POST-TENSIONED SLABS

SPECIALISED ENGINEERED SOLUTIONS FOR STRUCTURES

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02/03

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DESIGN SOLUTIONS

CCL carries out complete designs for post-tensioned concrete applications. Experience and expertise gained from working on projects around the world, are combined to deliver prompt, effective solutions. The company uses the latest design software which is continually updated to reflect current international construction codes of practice.

CCL specialists help structural engineers determine the most appropriate option for their specific project requirements at early design stage using extensive value engineering. CCL can provide a detailed scheme with sufficient information for tender purposes. Upon execution, the company's specialised design team will develop the design and provide shop drawings for construction.

"Experience and expertise, gained from working on projects around the world, are combined to deliver prompt, effective solutions."

INTELLIGENT SOLUTIONS

CCL Post-Tensioned Slabs represent continuous development through involvement in building structures worldwide. CCL systems present innovative solutions to some of the common restrictions faced by architects, engineers and contractors.

- Open-plan spaces with large spans unrestricted by awkward columns.
- Flat slabs without drop elements, to facilitate the layout of partitions and services.
- Thin slabs that increase planned clearance under ceilings or reduce total building height.
- Greater architectural freedom in design of slab shapes and positioning of columns.
- Slabs with fewer or no expansion joints.
- Slabs with reduced, simple to fix reinforcement and less concrete.
- Faster stripping of shuttering allowing quicker redeployment of formwork.

REAL BENEFITS

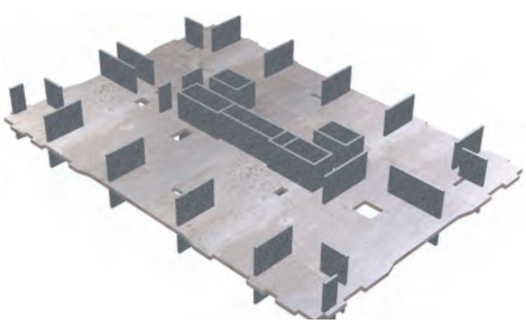
CCL Post-Tensioned Slabs are the first choice for many architects, contractors and engineers around the world. The intelligent use of post-tensioning technology by CCL's experienced engineers can bring bespoke solutions to suit each unique situation.

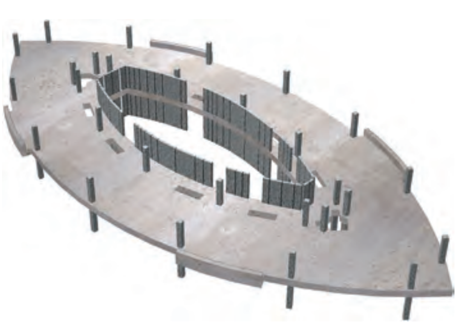
ARCHITECTURAL INTELLIGENCE

CCL Post-Tensioned Slabs can bring unique freedom over conventional building methods. Stronger, more efficient floor slab design creates longer spans and reduces the need for columns within the structure.

COMMERCIAL OPPORTUNITIES

CCL post-tensioning results in thinner concrete slabs making the valuable savings in floor to floor height available as additional floors. This can provide extra rentable space within the same overall building height.





SUSTAINABLE FUNDAMENTALS

A CCL-designed post-tensioned slab can contain less concrete (20% - 30%), less reinforcement and less complicated rebar shaping than conventional reinforced concrete slabs.

STRUCTURAL RELIABILITY

CCL Post-Tensioned Slabs show reduced cracking for improved durability and lower maintenance costs.

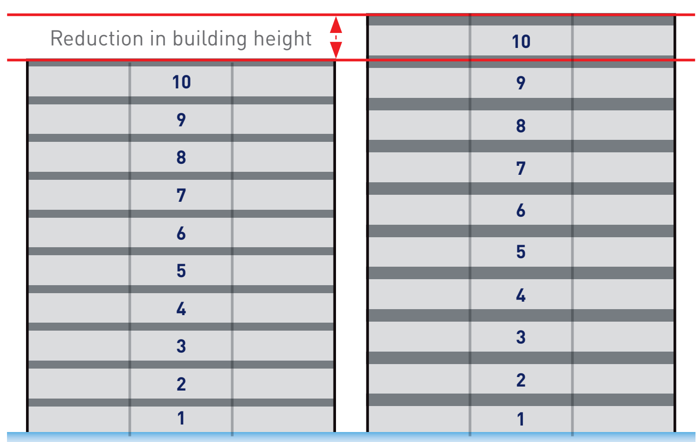
Their deflection can be controlled by varying the amount of post-tensioning to balance any portion of applied loads immediately after stressing.

INCREASING POPULARITY

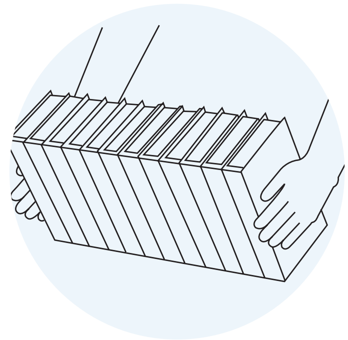
The growth in the use of CCL Post-Tensioned Slabs throughout the world continues to accelerate because of the significant benefits for developers, architects, engineers, contractors and end users.

EARLY PLANNING

To obtain maximum benefit from CCL Post-Tensioned Slabs it is recommended that they are incorporated into the building structure at early design stage.



REALISING THE POSSIBILITIES



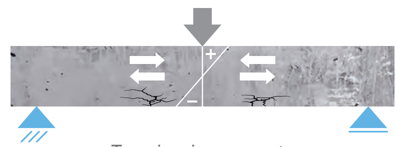
Post-tensioning provides a means to overcome the natural weakness of concrete in tension and to make better use of its strength in compression.

The principle is easily observed when holding together several books by pressing them laterally. Under such pressure the whole row gains enough stiffness and strength to ensure its integrity.

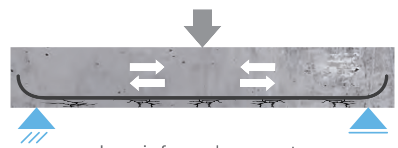
In concrete structures, this is achieved by placing high-tensile steel tendons/cables in the element before casting. When the concrete reaches the desired strength, the tendons are pulled by special hydraulic jacks and held in tension using specially designed anchorages fixed at each end of the tendon.

This provides compression at the edge of the structural member that increases the strength of the concrete for resisting tension stresses.

If tendons are appropriately curved to a certain profile, they will exert, in addition to compression at the perimeter, a beneficial upward set of forces (load balancing forces) that will counteract applied loads, relieving the structure from a portion of gravity effects.

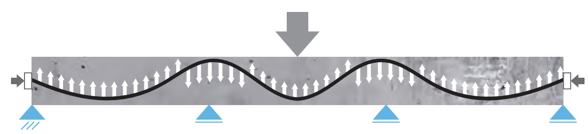


Tension in concrete produces cracking



In reinforced concrete rebar resists tension

In post-tensioned concrete pre-compression resists tension



Effects of curved post-tensioning tendon on the structure

TYPES OF SLABS

CCL Post-Tensioned Slab systems can be integrated into any type of slab, including flat, ribbed or waffle slabs, which may include drop caps, drop panels or band beams to produce optimal configurations.

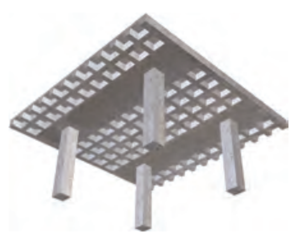
Solid flat slab

Solid flat slab with drop panels

Solid flat slab with drop caps

Banded flat slab

Waffle slab with solid panels



Waffle slab with band beam

Ribbed slab

Solid slab with narrow beam

POST-TENSIONING SYSTEMS

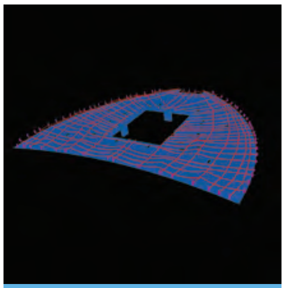
CCL provides bonded and unbonded post-tensioning systems. Both systems can be used independently or combined to provide the optimum design solution. Selection of a system depends on the specific requirements of each project. CCL specialists are available to discuss the most suitable solution for a particular situation.

IMPLEMENTATION

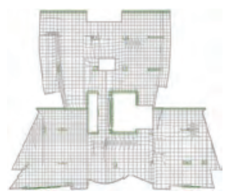
During construction, CCL supplies all materials necessary for post-tensioning tendons and will supervise or perform installation work as required. After casting, CCL's specialist site team can perform stressing and grouting operations to complete your building project.

STRUCTURAL DESIGN

Post-tensioning tendons are virtually replaced in the slab by the set of forces they exert on it: compression along the slab perimeter, upward forces in the spans and downward forces over the supports.



3D tendon perspective

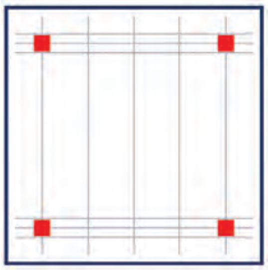


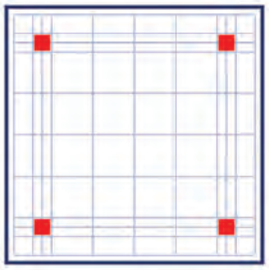
Finite element meshing

Stress distribution

Several elastic methods of analysis can be used to determine stresses in slabs under gravity loads and equivalent post-tensioning actions such as the Equivalent Frame Method (EFM) and the Finite Element Method (FEM). Stresses and deflections resulting from the elastic analysis are checked under Service Limit State (SLS) against allowable values imposed by the adopted code of practice.

TYPICAL TENDON DISTRIBUTIONS

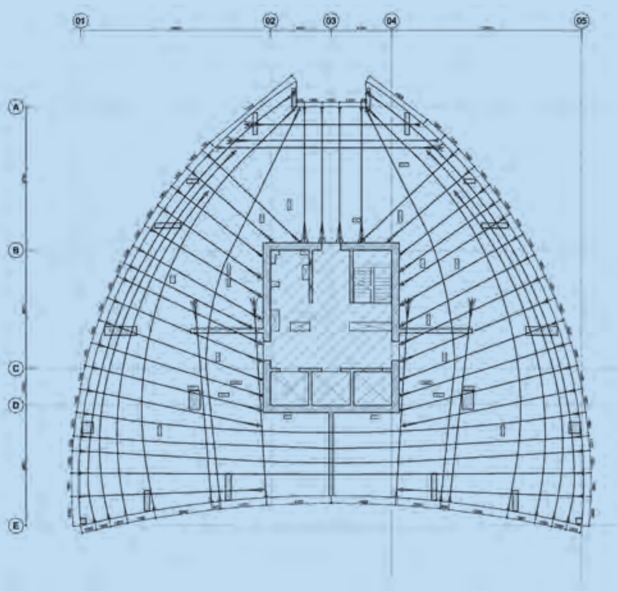




Other distributions can be accommodated depending upon constructability issues and code requirements.

Critical sections are checked under Ultimate Limit State (ULS) and, where a lack of resistance occurs, the addition of localised reinforcement is used to compensate. The punching shear is checked and if the corresponding resistance is insufficient, it is catered for by additional reinforcement or increased concrete thickness (drop caps). Alternatively CCL ShearTrack® punching shear reinforcement can be specified. Independently tested, ShearTrack® complies with ACI, IBC and ASTM standards.

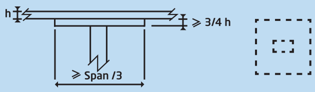
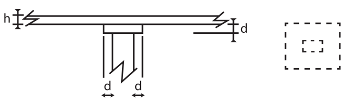
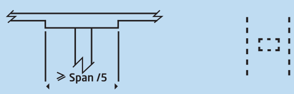
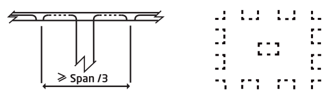
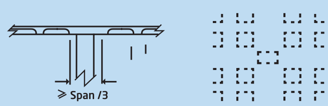
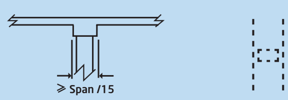
When an analysis is satisfactorily completed, structural detailing is carried out to show the layout and the dimensions of the slab; the distribution and profiles of the tendons; details of ordinary reinforcement; jacking forces and corresponding elongations in tendons due to stressing.



TYPICAL TENDON LAYOUT

TYPICAL SPAN TO DEPTH RATIOS

The following table gives span/depth ratios for a variety of section types of multi-span floors. The table can be used to determine slab thickness for a given span and loads.

Section Type		Total Imposed Load (kN/m²)	Span/Depth Ratio for 6 m ≤ L ≤ 13 m*
1. Solid flat slab		2.5 5.0 10.0	40 36 30
2. Solid flat slab with drop panels		2.5 5.0 10.0	44 40 35
3. Solid flat slab with drop caps		2.5 5.0 10.0	40 36 30
4. Banded flat slab		2.5 5.0 10.0	Slab: 45, 40, 35 Beam: 25, 22, 18
5. Waffle slab with solid panels		2.5 5.0 10.0	28 26 23
6. Waffle slab with band beam		2.5 5.0 10.0	28 26 23
7. Ribbed slab		2.5 5.0 10.0	30 27 24
8. Solid slab with narrow beam		2.5 5.0 10.0	Slab: 42, 38, 34 Beam: 18, 16, 13

* Span lengths outside of this range can also be accommodated. Please contact CCL for details.
The above table is based upon information contained within Technical Report 43 'Post-tensioned Concrete Floors'.

MONOSTRAND UNBONDED SYSTEMS

CCL's unbonded single-strand tendon system is quick to install; tendons can be easily deflected to avoid openings and to cope with irregular slab shapes. The system has reduced friction losses and increased eccentricity. It requires no grouting.

Single low relaxation PC 7-wire strands of 13 mm or 15 mm diameter are coated with permanent corrosion-inhibiting grease and encased in high-density polyethylene (HDPE) sheathing, continuously extruded over the entire strand length to form a single strand tendon.

Tendons are laid in the slab according to specific profiles before pouring concrete.

The grease reduces friction and the sheathing allows for free relative movement of the strand with respect to the surrounding concrete during stressing. Both grease and sheathing provide long-term corrosion protection to the steel.

The strands are individually anchored at both ends to CCL unbonded monostrand anchorages that are embedded in the concrete to transfer compression to the slab after stressing.

Plastic reusable fittings facilitate the fixing of live anchorages to the side shutters. Pocket formers are used to provide access for stressing at the edge of the slab.

Stressing is performed using CCL special hydraulic jacks.

Plastic caps filled with corrosion-inhibiting grease seal the strand end after stressing and cropping.

UNBONDED INSTALLATION

- Grease-coated and plastic-sheathed strands are cut to the required length and fitted with dead-end anchorages where applicable.
- The slab formwork is laid.
- Live-end anchorage positions are marked on the side shutters.
- The live-end anchorages are fitted to the side shutters.
- The bottom layer of reinforcement is fixed (where applicable).
- Tendons are laid and profiled on chairs to the correct design profile.
- Top reinforcement is fixed over supports.
- Concrete is poured and vibrated with care in order not to damage the tendons.
- Side shuttering is removed in preparation for stressing.
- The wedges are installed and the ends of the strands are marked for elongation measurement.
- Concrete strength is confirmed by crushing of cylinder (or cube) samples taken from the same pour.
- Calibrated CCL stressing equipment is assembled and set to the required force.
- CCL trained specialists stress the tendons according to the required stressing sequence and check the elongation.
- Tendon tails are cut with CCL strand croppers or cutting discs.
- The bottom formwork is stripped.
- Tendon tails are capped and stressing pockets are filled with non-shrink grout/mortar.

MULTISTRAND BONDED FLAT-SLAB SYSTEMS

CCL bonded systems incorporate groups of two, three, four, five or six strands contained within a tendon in a flat duct anchored at each end by CCL flat anchorages. This allows the tendons to be positioned close to the surface to obtain maximum eccentricity within the slab.

The tendons are laid in the slab according to specific profiles before pouring concrete. Ducts allow for free relative movement of the strand with respect to the surrounding concrete during stressing.

After the strands are locked within the anchorage by the wedge, they are individually stressed with CCL hydraulic jacks.

The ducts are then filled with a cement-based grout to fully bond the strands to the concrete through the duct wall and all along the length of the tendon.

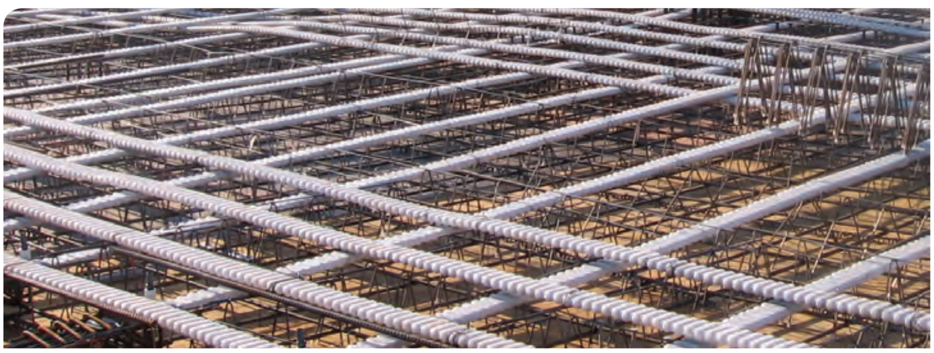
The grout creates an alkaline environment around the steel for permanent corrosion protection.

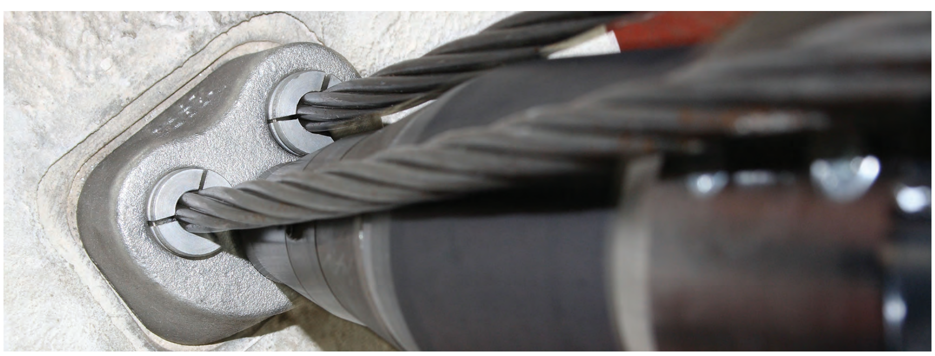
The strands are attached at one end to a CCL flat anchorage, and can be left exposed at the other end and embedded in the concrete through enough length to ensure their anchoring by bonding.

CCL's bonded system requires a reduced amount of ordinary reinforcement as bonding allows the strands to reach higher stress at ultimate state.

BONDED INSTALLATION

- The slab formwork is laid.
- Live anchorage positions are marked to side shutters.
- Live-end anchorages are fitted to side shutters.
- The bottom layer of reinforcement is fixed (where applicable).
- Ducts are laid out by connecting and sealing standard duct lengths.
- The appropriate number of strands are pushed through the ducts and cut to the required length; bonded dead ends are formed where required.
- Grout vents are installed and ducts are set upon chairs to the correct design profile.
- Top reinforcement is fixed over supports (where applicable).
- Concrete is poured and vibrated with care in order not to damage the tendons.
- Side shuttering is removed in preparation for stressing.
- Anchor heads and wedges are threaded onto the ends of the tendon.
- Tendon tails are marked for elongation measurement.
- Concrete strength is confirmed by crushing of cylinder (or cube) samples taken from the same pour.
- Calibrated CCL stressing equipment is assembled and set to the required force.
- CCL trained specialists stress the tendons according to the required stressing sequence and check the elongation.
- Tendon tails are cut and stressing pockets are filled with non-shrink grout/mortar.
- Formwork is stripped.
- Tendons are air tested.
- CCL trained specialists use CCL-approved grout mixers/pumps to grout and seal the tendons.

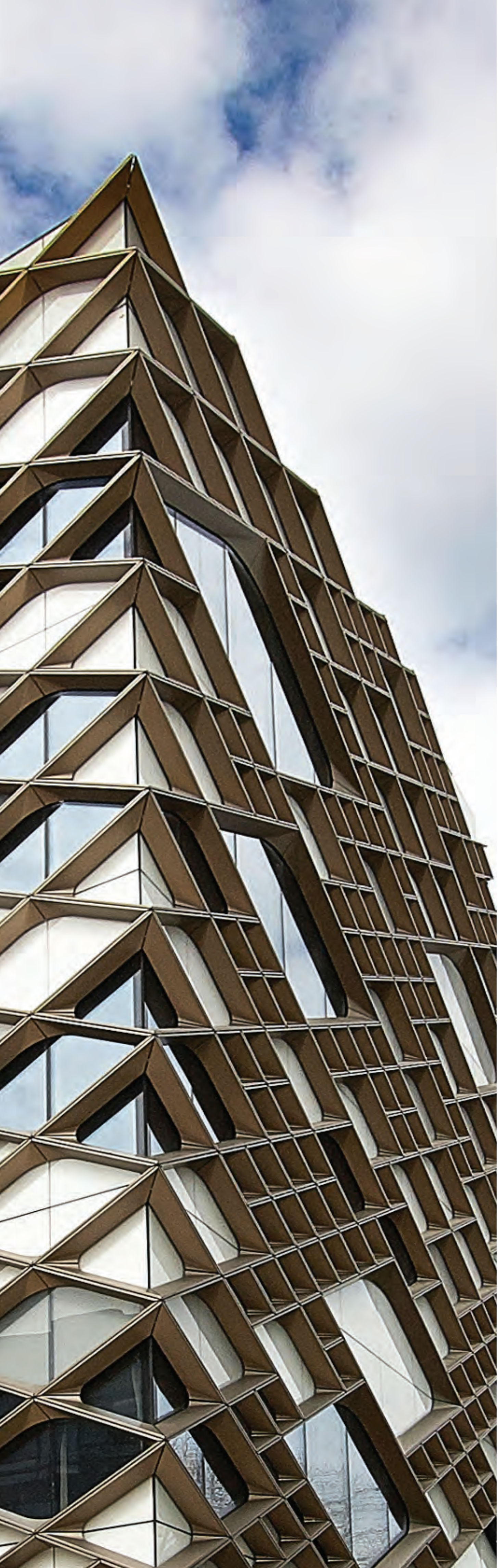





GLOBAL QUALITY

CCL operates globally, with a network of sister companies and partners to ensure a close proximity to projects worldwide. A combination of independence, expertise, attention to detail, integrity and service makes CCL the preferred choice on projects that matter.

CCL is an ISO-registered company which operates a quality management system compliant with ISO 9001. The company's high-performance anchorage systems are designed, manufactured and tested to exceed the latest European Standard ETAG 013, and AASHTO requirements.



Established in 1935, CCL has a long history of providing specialised engineered solutions for structures. Every day, CCL products and services are used in building and civil engineering structures across the world.

CCL's advanced solutions help engineers, planners and construction companies create and maintain these structures.

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