BULLETIN OF LESSONS LEARNED

LIFECYCLE TOWER ONE, DORNBIRN, AUSTRIA

This bulletin presents the lessons learned and experiences gathered from stakeholders who responded to an online questionairre and/or participated in interviews.

OWNER/DEVELOPER
Cree GmbH, a division of the Rhomberg Group

DESIGN TEAM
ARCHITECT: Architekten Hermann Kaufmann ZT GmbH
STRUCTURAL ENGINEER: Merz Kley Partner Zt GmbH

AUTHORITY HAVING JURISDICTION
Region of Vorarlberg

CONSTRUCTION TEAM
Cree GmbH, a division of the Rhomberg Group

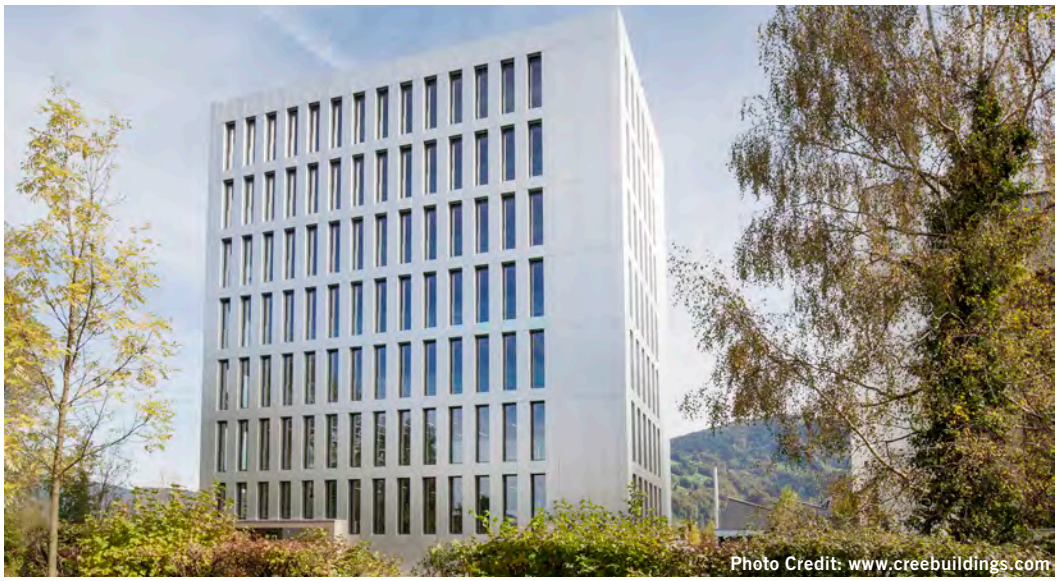
Photo Credit: www.creebuildings.com

The LifeCycle Tower ONE (LCT ONE) is an 8 storey commercial office tower developed by Cree GmbH. The building serves as a living educational laboratory to build industry capacity and transfer knowledge about the benefits of mass timber building.

LCT ONE was a prototype project to develop and test a structural system using mass timber, with a systemized and prefabricated design and construction approach. This building system was conceived as modular, a kit of parts, consisting structural components (slabs, columns, façade) and of mechanical and electrical systems that can be prefabricated and arranged to suit individual requirements.

LCT ONE uses glulam wood beams as the primary building material, combined with concrete. Structurally, the system relies upon hybrid wood-concrete slabs supported by glulam posts at the building's perimeter and by the central concrete core and interior post and beam frame on the interior. The slabs span 9m, maintaining an open floor plan that can be easily customized.

The timber post/slab configuration resists earthquake and fire damage without losing strength, while reducing material weight by 30% over a concrete building of similar size. The curtain wall system was engineered to maximize R-value and reduce thermal bridging, allowing the building to meet Passive House requirements.

PROJECT VITALS

LOCATION: Färbergasse 17, 6850 Dornbirn, Austria
COMPLETION DATE: September 2012
OCCUPANCY TYPE: Commercial Office
CONSTRUCTION COST: €4.5 million (~$6.8 million CAD)
TOTAL FLOOR AREA: 1,600m²
NUMBER OF LEVELS: 8
HEIGHT ABOVE GRADE: 27m

TECHNICAL RESOURCES + LINKS

Technical details of the building systems can be accessed through the following resources:

Cree Buildings. (2013) Cree Buildings Information Brochure. *http://www.creebuildings.com/files/CreeBrochure.pdf?PHPSESSID=ea7665320e71c5f167122d5562e442fc*

Tahan, Nabih. (2012) LCT ONE: Case Study of an Eight-story Wood Office Building. *http://woodworks.org/wp-content/uploads/C-WSF-2012-NABIH-LCT-1.pdf*

LESSONS LEARNED

OWNER/DEVELOPER

- Engage the fire protection authority early in the research and design process to facilitate a positive and collaborative relationship.
- Smart, passive energy strategies require less building services installations.
- Choose a prefabricated concrete core, rather than cast-in-place concrete, to avoid losing the schedule gains offered by the other prefabricated components.

DESIGN TEAM

- Access industry resources and develop relationships early in the project to ensure an effective integrated design process.
- Specify precast concrete core elements instead of cast-in-place concrete to gain the advantage of precision and schedule.
- Simple design concepts support a high quality, modular approach.
- Prefabrication is key to a structurally pre-defined solution and minimizing complex design details being realized on site.
- Fire testing informed a simplified approach for demonstrating the fire-integrity of the LCT system in future projects.
- Collaboration between the design team and the fire authority was central to obtaining approval for the building.

AUTHORITY HAVING JURISDICTION

- Work directly with the design team to resolve fire protection in collaboration.

CONSTRUCTION TEAM

- Encourage a collaborative and integrated design process early in the project.
- Select a prefabricated concrete core instead of cast-in-place to align speed of concrete installation with speed of timber erection.
- Confirm a strategy for coordinating trade sequencing to minimize damage to work previously completed, and maintain site cleanliness as the project progresses.
- Communicate effectively between disciplines to assess and select suppliers that are committed to quality, innovation and understand the prefabricated approach.

Photo Credit: www.creebuildings.com

THE OWNER / DEVELOPER

CREE GMBH (RHOMBERG GROUP)

Cree GmbH, a division of the Rhomberg Group, was responsible for the design, development and construction of LCT ONE.

RATIONALE

- Prove a business case for the use of mass timber products in construction.
- Develop a flexible, prefabricated construction system as a new, independent product compliant with technical and economic requirements of modern real estate markets and adaptable to international requirements.
- Demonstrate the combined effectiveness of Passive House technologies and mass timber.
- Gain a competitive advantage over conventional concrete and steel buildings in anticipation of a future carbon tax.
- Realize systematic improvement of resource and energy efficiency, and reduction of embodied energy and carbon emissions associated with new construction, thereby proving a case for environmentally sound buildings, based upon the following research conclusions:
  - Compared to a reinforced concrete building, tall high-performance timber buildings can reduce Carbon emissions and shorten construction times significantly.
  - When considering the embodied energy to produce wood, as well as the "end of life" potential to generate energy from the wood, a timber building would use 39% fewer resources during its lifetime.
- Test and develop a prototype building.

PROCESS

- LCT ONE was self-financed by the Rhomberg Group.
- Additional incentive funding of 400,000 Euros (~$640,000 CAD) was secured from The Austrian Research Promotion Agency (FFG) to support additional research requirements.

Photo Credit: www.creebuildings.com

- Joint research, focused on life cycle assessment and performance, was undertaken through collaboration with Cree's parent company (Rhomberg Bau), the Berlin office of the global engineering firm Arup, and renowned Austrian architect Hermann Kaufmann.
- A mock-up was built to test structural integrity to help overcome any preconceived risks associated with the mass timber solution.
- Design was informed and fire protection concerns were addressed early by working closely with the fire authority and conducting several fire tests in a full-size fire chamber.

CHALLENGES

- Justifying project financing given that timber represents slightly higher costs over concrete/steel structures.
- Investing additional time to research and secure funding streams.
- Educating product suppliers on how to work with an unfamiliar prefabricated approach, whilst maintaining a focus on precision and durability.
- Coordinating large visitor groups during installation to minimize interruption and scheduling delays.

SUCCESSES

- LCT ONE validated proof of concept for the LCT system and feasibility of mass timber buildings.
- The LCT ONE precedent demonstrated that wood buildings can safely exceed building code height requirements with innovative structural and fire protection solutions.
- Construction completed at the rate of one storey per day, confirmed the effectiveness of prefabricated tall mass timber buildings.
- International recognition and feedback from industry stakeholders has generated future business opportunities.
- Integration of the LifeCycle Hub exhibition in the building supports experiential knowledge sharing and education.

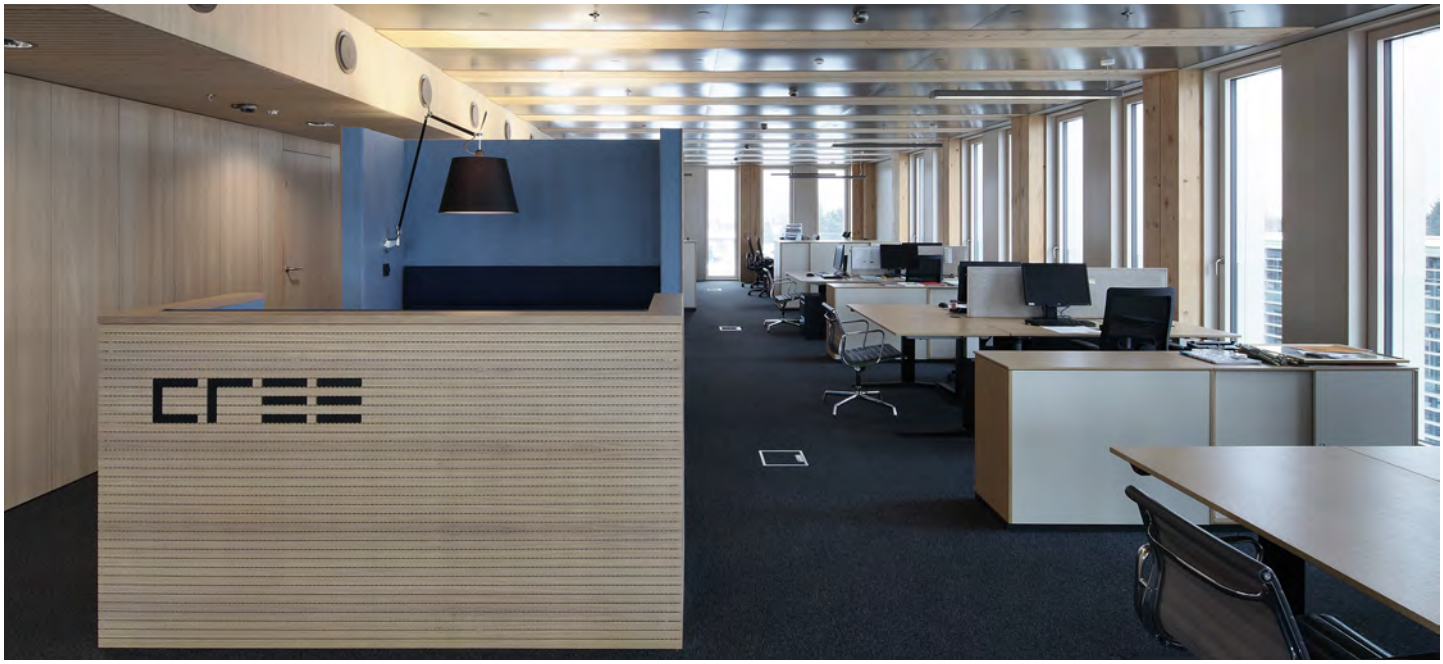

Photo Credit: www.creebuildings.com

THE DESIGN TEAM

HERMANN KAUFMANN ZT GMBH, MERZ KLEY PARTNER ZT GMBH

Hermann Kaufmann ZT GmbH completed the architectural design and Merz Kley Partner ZT GmbH were the structural engineers.

RATIONALE

- Respond to client vision for a timber solution.
- Expand the use of mass timber in tall buildings.
- Develop the existing methods of wood construction to achieve large scale precision, building capacity in the local carpentry industry.

DESIGN PROCESS

- Decision to use wood was made by the Owner, prior to design.
- Design team selection was based on their previous experience with timber design and construction.
- LCT ONE is the proof of concept for Cree's Lifecycle Tower (LCT) system developed as a research project which proposes a resource efficient, modular, 20 storey building.
- Structural design focuses on solving shrinkage issues by using a wood/concrete hybrid slab, strictly avoiding cross grain pressures.
- The structural system prioritizes simple design and straight forward engineering focused on standardization of key elements and modularity.
- The criteria for selecting technologies were based on the fastest and most replicable solutions.
- Different hybrid slab options tested included up to 20cm of concrete topping. Fire testing confirmed only 8cm could achieve the required fire rating and contribute significantly to limiting noise transfer between floors.
- Structural design effort was double that of a concrete building.
- More detailing and pre-construction planning was required as compared to conventional construction process.

Installation of prefabricated wall panels.
Photo Credit: www.creebuildings.com

DESIGN SOLUTIONS

STRUCTURE

- Concrete basement and ground floor.
- Each storey and associated technical services are accessed via one centralized concrete access core which serves as the lateral load resisting element of the building. Cast-in-place concrete was used for core construction.
- The exterior walls consist of load bearing glulam posts, and a curtain wall building envelope.
- The floor system is a hybrid wood/concrete slab approximately 9m long and 3m wide.
- Walls and floor slabs were prefabricated and brought to site for installation.
- Connections between the concrete core and hybrid slabs are made with angled steel brackets
- Mortise and tenon joints address lateral forces between the hinged columns and the hybrid slabs.
- Structural solution was developed as a kit of parts to facilitate a prefabricated, modular system which minimized complexity during construction.

FIRE PROTECTION

- Fire was perceived as the primary project risk.
- Design solutions depended heavily on results of the fire testing phase.
- The concrete core addresses the requirement for a non-combustible egress route.
- Smoke alarms wired directly to the fire department are strategically located.
- Exposed wood structure triggered the requirement for a sprinkler system, which was determined to be redundant by the authority having jurisdiction after installation. Although sprinkler infrastructure is in place, it is not connected to the water mains.
- The hybrid slabs were tested in a full-size fire chamber; initial floor slab fire tests failed, achieving only a 30 minute rating. The concrete mix was then revised and subsequent tests earned a 120 minute fire rating.
- Concrete topping on the wood panels addresses fire separation between each floor with no wood-to-wood contact.
- Timer members are oversized to provide a char layer.
- Elimination of cavities and penetrations within walls to reduce potential risk of fire spread.

ACOUSTICS + VIBRATION

- Extensive acoustical testing was done for several design scenarios.
- The concrete topping on the floor slab addresses noise transfer and vibration between floors, and testing was done with 12cm and 8cm. Tests confirmed that in combination with the wood members, 8cm of concrete topping was adequate to meet code requirements.
- Metal panels installed between the wood beams to conceal the building systems also improved the acoustics in the space.

Modular system of interlocking prefabricated components with centralized concrete access core.
Detail Credit: www.creebuildings.com

Hybrid floor slab features wood-concrete composite rib construction.
Photo Credit: www.creebuildings.com

Hybrid floor slab and double wood columns comprise the load-bearing timber structure
Detail Credit: www.creebuildings.com

MOISTURE PROTECTION + DURABILITY

- The concrete foundation in the basement and ground floor protects the timber structure from moisture.
- No structural timber elements are exposed to the exterior, all are protected within the envelope.
- Prefabricated wall elements result in a weather tight enclosure as soon as they are installed.
- Insulation and structural elements are kept separate to accommodate variations in material lifecycles: insulation can be easily replaced after 20 years, while structural components are designed to last more than 100 years.

SYSTEMS INTEGRATION

- Systems were integrated into the available ceiling spaces between each glulam beam and concealed with aluminum facing panels, eliminating the need for a deeper dropped ceiling.

CHALLENGES

- Understanding and predicting the behavior of the hybrid slab over time.
- Determining the variations in precision and tolerances between concrete and timber.
- Planning for systems integration was a challenge due to fragmented work split among several design disciplines, leading to late design changes on-site.
- Managing the extensive testing that was required to meet the acoustic requirements.

SUCCESSES

- The hybrid slab production process was improved to eliminate concrete formwork.
- Seamless integration of systems eliminated the need for dropped ceilings.
- Large floor spans and a 2.80m floor-to-ceiling height created flexibility to support many floor plans.
- Prefabrication allowed for easy customization of floor layout.
- The prefabricated modular system created pre-defined solutions which eliminated execution of complex details during construction.
- Low energy building designed to meet Passive House* requirements.
- Minimal use of concrete led to a lighter structure with up to 90% less CO2e emissions than a conventional concrete building.
- No additional architectural resources, design time or tools were required throughout the design process.
- Flexible, open floor space achieved by using concrete girders in combination with timber elements allows for easy conversion and reconfiguration, extending the building lifetime.

Angled steel brackets connect hybrid floor slabs to concrete access core.
Photo Credit: www.creebuildings.com

Angled steel brackets connect hybrid floor slabs to concrete access core.
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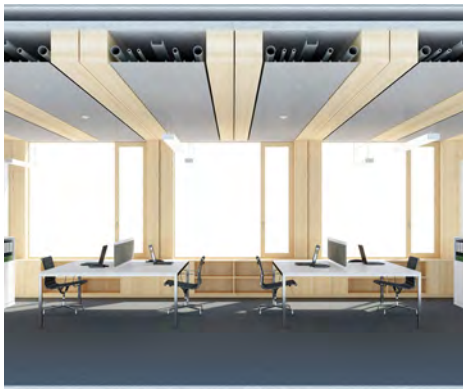

Systems are concealed behind aluminum panels within ceiling cavities.
www.creebuildings.com

*Passive House is a rigourous, voluntary energy performance standard for buildings, which aims to reduce the requirement for space heating and cooling, whilst also creating excellent indoor air quality and comfort levels. www.passivehouse.ca

THE AUTHORITY HAVING JURISDICTION

REGION OF VORARLBERG

Authority representatives were not available to provide their perspectives, however the information presented here reflects feedback from other project stakeholders on the permissions and approvals process at LCT ONE.

RATIONALE

- Structural timber is not explicit in the local building code; LCT ONE required an exception to obtain approval.

PROCESS

- The process was unique in that the project team worked closely with the fire authority to research, test, and prove final concept.
- The fire authority was engaged in evaluating the fire risk associated with the hybrid system, monitoring the assembly on-site, and determining the final approval of the building.
- Extensive fire testing was required.

CHALLENGES

- Several fire tests were undertaken to determine acceptable solutions.

SUCCESSES

- Collaboration between the design team and the fire authority led to an acceptable solution.
- Quality and simplicity of building structure reduced fire risk and confirmed the level of fire safety performance for the authority having jurisdiction, consequently allowing the requirement for sprinklers to be removed.

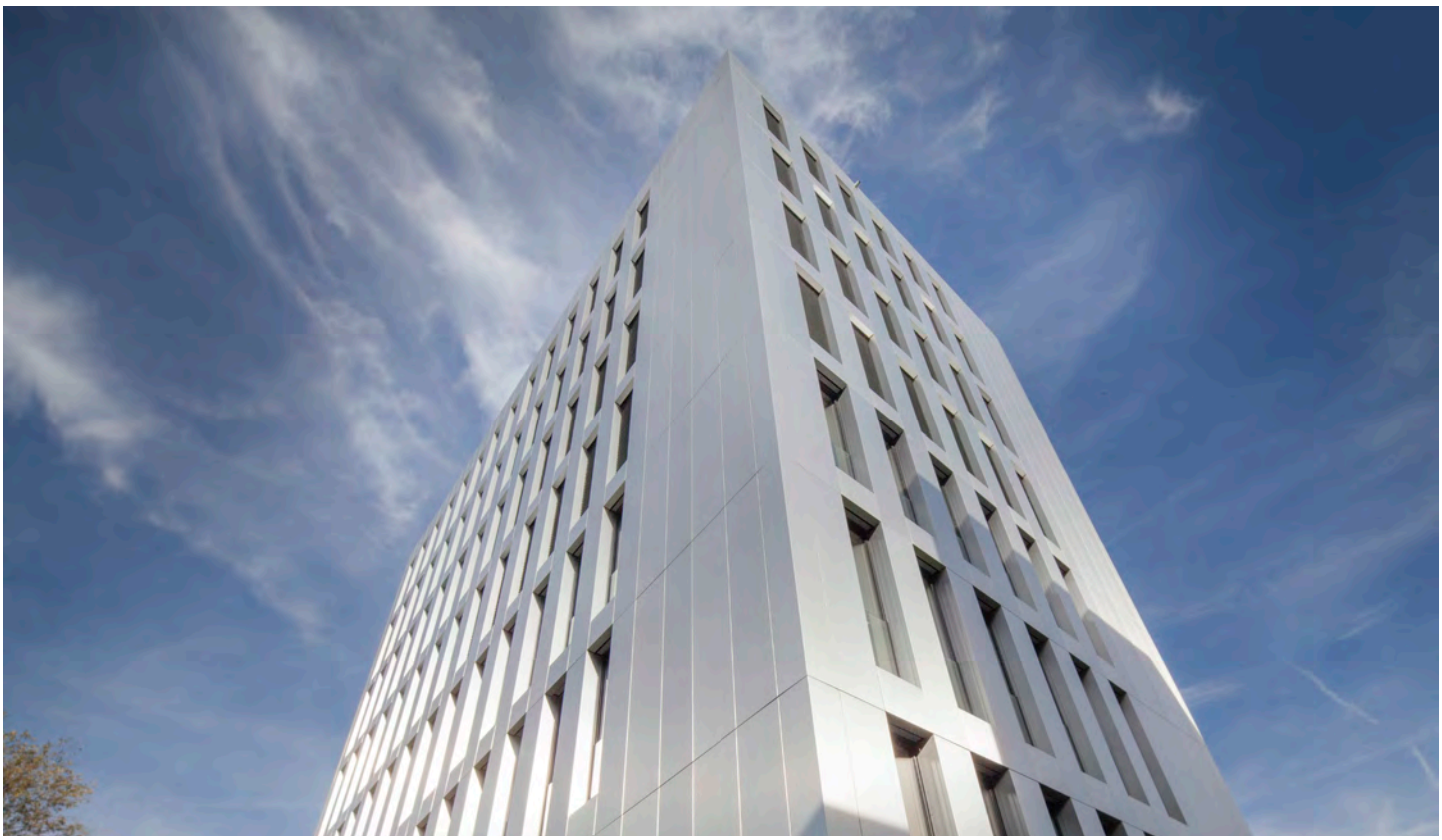

Photo Credit: www.creebuildings.com

THE CONSTRUCTION TEAM

CREE GMBH (RHOMBERG GROUP)

Cree GmbH, a division of the Rhomberg Group, managed the construction process and supplied the LCT hybrid system.

RATIONALE

- Prove a strong, profitable business case for the use of mass timber products in construction.
- Further expand expertise and develop industry capacity for mass timber projects.
- Invest and expand skilled labour for future mass timber projects.

PROCESS

- Cree provided on-site training for the crew to learn to install the prefabricated elements.
- Meticulous planning and prefabrication greatly reduced changes made during construction.
- The concrete core was cast-in-place and completed before any other building assembly.
- Total erection time for the timber elements was eight days, two days for the first level and one day for each remaining level.
- Efficient scheduling and delivery planning were essential to support successful assembly of prefabricated elements.
- Construction team and trades were regularly informed of the fabrication timelines to assist with construction phase scheduling.

Photo Credit: www.creebuildings.com

CONSTRUCTION SOLUTIONS

STRUCTURE

- Concrete core was cast-in-place, and completed before the building was assembled around it.
- The installation crew took the time to learn proper assembly techniques on the first floor; assembly of subsequent levels was much quicker.

MOISTURE PROTECTION + DURABILITY

- An emergency, temporary plywood roof was constructed which required 1.5 hours to put in place over the building footprint, and was used only once due to sustained dry weather during construction.

CHALLENGES

- Finalizing architectural, structural and mechanical details well in advance of prefabrication.
- The scheduling advantage of modular construction was reduced with the curing time required for the cast-in-place concrete core.
- Educating trades about protecting the exposed wood surfaces from physical damage and staining as they progressed through the sequence of finishing.
- Delayed procurement decisions by the owner challenged the panel fabrication timeline and construction schedule.

SUCCESSES

- Overall speed of construction was faster than a conventional building; completing at the rate of one storey per day.
- Noise and dust pollution were reduced during the construction phase.
- Prefabrication minimized errors on-site
- Local trades were trained in structural timber and modular construction techniques, increasing industry capacity.

Efficient scheduling and delivery planning were essential for a smooth construction phase.
Photo Credit: www.creebuildings.com

Installation of hybrid floor slab.
Photo Credit: www.creebuildings.com