Innovative post-tensioned Expan timber building

The refurbishment of BRANZ's research site includes construction of the Nikau building, the only major new building in the refurbishment.

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BRANZ's new Nikau building is constructed using large-span laminated veneer lumber (LVL) portal frames and plywood shear walls, which produce a large, flexible open-plan office space. The building incorporates an innovative structural system using sustainable materials – both important requirements set out by BRANZ at the start of the project.

The initial cost plan included a conventional glulam rafter and braced wall scheme for the Nikau building. However, discussions with Robert Finch, Chief Executive of the Structural Timber Innovation Company (STIC), led to a proposal to use Expan post-tensioned LVL frames as an innovative design alternative.

Innovative structural design

The University of Canterbury provided architects Warren and Mahoney and engineers Aurecon with a concept design for a post-tensioned LVL portal frame that could span the width of the building, support the roof and resist lateral loads in the transverse direction. Plywood shear walls were used for lateral loads in the longitudinal direction. The price was within budget, and after conducting a review and getting approval, BRANZ accepted the concept design.

Post-tensioned Expan buildings are in their infancy, a fact that attracted BRANZ, hoping that the refurbishment project could incorporate innovative technologies as an example to the building industry. The University of Canterbury has been carrying out research into Expan post-tensioned LVL buildings for several years, using its patented Pres-Lam technology. The 2-storey, post-tensioned LVL building it tested successfully in the laboratory is now being reassembled in Christchurch to become the new Expan head office.

Last year, the construction of the new Arts and Media building at the Nelson Marlborough Institute of Technology was completed using a LVL frame structure and post-tensioned LVL coupled shear walls, designed by Aurecon, also using Expan technology (see pages 72–73 in this *Build*). BRANZ's Nikau building follows on from this work by using LVL and post-tensioned bars, but in a different structural form.

Aurecon developed the detailed designs through to the final design solution. This incorporated materials and details that were readily available and constructible and allowed for architectural details like the cantilevered eave to the north for solar shading and floor trenches for services.

The Nikau building

The Nikau building is a single-storey, monopitched building with five portal frames spanning the width of the building and two plywood shear walls in the longitudinal direction. The building is 12 m wide by 22.5 m long and 4.3 m high at the top of the monopitch (see Figures 1 and 2).

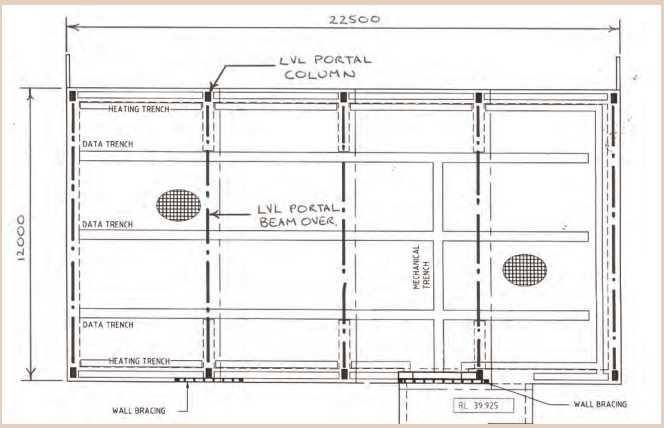

Figure 1: Plan view of the Nikau building.

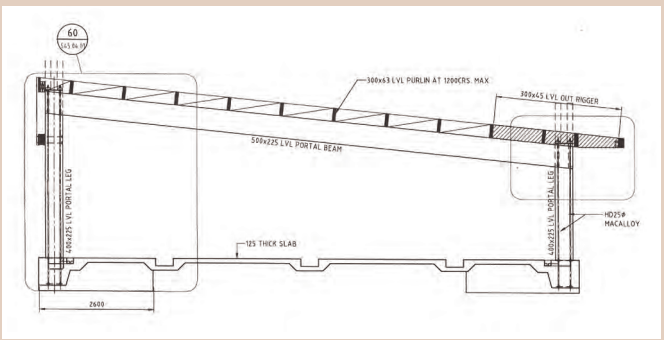

Figure 2: Transverse section of the Nikau building showing Expan portal frame.

The plywood shear walls have been placed on the south face of the building to allow as much heat gain as possible from the windows on the north face during winter. Shading reduces the heat gain during the summer months.

Each portal frame column has two 25 mm diameter post-tensioned bars that run the height of the column within individual 45 mm × 45 mm voids. The bottoms of the bars are anchored into the reinforced concrete ground beams, and the tops of the bars extend through 45 mm × 45 mm voids in the beams with a bearing plate and washer on top of the beam (see Figure 3). The laminations in the beams are arranged so that all post-tensioning stresses are parallel to the grain of the timber. The post-tensioned bars provide moment-resisting knee joints to resist both vertical and lateral design loads.

The refurbishment of the BRANZ site includes construction of the new Nikau building – a single-storey, monopitched office space constructed using a post-tensioned LVL portal frame that spans the width of the structure.

Construction process

The construction of the new Nikau building can be separated into five stages:

1. Cast the reinforced concrete foundations.
2. Erect the structure, including the LVL portals, plywood shear walls, roof purlins and roof bracing.
3. Post-tension the LVL portal frames.
4. Close in the building.
5. Internal fit-out.

Fletcher Construction has reached stage 4 and found the construction relatively simple, given that this is the first portal frame to be constructed using this type of structural system. The construction used very tight tolerances that were necessary to ensure the post-tensioned bars fit within the voids of the LVL members, which must align precisely. Fletchers also coordinated the construction between the different sub-contractors, including the LVL fabricators McIntosh Laminates and the post-tensioning contractor BBR Contech.

Lessons from being first

While the Nikau building has been a design, construction and client satisfaction success, a number of lessons have emerged from the new technology on this project:

- Fabrication tolerances mean the LVL beams and columns do not always fit neatly together. (This was complicated by the shear key detail at the end of the beams, which could be simplified on future jobs.)
- Provide sufficient clearance for the post-tensioning jack.
- The LVL fabrication requires tight tolerances to ensure the bearing surface in the beam-column joint is fully activated.
- Architectural details must allow for checking stresses and restressing the bars in the future.

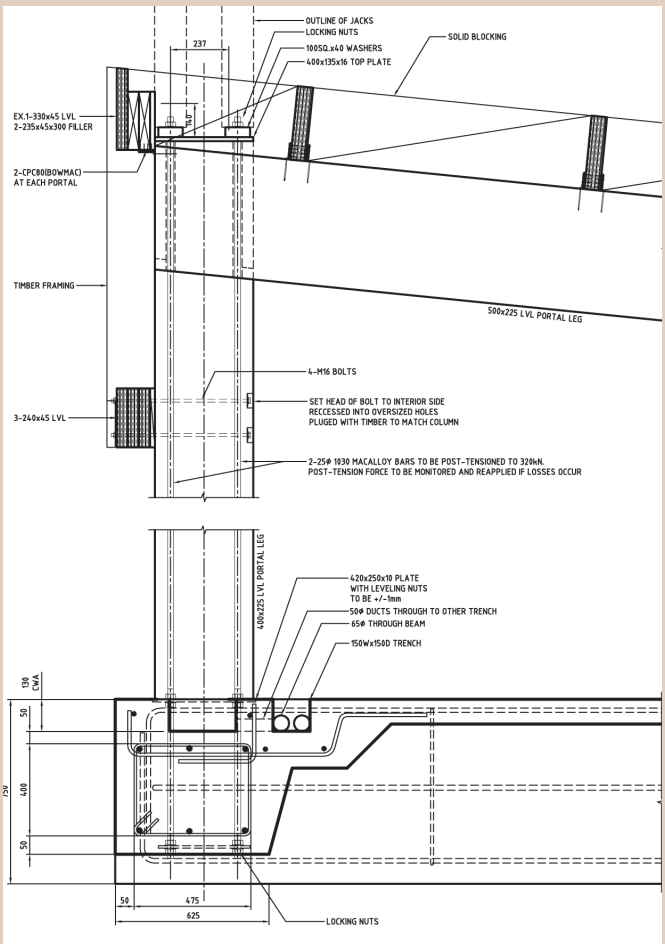

Figure 3: The Expan portal column showing the post-tensioned bars.