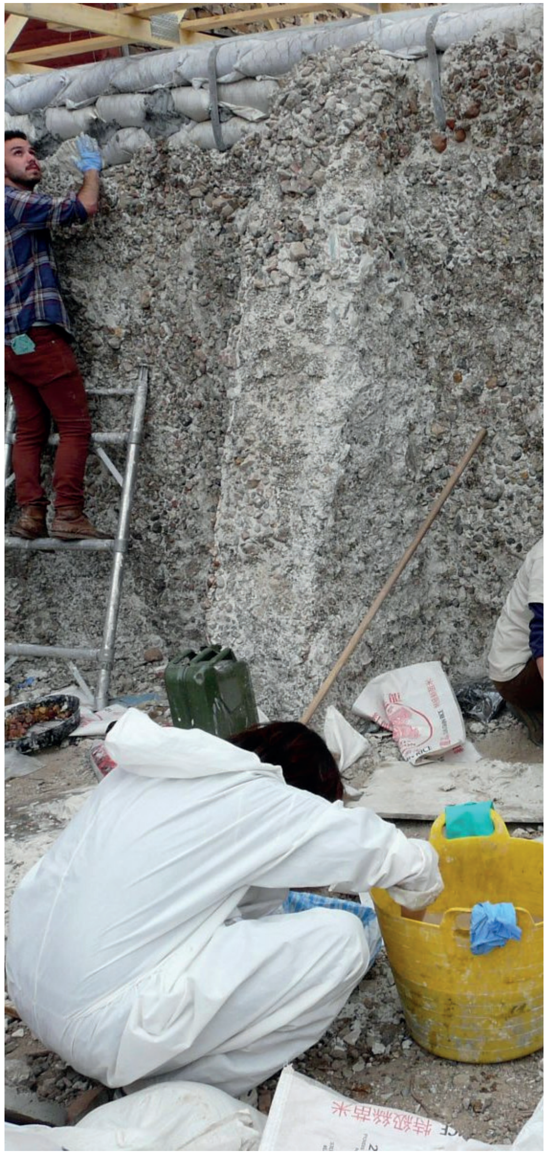
exterior 'rubble-dash' render



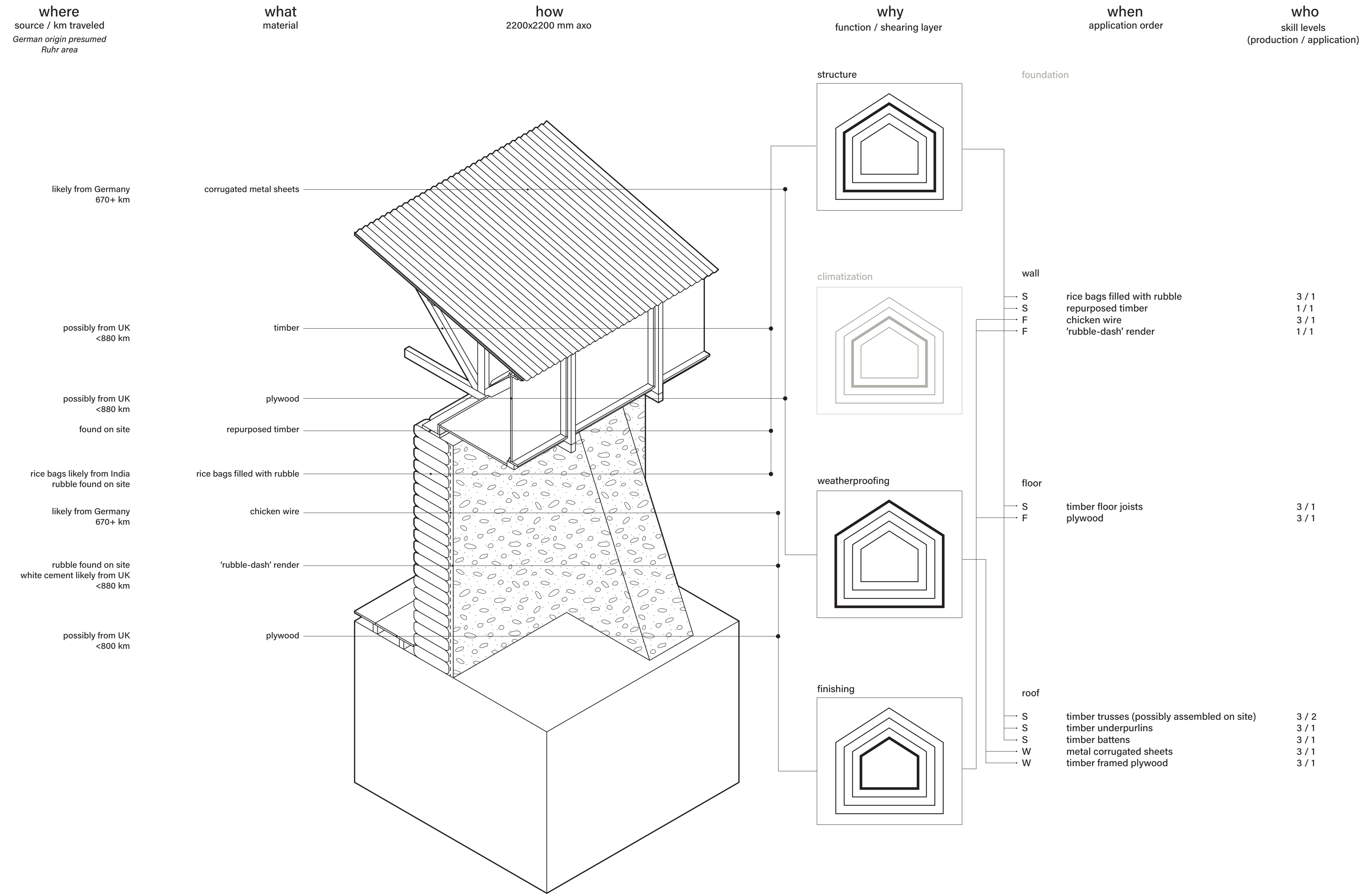


scale 1:20





material chain overview



elaboration

Where
The site of the project was covered with rubble in 'big-bags', which formed the basis of the structure. The rice bags were likely imported en masse from India (possibly Ahmedabad), where the largest rice bag producers are settled.
Some of the timber used was also present on-site. Other wood was likely collected budget-friendly from hardware stores or local sawmills, as is probably also the case for the roofing material.

What
The main part of the structure are the rice bags filled with rubble. They have been filled and then compressed to create easy to use building blocks. The same rubble is used to decorate the exterior of the walls in a 'rubble-dash' render, which is supported by chicken wire.
Timber is used for all other purposes, except the external roofing material, which is metal corrugated sheets. Mulitple forms of timber are used, ranging from basic boards and planks, to plywood sheets.

How
The filled rice bags are stacked in a brick-like manner, ensuring solidity. Buttresses made from the same material are interwoven into this pattern, providing stability in the perpendicular directions.
On top of this structure sits a timber trussed roof, lifted in place presumably by crane. The roof consists of a layer of plywood, some battens and metal corrugated sheets.
There is no foundation, just boards on flat soil which hold the underlayment which forms the foor.

Why
The building has a limited program, namely a workshop space and event venue, which is just a single, uninsulated open space. It therefore has no climatisation in the MCO. The rice bags and the trusses form the main structural elements.
The plywood siding the truss structure is considered weatherproofing, as it only protects the inside from rain and sunlight; it serves little to no function as an insulator.
According to the architects, the rendering on the outside of the walls only serves a decorative function.

When
As mentioned before, the structure has no foundation. Rice bags are placed directly onto the ground, and at a height of ca. 3 meters, a wooden board is placed upon it, on which will sit the trusses forming the roof structure. Underneath this board, chicken wire is anchored and covered with the render. The interior floor is constructed lastly.
Noteworthy about this case is the continuous addition and replacement of material, as the user adapts the structure to their current needs. Apparently, the way this structure is built provides the user with freedom for adjustment and adaptation.

Who
Unique to this case are the low scores for both application and production of the materials used. It should be mentioned that this is partly due to the simplicity of the program, but these two things are not mutually exclusive. A far more complated structure could have been designed, but it would not have necessarily better fulfilled its purpose.
Another important reason is the involvement of volunteers in both the construction and the design process, which coevolved as the project proceeded. The most notable example of this is the use of the rubble to decorate the rendering.

conclusions

OTOProjects is an exceptional example of hyper-local, urban architecture. Its creative use of materials which were already present on-site makes it an inspiration for designers seeking to incorporate material that is considered waste. OTOProjects shows that a material is considered waste until it is not. However, it should be noted that foreign material is required to make it work. The rice bags are likely imported from East-Asia, adding carbon emmissions. It is unclear where the rice bags are from. Ideally, they were already close-by and sitting unused. Also, the origins of the timber used for the roof structure is indiscernable, but considering the low budget for the project and the apparent quality of the wood, it looks like it was collected from a relatively local source. The question remains where one party's responsibility ends and where another's starts. All in all, it is an ambitious and successful attempt at upcycling waste for the greater good of the community.

design/material

The design process was heavily influenced by input from all parties, most notably the volunteers building the structure. As they constructed, they experimented with the material and saw the potentials for improvement. This experimental nature of the design process results in a one of a kind building that proudly wears its material origins for the world to see.

Assemble Studio realised that the rubble could be put to good use by putting it in rice bags and compressing it, creating the building block for the structure. By employing a low-cost foreign material, the waste was no longer waste. The same applies to the 'rubble-dash' render on the exterior, which was an ingenious addition developed by the volunteers, further extending the use of waste, by sheer trial and error.

Thinking non-traditionally about what a building material could be radically expands the possibilities of construction. Cases like OTOProjects, where climatic demands and program are relatively primitive, grant a larger freedom than, say, residential units. Nevertheless, it should inspire architects and developers alike to look beyond standard materials which have been proven to substantially impact the global environment.

model

Yusuhara Marche

introduction

project name:	Yusuhara Marche
architect:	Kengo Kuma & Associates
location:	Yusuhara, Japan
date:	2010

Yusuhara Marche is a community market and hotel in Kochi Prefecture, Japan. The rooms are centered around an atrium which hosts the market, offering travelers a taste of locally grown food while resting on their journey. The building's distinctive facade is a reference to the tea houses with thatched roofs that once welcomed travelers passing through Yusuhara, reimagining the spirit of hospitality in the modern age.

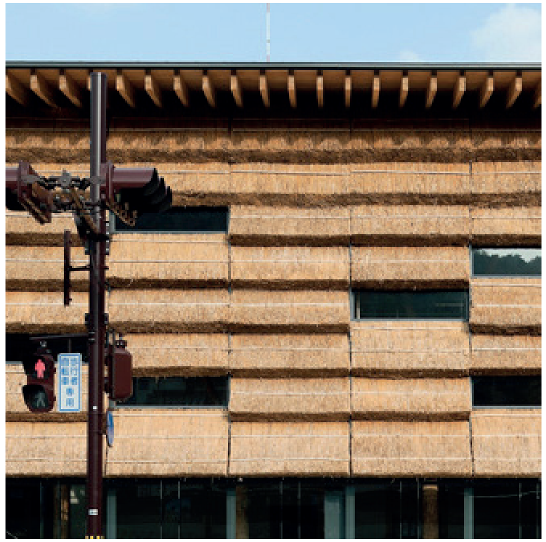
key words: thatching, traditional, innovation, maintenance

structural context
focus material: thatching

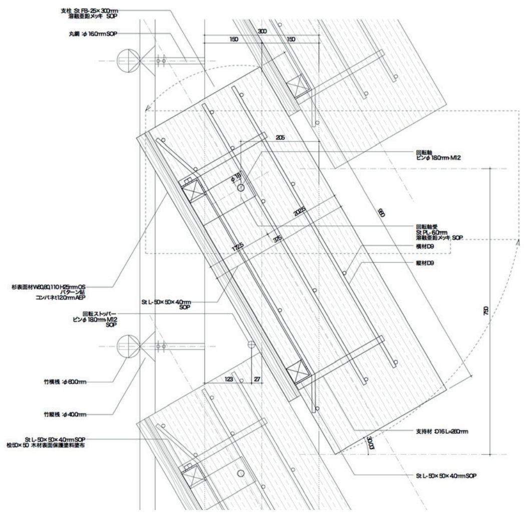
Yusuhara Marche features thatched elements in a curtain wall, a technique not used before. The elements, (approx. 2 000 mm x 980 mm x 300 mm) are attached to the curtain wall columns on a rotating steel axis, allowing for extra ventilation and easy access for maintenance. The reeds are anchored using rebar, and the elements are clad internally with cedar, a type of timber commonly used in Japan. Apart from this facade, the building is mostly made out of concrete and steel, although it does feature tree-sized cedar logs which support the ceiling of the indoor marketplace, which is directly behind the curtain wall and therefore uninsulated.

Altough reeds are grown in Japan, it is common to import reeds from Chinese producers, mainly from the Shandong and Liaoning provinces.

interior cedar

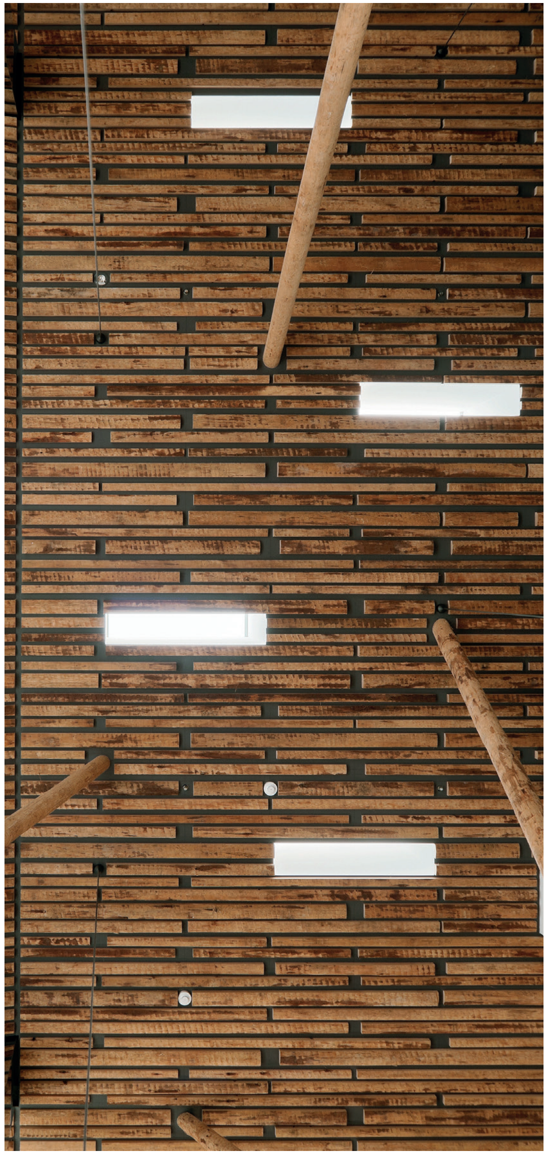


exterior thatching

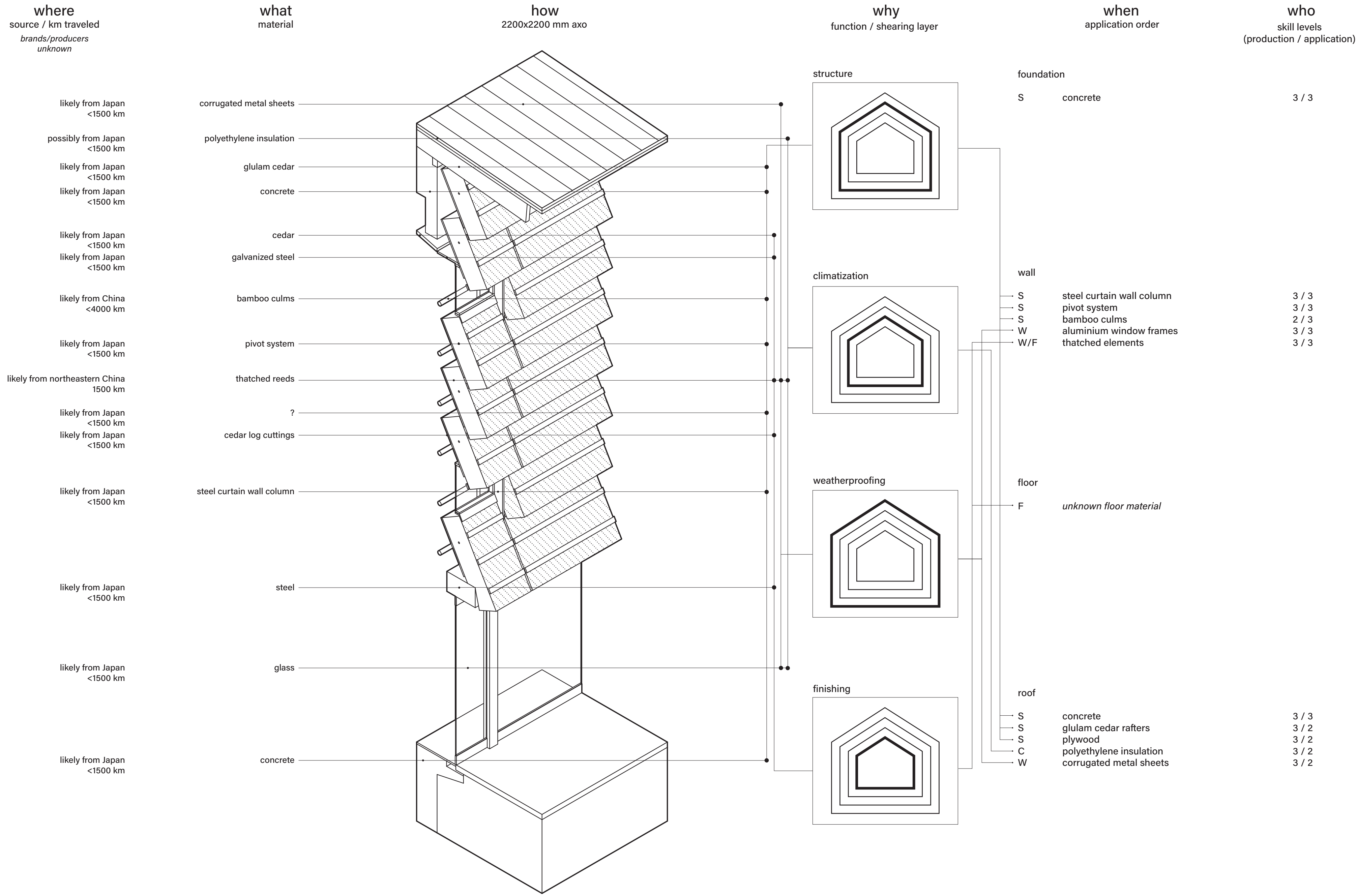


scale 1:20 (original 1:5)


まちの駅「ゆすはら」



material chain overview



elaboration

Where

As with many places around the world, water reed has been a part of Japanese vernacular architecture for centuries. The origin of the reed for his project remains undisclosed, but presumably, the reeds have been imported from China, which is the world leading exporter of unprocessed water reed, in particular in the northeast, where river deltas form the perfect conditions for growing the crop.

The bamboo suspended before the interior of the facade is possibly also imported from China, altough the use of Japanese grown bamboo is not unlikely.

The origins of the other materials, such as concrete and steel, is just as obscure, leading to the assumption that most of it is likely imported from China.

What

Water reed is traditionally used for roofing because of its innate water resistant qualities. Although a thick layer (ca. 300 mm) of reeds is needed in order to achieve this waterproofing, it provides very little thermal insulation. Nowadays, thatched roofs are often insulated internally to meet insulation requirements. In this case, the facade is uninsulated, since the space behind it does not need a constantly comfortable temperature. The structural elements of the curtain wall are made of steel, and concrete forms the roof and walls of the structure.

How

The reed is bound into block shaped elements which have an internal 'skeleton' of rebar holding the reed in place. The skeleton is attached to the back plate of the element, onto which a horizontal axis is mounted. This axis connects the element to the curtain wall columns, allowing the element to rotate. The windows in the facade are conventionally attached to the columns, do not appear to be able to rotate.

The bamboo structure is suspended from the curtain wall columns using metal pins along the entire length of the bamboo culms.

The roof is made from concrete from which a laminated timber crown protrudes, covered with metal (probably corrugated) sheets.

A glass facade fills the gaps between the columns on the ground floor, which is a simple concrete construction with a single topping screed layer.

Why

The reed performs just a single function: weatherproofing. As mentioned before, the insulating qualities of thatched reed are unremarkable, so it does not aid with any interior climatisation. It only averts rainwater and wind, keeping the interior dry and still. One could argue that it also performs the function of a finishing, but it is not its primary function, and since weatherproofing is higher up the hierarchy, it does not belong in this category.

In order to support this facade, steel is used, presumably because the weight of the reeds exceeds the limits of what a wooden structure could support, especially with dimensions as frail as are currently in place. By using steel, the columns almost disappear.

Why concrete is used for the roof structure is not clear. Perhaps a rigid base like concrete allows for the absence of stabilising elements in the open space behind the facade.

When

First, the concrete foundations are cast in situ. The concrete walls and roof are then constructed, it is unclear of this is a prefab system or also an in situ cast. After this base has been established, the steel columns of the curtain wall are put into place. Between these, the window frames on the ground floor and the individual thatched elements are attached. Again, it is unclear whether these are prefabricated as a complete element, or if the thatching is done after the element is installed. The latter option seems more practical, since the reed may prohibit access to key assembly points.

Also, the attaching of the axis to the columns, or for that matter, any other metal working on-site, may involve high temperatures due to soldering, risking ignition of the reed.

Who

As is visible in the diagram, most materials score 3/3. This structure is highly intricate, and mixes many different materials and attachment media. For that reason, professionals are needed for almost all steps in the construction of every element of the facade, let alone the facade as a whole.

conclusions

Yusuhara Marche merges sustainability and historical context by empoying a fully natural material that has been used in the area for hundreds of years. It revolutionises the use of a traditional material, touching on both past and present. However, this is just a facade. Behind it is a structure that is by no means natural and requires a lot of energy and emissions to produce. This building serves as an inspiration for those who seek to innovate with the pre-existing or even the past. Kengo Kuma carefully incorporate access to the facade for maintenance, lowering the threshold for performing such maintenance and increasing the longevity of the structure. Yusuhara Marche is a prudent yet successful attempt at marrying the old and the new. It integrates all facets of building with a high maintenance material in an (sub)urban context.

design/material

The difficulties of designing with natural, often high maintenance materials have been present for the entirety of the use of these materials. It should come as no surprise that vernacular solutions to these difficulties are grounded in centuries of trial and error, and would therefore be insensible to ignore. However, very little seems left of the traditional in Yusuhara Marche. By careful analysis of the opportunities and limitations present in thatching, an altered typology has been created, suitable for facades more than roofs. It maintains the principle of a minimum of a 45 degree angle for water resistance, yet does this in a segmented manner. It is seemingly simple solutions like these that can revolutionise the use of a material.

model

general conclusions

The aim of this case study is to gain insights into how bio-based, low-tech materials are developed and used in existing buildings. For each of the three cases, a different focus material was selected to delve deeper into its workings and origins. Because of this variety of materials, we see diverse outcomes between the case study results. To sum up, these are the main points deducted from each case:

Flat House
Hemp (among other crops) has a mulitude of applications, which provides varying bio-based solutions for standard building practices, such as weatherproofing and insulation. Through careful design, this potential can be exploited. However, it should be mentioned that the facilities needed to process hemp are still scarce, which currently adds to the embodied carbon of the structure because of transport.

OTOProjects
Through creative vision, a nearly free structural material was developed for a very specific site and program. Here, site and material truly informed the design, as it is a result of harmonising with the preexisting conditions and available resources. Inventiveness and resourcefulness are the reasons for the success of this low-budget project, as well as the engagement from the volunteers who constructed and later were to use it.

Yusuhara Marche
Though not for sustainability reasons, a bio-based, tradional material is used in an unprecendented way. By cleverly manipulating the material so that it does not lose any of its traditionally known abilities, new forms can be achieved. This project updates the catalogue for technical and aesthetical possibilities of thatched reed, while keeping in mind the relatively high maintenance it requires.

When comparing the conslusions, we see a similarity between the use of material in the case projects, namely the innovative ways materials are used through attentive development. This highlights the wide potential materials can have, even if they are traditional or considered waste. Inventiveness and resourcefulness are the key words in this matter. However, the experimental nature of some of these projects reveals the dependency construction still has on non-renewable sources of energy and material. Also, the non-transparency about the origins of materials often present in project publications shows the obscurity of material chains, which is especially cumbersome for outsiders who are trying to learn in order to improve construction culture.

discussion

As mentioned before, extensive documentation of building materials is needed in order to get a sense of the implications of a project on the environment, let alone express it in absolute values. The complexity of resource supply chains and them coming together in a single building far outreaches our understanding of our impact. Therefore, the findings in this case study cannot be numerically backed, as the data they depend on are left unpubished or are unknown in general. The conclusions function to rethink the role of the architect in the resource supply chain as the ultimately responsible actor. That is also why they are summarised in design take-aways on the next page.

In order to fill the gaps in the data about supply chains in construction, investigation is needed to both document current supply chains and all their complexity, and to find alternatives to these nearly incomprehensible streams of materials, such as is done in OTOProjects and Flat House. The latter sheds light on another current difficulty, namely the absence of proper facilities that can process bio-based materials (in this case hemp) for construction purposes. We need to ask ourselves how we can repurpose current material processing facilities for greener ones. What is needed to make the transition, and how can it also be made financially viable and competitive to current industrial alternatives? Not only bio-based materials require such investigation, but also construction materials based on existing waste streams from sectors such as construction itself, but also manufacturing, agriculture, etc. All of this comes round to the concept of a circular economy, where waste does not exist. It is essential for minimising the impact of construction on the environment.

In general, a field as complex as construction requires thourough understanding of its implications. A shorter supply chain could drastically increase our understanding, and one way of achieving this is by adopting more bio-based materials. Of course, the implications bio-based materials have on construction methods are extensive, and their viability needs to be tested to see how they compare to traditional materials when including factors such as maintenance cycles, which are often more intrusive for bio-based materials. How viable are they for large-scale construction? And are they applicable for any and all programs?

It is crucial that information is shared among builders, manufacturers, and designers to allow for further innovation and adoption. In a field that is highly competitive and dominated by financial interests, it proves much too easy for developers to sacrifice sustainable decisions for economical ones. Awareness of the impact of our building culture and the innovation of green alternatives is urgent. As the industry continues to evolve, creativity, resourcefulness, and education are critical in generating a more sustainable building culture.

reflection (post-project)

What is the relation between your graduation project topic, your master track (A, U, BT, LA, MBE), and your master programme (MSc AUBS)?

It is a commonly known fact among architects that the construction industry is responsible for a large portion of greenhouse gas emissions and waste production globally. It is the responsibility of architects to reduce the impact construction has on the environment. My topic of using vernacular, bio-based materials in a context that traditionally does not consist of such materials is an attempt to fulfill this responsibility.
I started the project with the desire to reverse the standard order of architectural design through the scales, from large to small to small to large. In my view, material and the way in which it forms the larger structure, or in other words, detail, was too often treated as an afterthought in my preceding projects during my masters of Architecture. I felt this was not beneficial in a sustainability sense, where material and its sourcing, processing, transportation, application, and expiration are the main contributors to the environmental impact of construction. Reversing the scale order led to a completely different process than I would normally go through, putting material at the center of the project while other domains conformed. I think this could be applicable beyond just the Architecture track, as all tracks within the master programme (except MBE) ultimately depend on material to realize their ambitions.

How did your research influence your design/ recommendations and how did the design/ recommendations influence your research?

The research set the tone for my design project in two ways: firstly, rather superficially, the case studies provided me with concrete information and inspiration to apply in my design. Investigating how and why the focus materials were used, and which conditions influenced these considerations shaped the general direction in which the design would evolve. After all, the case projects were chosen based on their appearance and the presence of bio-based, local materials. Secondly, much more sophisticatedly, they encouraged me to be critical of my own design choices, as they underwent the same treatment from me. The most surprising conclusion of the research for me was that tectonics can be misleading. Buildings that convincingly present themselves as being highly sustainable, often hide unsustainable secrets.

The design itself also influenced the research in two ways: firstly, after the initial sketches had been made for P2, it was decided to shift focus from continuing researching a rural building (BKRK Bakery) to researching one in an urban setting (Yusuhara Marche). The engaging contrast between vernacular materials and the (by now) traditional concrete and steel subsequently prompted me to redirect my design towards an urban setting. Secondly, alongside the case studies, more research was carried out based on what was demanded from the project, such as the origins and properties of native Dutch materials, their application in vernacular structures, suitable alternatives for a modern context, how to build multiple storeys using these materials, etc.

How do you assess the value of your way of working (your approach, your used methods, used methodology)?

I believe learning from the precedent is an efficient way of generating alterations to existing concepts. Evolution based on preceding experiments ultimately drives us forward, as untested ideas cannot prove anything. In the case of exploring material opportunities and challenges, tried and tested structures offer valuable information on durability, applicability, and other material properties. The case studies provided me with just that, as well as an indication of the appearance of the focus materials. Also, looking beyond this focus material to the entire surrounding structure showed me how reliant we still are on environmentally impactful materials and processes. Therefore, in a material sense, it was a fruitful endeavour. However, the project touches upon more themes than just material, and I think that this hyperfocus resulted in some shortcomings, such as designing for communities and designing in a historical context. These are two undeniable themes in my project, yet they are not formally researched with the same depth as the material theme. I do believe this translates into my project, yet with a fixed amount of time, some areas of attention will always be compromised.

How do you assess the academic and societal value, scope and implication of your graduation project, including ethical aspects?

The use of material as seen in my project ideally inspires others to employ similar techniques, and most importantly to source materials similarly. In the pursuit of tectonic qualities, the project's structural typology mixes vernacular techniques with a contemporary appearance, showing the opportunities these sustainable materials still have today. Academically, additional research will have to support the viability of the project. For example, what are the implications for land use in the Netherlands in the scenario that most new construction will use this system? Questions like these can critically test viability, but also form the basis for different construction methods using bio-based local materials.
In a more ideological sense, the value of the project lies in the notion of compromising certain luxuries that come with non-sustainable materials in favor of bio-based local materials that require more space and maintenance. In this way, only the user themself is impacted by the material that makes up their dwelling, instead of moving the implications of the material use to people and places more vulnerable to the effects of climate change.

How do you assess the value of the transferability of your project results?

The case study concludes with a list of take-aways for design projects, which aim to increase awareness of the implications of material use. In this way, the research is broadened from the specificity of the case projects to general use. Of course, they tie back closely to the case projects, so for understanding the reasoning behind the take-aways it is crucial to critically interpret the case studies themselves. For the design project, critical analysis is also needed for transferability, since the concept is not tested; it is an experiment which attempts to combine many different themes into one. Generally speaking, though, the notion that a compromise is needed from the user side in order to reside responsibly in today's urgencies goes well beyond this project, and may be the most crucial take-away.

What have I learned from the reversion of design scales; how has it influenced the design and the process?

I am grateful that I got the opportunity to realize my desire to reverse the design scales, and I am happy to state that the outcome is not what I expected it to be. I expected that I was going to be able to move through the design scales quite linearly; that from the material limitations would come answers regarding questions on larger scales, but also on contextual and social levels. This, however, was not the case. In the spirit of Elise van Dooren's theories on the design process, it was proven to me that there is no such thing as designing linearly, but a continuous moving back and forth is innate to the design process. The multi-leveled implications any decision has requires the designer to reassess themself constantly. This also manifested in the design, where many alterations to an otherwise simple material structure had to be made to fit the surrounding context, and also to protect user interests. Matters that I had originally left aside. Supposedly, starting at any scale sets the initial boundaries in which other scales can be manipulated quite freely, until a point is reached where the starting scale needs to give way to considerations from other scales.

How do tectonics result from the themes 'native materials', 'modularity', and 'community' in my design?

These three themes played key roles in the decision making process in my design. They shaped the framework in which I had the freedom to explore tectonic possibilities, often intuitively. In the steps leading up to the design phase, I have described the architectural expression of the design to ideally be a 'secondary guarantee', after physical considerations. Admittedly, my approach to this has not changed much during the design process. In the case of 'native materials', I did not feel like there was much room for radical experimentation; they are tried and tested materials that function best when used according to centuries old traditions. The experimentation lied in the combination of these techniques with the contemporary urban context. 'Modularity' is one result of this combination, where construction speed and translatability is desirable. Modular construction, of course, has a foundational impact on the tectonics of a structure. The theme 'community' demanded a certain legibility from the structure, especially in light of maintenance. In order to establish a connection between the users and the building, visibility is key. This led to a low-tech approach in which faulty elements could easily be detected. Additionally, the individual sense of responsibility should expand to a collective sense of responsibility, where the integrity of the structure is dependent on communal agency.

design take-aways

1. Be inventive and resourceful: what is already present and available, and how can it be used?

2. Think outside of the box: how can the material be manipulated in such a way that it retains its technical qualities, but attains a new form?

3. Look beyond: how can the material be exploited to fill multiple functional niches?

4. Be realistic: consider the dependency your choices have on the current availability of resources and facilities.

5. Rethink your standards: can it be done simpler or by using less material?

6. Take into account all aspects: does your material require unconventional accessibility, for example for maintenance?

7. Recognize all parties: who will build your design, and who will take care of it?

8. Be transparent: document the use of material in such a way that future designers can learn and benefit.

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