the Mortice and Tenon

The Carpenters' Fellowship Journal of
Traditional Timber Frame Carpentry

NUMBER 50 WINTER 2012

Thomas Heatherwick ***Making*** *Building The Big Shed*
Reconstructing the Tai-an Teahouse and the Kintaikyo Bridge
Framing in Norway

Image Henrietta Williams

Building the Big Shed: Part I

Jack Draper

Hooke Park is a woodland located in southwest Dorset. The 350 acre working forest, most of which was planted in the 1950s, consists of spruce, beech, Douglas fir, western red cedar and larch. Purchased by the Parnham Trust in 1983, the park became home to Hooke Park College in 1989. John Makepeace, the well-known British furniture designer, established the college to research and teach the many different ways in which low value timber and forest thinnings could be used creatively. A small campus was constructed around three innovative timber frame buildings, each of which was designed to demonstrate the potential of round wood construction as well as the benefits of mixing traditional and contemporary materials and methods.

I grew up in the nearby town of Bridport and as a boy I often visited Hooke Park. I remember how interesting those three buildings looked; imaginative and majestic, they were nothing like the traditional Dorset cottages that sat nearby. Maybe seeing those buildings at an early age inspired me to become a timber frame carpenter…

Because of financial problems, the full-time degree program at the college came to an end in 1994. Part time courses continued but there didn't seem to be much of a future for the sort of trail blazing craft education Makepeace initially envisioned. Fortunately, in 2002, the 350 acre park, as well as the site and buildings of the college, were acquired from the Trust by the Architectural Association. The site made the perfect rural workshop and the ideal place to continue the study of sustainable and imaginative forms of timber frame construction. Having had students undertake and complete a number of small scale building projects (a bridge and a number of pavilions for example) the AA launched its first post graduate program based at Hooke in 2010. Called Design and Make, the ambitious program was created to enable students to experience the entire process of architecture by designing and making buildings at full scale, on site.

The first of these new buildings was to be called the "Big Shed". It was designed as an open space workshop to be used by future students engaged in the 1:1 construction of buildings. The Big Shed was designed by AA student Nozomi Nakabayashi who worked in collaboration with other AA students as well as Mitchell Taylor Workshop, Atelier One and Buro Happold. The idea of the structure was to use larch poles felled within the park to make up a series of large span trusses which would then be tied together by an outer skin of faceted panels. The challenge from the engineering point of view was to develop a quick and strong way of jointing these irregular poles together. A series of tests were undertaken

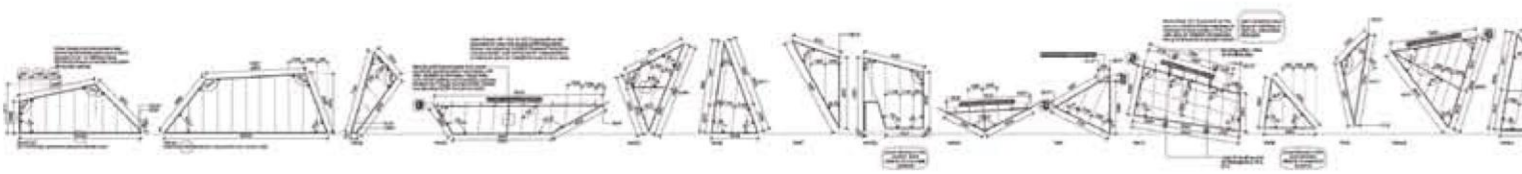


Image Mitchell Taylor Workshop

to find the best method. Mortise and tenon joints were too slow to make, steel flitch plates were too obtrusive and expensive. Structural engineers at Atelier One came up with a solution: steel flitch plates for the major joints and a new bespoke screw, made by the German company Heco, for the hundreds of smaller connections. Up to 450mm in length, these screws had two separate threads which helped pull the joints together. The structural engineer Luis Fernandez provided detailed instructions on the angle at which each screw had to be inserted for each joint on all of the trusses. Tests were also done on this type of joint at Bath University and, with a bit of playing around with the angles and spacing, a very strong and quick to make joint was developed.

Charley Brentnall headed up a team of ten framers that worked with two sets of summer students for two months. The build had two main parts: building and erecting the trusses and making and fitting the faceted panels. The plan was to have the first set of summer students involved in truss production and the second set erecting the trusses and working on the panels. Like most building projects there was a setback - there were not enough larch trees harvested from Hooke Park and extras had to be brought in from local woodlands; this led to a month's delay and unfortunately the first lot of summer build students didn't get to do much building.

When I started as part of Charley's team in early September, the weather was good. I joined Henry Russell and three students. There were two other teams of a similar number. Each group had the job of constructing three trusses; there were eight main trusses and one complex truss that spanned nearly nine metres over the main entrance to allow vehicle access. We had a series of plans for each truss detailing measurements, minimum pole diameter, node positions, flitch plate and screw/joint locations and angles. The framing of the trusses began by gathering up the major poles with a telehandler. We then looked at each log for any major knots, defects, taper or bend. Because all the poles were over length, we were able to decide what section would be best to use. Once the section was decided upon, we rough cut it to length using a chain saw; then, centre lines were snapped along the log. Using the centre line drawing of the truss, we marked all the node positions and the name of the intersecting pole; we also marked the angle at which the joining pole would face. This was done by using an angle finder and simply sighting along it and marking the pole with a pencil.

Once all major poles within the truss were marked, a rough layout could be done. All logs were put on saw horses and levelled up along their side-centre line either by using a spirit level or a site level. Where all major joints using the flitch plates were located, intersecting poles had to be cut back from the node positions. This was all detailed in the plans but did depend on what diameter the log was at each node point. Cross cuts through the log were marked in one of two ways. The first method was to use a marking jig which consisted of a square of ply with a round hole to allow a log to be inserted with a hinged timber attached to the ply at 90 degrees. This could be tacked to the top centre line of the log and levelling the timber made the ply perpendicular to the side centre line. You could then set the crosscut angle with an angle finder, placing a straight edge against the ply you could simply mark around the log where you wanted to cut. There were only two of these jigs on site and three groups needing them, so Henry developed his own way of marking these cuts by setting the angle finder on the top centre line and using a plumb bob against it. One could then eye through the two and mark

Image Mitchell Taylor Workshop

3D image illustrating fixing detail

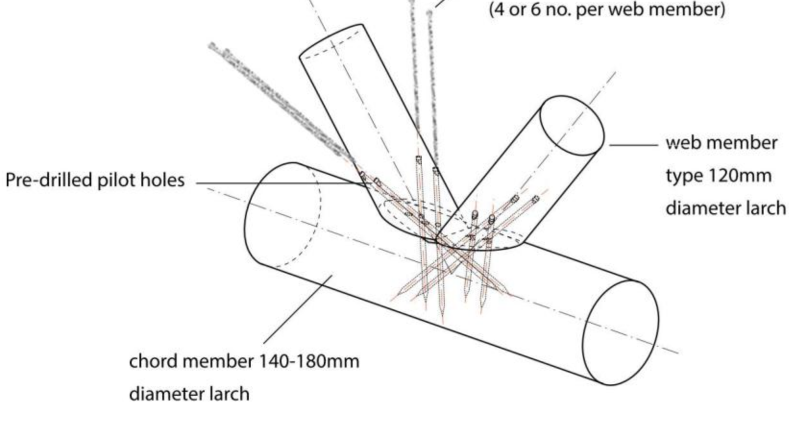
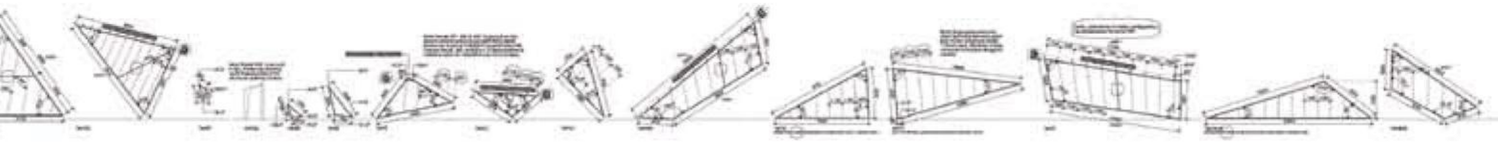


Image Henrietta Williams



the angle cut. This method did involve two people but was fast and produced an accurate line and became the preferred method by all groups. There were a lot of methods and little tricks developed as the build went on and we all shared ideas during lunch.

Once all of the major poles were cut and laid out, temporary plywood flitches were inserted which were used to mark the placement of the steel flitches All small infill poles could be scribed into the main poles: this was done by creating a flat with a chainsaw on the node points (to speed things up, most work was done with a chainsaw; as time went on we all became quite accurate with it). All Heco screw joints were specified on the plan and the spacing of the screws varied according to the diameter of the log. The students from the previous month had made the drilling jig which we used to pre-drill all screw joint members; it was important to use the jig so that all the building's screws were spaced and angled correctly.

From my point of view the whole process of constructing the Big Shed felt very design led and most details had been thought through carefully and documented so that, prior to each phase of construction, the whole team was on the same page. This resulted in the architectural students getting the hang of the hands-on practical work really quickly as the plans and details were in an architectural language that they could relate to. Some challenges came up, like in every experimental project, but Charley was in the office and on the phone working them out before it affected progress on site. The work usually consisted of professional timber framers and students laying out and marking logs; once the students picked this up, they would mark the logs and we would cut them (some of the students did chainsaw training and were able to do some cutting). Working as a team like this we were able to work fast; in fact our team managed to produce the trusses fastest – not that it was a competition or that we mentioned it to anyone else…much!

When the trusses were completed, the crane was booked; this was an exciting moment… was it all going to work? We had a meeting at which each person was given a role and responsibility; every crane lift can be dangerous, but with this job there was more concern because we had never lifted anything like this before. Oscar Emanuel was in charge of the lift and the lifting team; Charley oversaw everything and hovered around nervously hoping it was all going to work.

The main challenge was rigging the trusses so that their feet would come up level. Because the top cord of each truss was located in two different positions and because each truss was unique, there was a lot to work out. Even though Charley and Oscar had planned this out, at the start of each lift different points of the truss would start lifting at different times. This could have been a problem as it meant there was an increased load at points that weren't designed to take it. We got round this by attaching strong backing to the trusses with ratchet straps, which gave them the extra strength they needed, although there was still a bit of bending. Once the first truss was airborne, there was a sigh of relief. After it was lowered into position and held in place by guy ropes, the crane was released to a round of applause from the crowd watching in the rain. All of the other trusses were raised in the same way. When they were all in position, temporary bracing was fixed to keep them in place. It took nearly three days to lift six of the main trusses, leaving the two middle ones out until the steel lintel was up.

It was a slow but steady procedure that only went over by a day, mainly because the shape of the last truss made it difficult to lift without one end bending considerably before the other end was in the air. We tried lots of different methods of strong backing and different rigging positions but couldn't get it right. In the end, Charley just told Oscar to "go for it" and when he did there was a massive bend on the poles; just when we thought it was going to go, the other side came up and all was fine.

The lintel that spanned the main entrance was designed in steel due to the large span and the size of log needed if it were to be in wood. Once this was lifted into position, it was bolted to the adjacent trusses flitch plate and the two trusses bearing on the lintel could then be craned in.

In just over a month, the main structure was up and it was time to say goodbye to the students except for two who stayed on as paid employees. A French compagnon returned home but was replaced by another. Working with these French compagnon guys made me realize what an amazing training system they have in France; something which we don't yet have here in the UK.

With fresh blood and the frame standing, we were all set; then the rain came and it came hard for the next two months. It seemed to rain almost every day with no shelter, making things that extra little bit tougher. We were split into three groups with most of us working on making and lifting the panels into place while a few people made final adjustments to the frame. The guys making the panels had their work cut out for them as there were over forty different panel sizes and shapes to make. They were made out of 8"x2" larch clad in either cedar for the walls, galvanized sheet roofing or polycarbonate for the windows. All of the cedar was felled and machined onsite and the larch was sourced locally. With the panels, everything had been planned, even the position of the joints; this made the job smoother.

I was in charge of the panel lifting team which consisted of myself driving a large telehandler and two or three others depending on who was available. The original plan was to use a crane but after a test lift it became apparent that the telehandler was more than capable and made a great financial saving as it was going to be a very slow job. Once a panel was finished, it was moved horizontally to the position where it was going to be raised; it was then rigged so it could be lifted vertically with the bottom of the panel at roughly the same angle at which it was to be lowered. There was usually a bit of trial and error involved but I got better at judging it after doing a few. Once up in the air, the panel could be easily moved and lowered into position. It was all quite straight forward apart from the larger panels which had to be moved into tight areas – moving a large weight around at full-beam is not something you find in the operating manual. It was all quite fast at the start but when we started getting panels meeting panels that's when the fun started: there was lots of lifting up and down and tightening and loosening of straps to get it to sit in the right position. It was a long process and we were lucky to lift and secure two panels in a day. All panels had timber wedges between them which were Heco screwed to stitch the outer skin together. It was now Christmas time and we all went away for two weeks to reconvene in 2012.

The New Year came and it was still wet and very cold but it was the final push to the end. The crane came to lift the large roof panels that the telehandler couldn't reach and all that was left was all the little bits of bracing and glazing. I left at the end of the third week in January to begin other projects along with a few others. There was a small team left doing all the little bits of finishing and the project was finally completed in March.

I went to visit on a sunny April morning to take some photographs and as I drove down to the site I was met with this space ship-like structure that looked completely different without the wrap of scaffolding around it. It was standing by itself, holding its ground. Driving down the road it looks small and it isn't until you get to the other side that you realise how big and tall it is. It sits within the landscape and doesn't look out of place. I like the way it is slightly futuristic but slightly agricultural looking at the same time. I think this is down to the methods and materials used: high end design and a few simple logs, planks and a bit of tin; that's all it is and it works.

We had the topping out party in May with Nozomi cooking us all Japanese food, another one of her talents. It was a privilege to be part of such an interesting and unconventional project. As with every job, it's down to the people you work with; and this was the perfect team – we all had a lot of fun. It was really great to work with the architecture students; I think they went away with a better understanding of how things actually work, and sometimes don't, in the construction phase of a building project.

Jack Draper *is a carpenter and joiner specialising in roundwood contsruction*


Image **Henrietta Williams**

Building the Big Shed: Part II

Nozomi Nakabayashi

The phone rings in a busy architectural practice. It's a project manager calling from a building site thousands of miles away. He needs to talk with one of the architects to clarify a number of details. Suddenly, the architect's theoretical vision is challenged by the practical realities and demands of modern construction. Today, this sort of dilemma is very common. More often than not, a site visit and conversation with the builder would easily resolve the issue. For several reasons – historic, economic, technological – this is no longer considered the best or most efficient option. Consequently, over time, the experience of thinking and making has been stretched apart – disconnected. After five years working in the United States and Japan for a number of architecture firms, I decided to return to school. In my experience, whether working on a high-rise project 2000 km away or a museum across the ocean, I felt that I was missing a crucial part of the architectural process: the process of construction. An architect always imagines how the idea for a building becomes a building; in fact, I believe that it is the joy of seeing an idea made into reality that keeps architects up working nights on end. With this in mind, I moved to the UK to study at the Architectural Association's new Design and Make program. Based in Dorset, in the working woodlands of Hooke Park, students of Design and Make were meant to take on full-scale building projects from design to construction. When I arrived in late autumn of 2010, the first year of the Design and Make program, I was looking forward to the unique experience of being able to live on a building site while designing and helping to construct

Aerial view of the initial stages of construction

Image Henrietta Williams

Image **Valerie Bennett-Architectural Association**

The main entrance to the Hooke Campus

Interior view of the Big Shed

Image **Nozomi Nakabayashi**

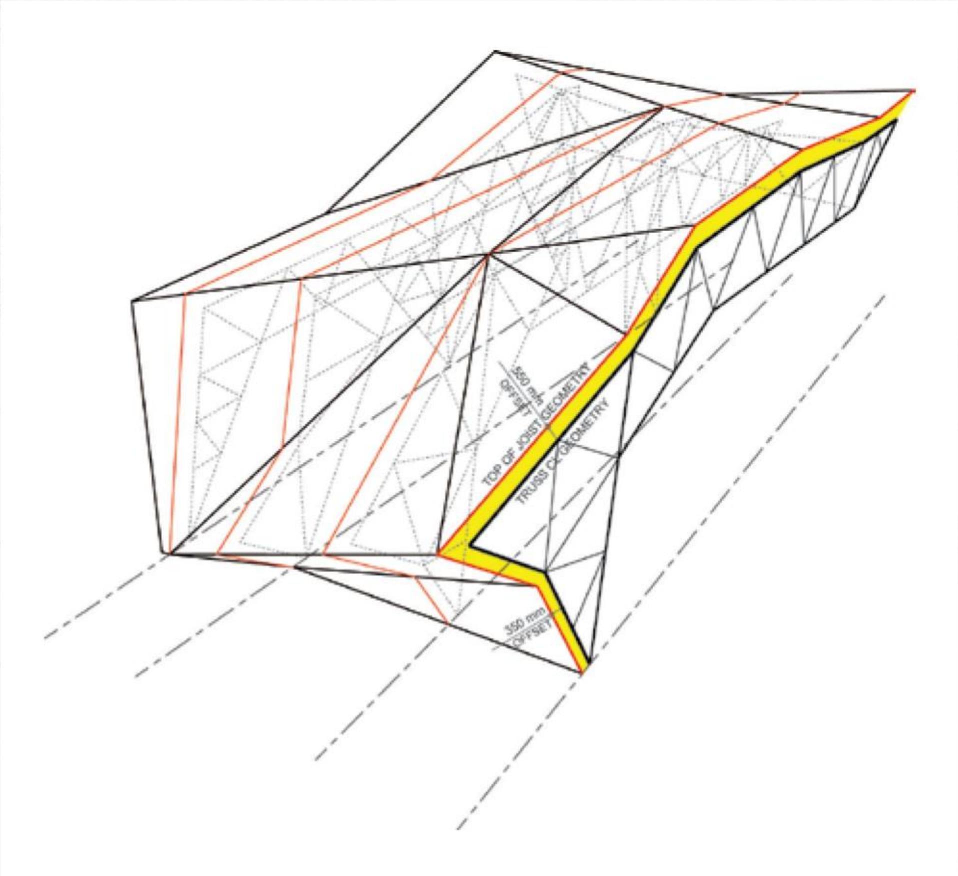


Image Nozomi Nakabayashi

CAD generated drawing illustrating the complex geometry of the frame

a building. The first brief was to create an assembly workshop - a covered shelter to carry out the large-scale fabrication of subsequent building projects. The workshop would be called The Big Shed. We began by collaboratively conceiving the building envelope as a playful faceted form of geometry. At each quadrant, the envelope would form specific site relationships informed by our daily observations of the site. For example, on a winter afternoon, standing at the empty site (a clearing left by the trees up-rooted by the 1987 hurricane that swept through Dorset) we felt that the campus needed to convey to its visitors a sense of their having arrived somewhere. This resulted in our decision to locate the Big Shed so that it would directly face the North entrance of the campus. While standing outside of the existing workshop during tea breaks we felt rather bare against the extensive forest. This led to our decision to design a cantilevered canopy on the Big Shed's Western side: this provides covered outdoor space overlooking the beech forest. The Eastern side of the building would open on to a large central work yard, in which saw milling and fabrication activities would be carried out. In an effort to continue past experiments at Hooke Park on the structural use of small diameter round-section timber, we designed the Big Shed to consist of a series of round-wood trusses. The construction of the project ran in parallel with the design development – the immediacy between constructional consequences and our design decisions was one of the most valuable lessons I learned from my involvement with the Big Shed project. Every design decision we were taking had an immediate full-scale visual and physical reference – one of the designs that benefited the most from this was the design of the trusses' top chord. Our decision to use round-wood timber posed a challenge: using irregular building material made it difficult to achieve a complex faceted exterior envelope – especially in our trying to secure a constant datum off the envelope geometry while the top chord of the trusses' varied in diameter. The diameter variance on some of the long members exceeded 150mm, some with visible sway. The solution came by devising a series of varying depth packers on top of the trusses' top chord. This enabled us to raise the backing rafter (running in parallel to the trusses' top chord) to a set datum with a backing cut to carry the cladding joists, which achieved the final envelope geometry. Looking up into the ceiling of the Big Shed now, I feel that, metaphorically, the gap between the top chords of the trusses and the cladding where the timbers sway and vary in diameter, while supporting the playful faceted exterior envelope, illustrates a design philosophy that reconciles the building's reality (its materials and methods of construction) with its theory – its architectural design. Although the Big Shed project was carried out in a non-commercial academic

Students marking joints

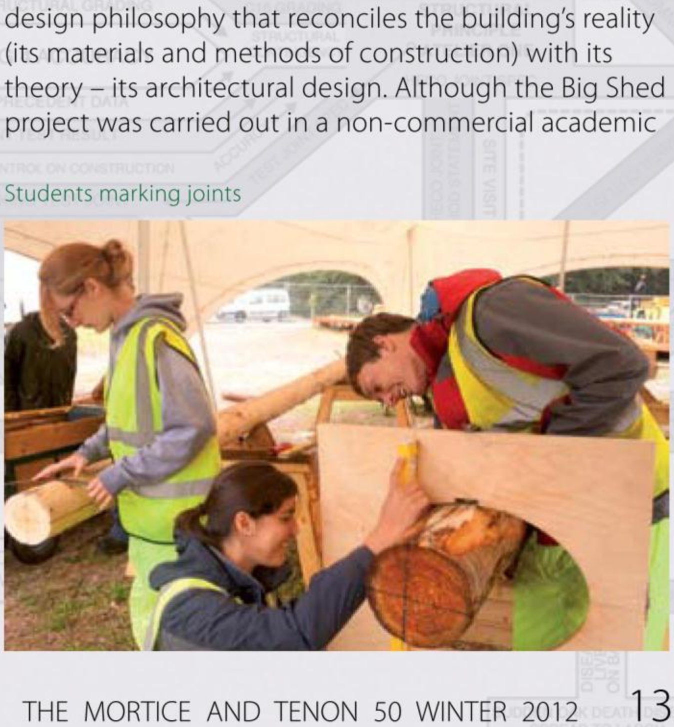


Image Henrietta Williams

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Build up at the truss top chord (backing rafter and packers installed)

setting, the cross-disciplinary collaboration between construction (site) and design (office) and between builders and architects seems to suggest an alternative practice model where the architect may no longer work exclusively as an off-site designer.

After graduating from the Design and Make program, the challenge for me now is to translate what I have learned into a viable practice model. To successfully realize cross-disciplinary collaboration within an actual practice, my initial hunch is that projects – no longer under the academic umbrella – will need to be conceived and carried out on a small scale. I am currently working on two small timber projects, both of which involve direct collaboration with the contractor

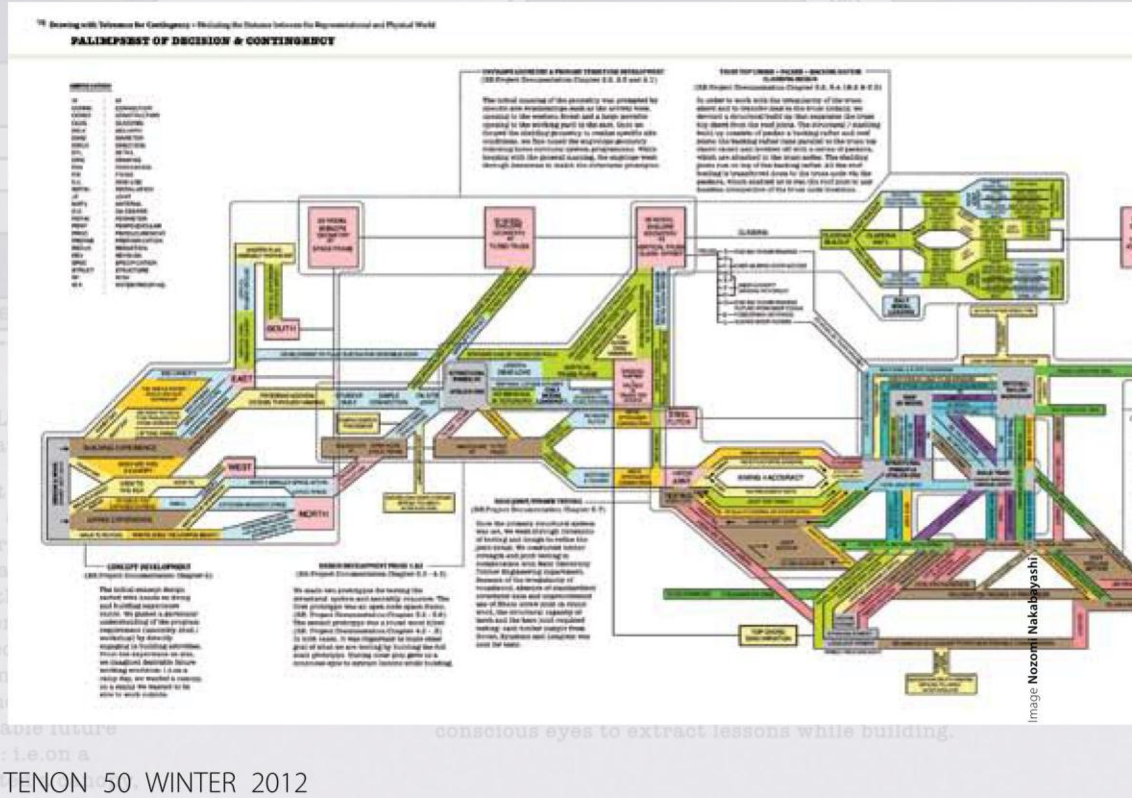

Image Nozomi Nakabayashi

The process: the complex evolution of the project including various contingencies was mapped out on a 'palimpsest' chart

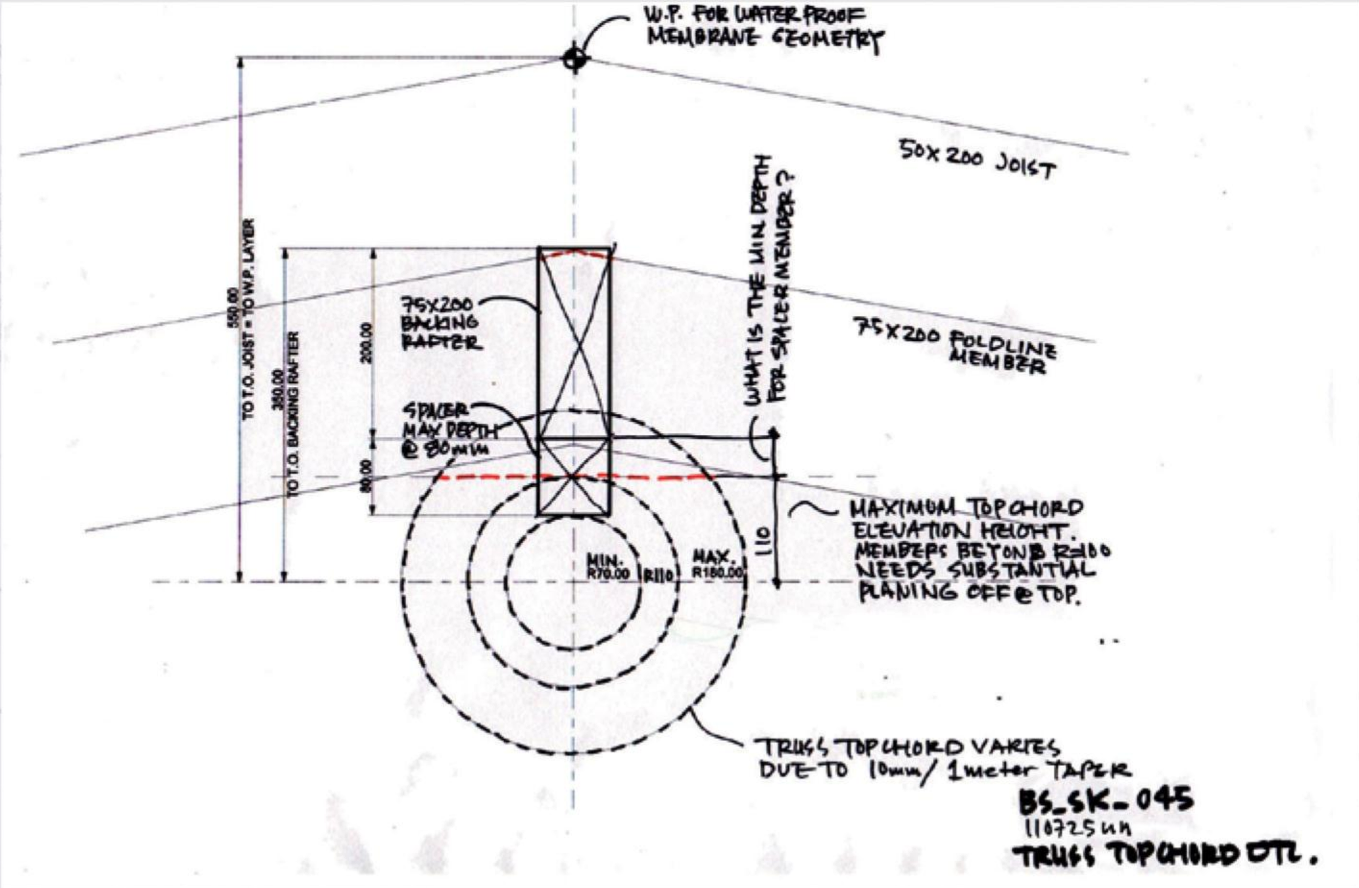

Image **Nozomi Nakabayashi**

Section through the truss showing the offset between the truss centerline and the envelope geometry

and the builder. In contrast to the highly specialized division of labor required for today's large scale projects, I think focusing on small scale bespoke projects will offer those architects interested in moving between the office and site the opportunity, and their clients the benefits, of their combining designing and making. What we lose from not relying on the economic gain from a large-scale project, we gain back from possibly developing and owning our own projects. How this manifests itself into an actual business model remains a challenge to be explored.

***Nozomi Nakabayashi** is an architect working on timber frames, who studied at the AA and was the first student to graduate from the school's Design and Make program.*