From crane to concrete core: Follow the load path with IDEA StatiCa

When the building becomes part of the crane-support system

Finding space for tower cranes on constrained urban sites is increasingly difficult. Basements, buried services, neighbouring buildings and access requirements can prevent a conventional crane base from being placed in the optimum position.

In such cases, the crane support may become part of the building itself. Steel grillages can bear on basement structures or cores, or cantilever from reinforced-concrete walls. Crane ties may also transfer significant horizontal forces into the permanent structure.

These solutions create a demanding load path: from the crane mast, through the grillage and its connections, into cast-in plates, anchors and reinforcement, and finally into the building's core, floors or frame.

The design therefore extends beyond an isolated crane base or steel connection. Engineers must understand how forces pass between components and materials, supported by coordinated design and appropriate independent checking.

IDEA StatiCa provides particular value at these critical interfaces, enabling complex geometry and concentrated actions to be analysed from steel connection to reinforced concrete.

A floating crane at 2 Finsbury Avenue

A striking example can be found at 2 Finsbury Avenue in London.

The project required a tower crane near the north-east corner of the development to achieve the necessary hook coverage. However, the space beside the building had to remain available for emergency access, while congested underground services made a conventional foundation difficult.

The project team's answer was to take the crane off the ground.

The crane was supported on a substantial steel grillage cantilevering from the reinforced-concrete core of the East Tower. The grillage was cranked to suit the building and facade geometry, creating what the project team described as a 'floating crane'.

Although visually unusual, the underlying engineering challenge is becoming increasingly relevant. At One Leadenhall, for example, another externally supported floating tower crane was developed to suit a constrained City of London project. Other schemes have used grillages supported by the superstructure or positioned around and above concrete cores.

In every case, the success of the concept depends heavily on its connections.

Complex structures require more than standard connection checks

Crane-support grillages rarely use straightforward beam-to-beam connections. They may combine rolled and fabricated sections, box members, haunches, diaphragms, stiffeners and large splice plates, often meeting at different angles or levels

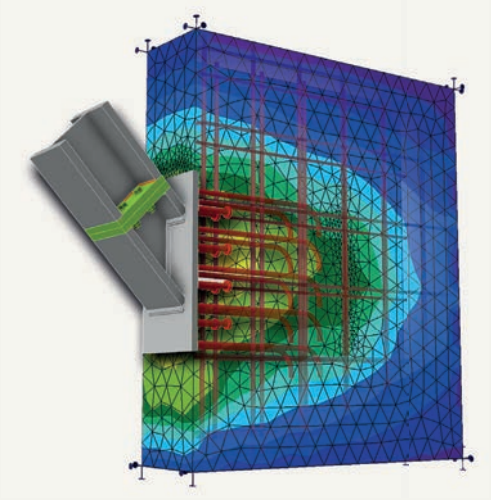
Their connections must resist combinations of axial force, shear, bending, torsion, load reversal and concentrated forces. These actions can change as the crane slews, lifts at different radii or moves between operating conditions.

Traditional calculations often require the joint to be separated into individual components, with assumptions made about force distribution. This becomes difficult when several members meet at one node, the geometry is irregular or local stiffness influences the load path.

IDEA StatiCa Connection allows engineers to model the actual joint geometry and analyse its behaviour using the CBFEM method. Plates and members are represented by finite elements, while bolts, welds, anchors and contacts are modelled as structural components.

This approach can be applied to crane supports, grillage intersections, stiffened cantilevers, bolted splices, bracing nodes and connections to embedded steelwork. Engineers can review plate stresses and plastic strain, bolt forces, weld utilisation, deformation, buckling resistance and connection stiffness.

This matters because connection behaviour can influence how crane reactions are distributed through the wider structure.



The critical transition from steel to concrete

Where a grillage is supported from a building core, the steel-to-concrete interface can be the most challenging part of the design.

Cast-in plates may transfer significant combinations of tension, compression, shear and moment into the core wall. Their behaviour depends on three interacting systems: the external steel connection, the plate and its anchors, and the surrounding concrete and reinforcement.

These systems cannot be considered independently. Plate flexibility affects the distribution of forces between anchors, while anchor stiffness and position influence how tension and shear are resisted. The reinforcement must then transfer these concentrated actions into the wider wall.

Current codes provide limited guidance for some arrangements, including combinations of headed studs and tension bars, interaction with reinforcement and discontinuities near the support. Assuming an equal distribution between anchors can therefore be misleading, particularly with eccentric loading, flexible plates or mixed fasteners.

SCI P416 guidance provides established methods for common cast-in plate arrangements, but more complex geometry and loading may require detailed analysis.

This is where IDEA StatiCa's connected steel, anchorage and reinforced-concrete workflow becomes especially valuable.

Designing cast-in plates in IDEA StatiCa

IDEA StatiCa allows the external steelwork and cast-in plate to be analysed within the same connection model, including:

- →| supporting members, end plates, brackets and haunches
- →| embedded plates, stiffeners and diaphragms
- →| bolts and welds
- →| headed studs and welded reinforcement anchors
- →| combined arrangements of studs and reinforcement.

Rather than treating the concrete face as an idealised fixed support, the software analyses how the connection deforms and distributes forces between the plate, welds and individual anchors. This is particularly valuable for eccentric connections and arrangements where component stiffness controls the load distribution.

For Eurocode projects, engineers can select the most appropriate design approach for the project requirements. Studs may be checked to EN 1994-1-1 or EN 1992-4, while reinforcement can be assessed to EN 1992-1-1 or EN 1992-4.

The guided workflow helps engineers define the connection, examine its load-transfer mechanisms and complete the relevant checks within a consistent model.

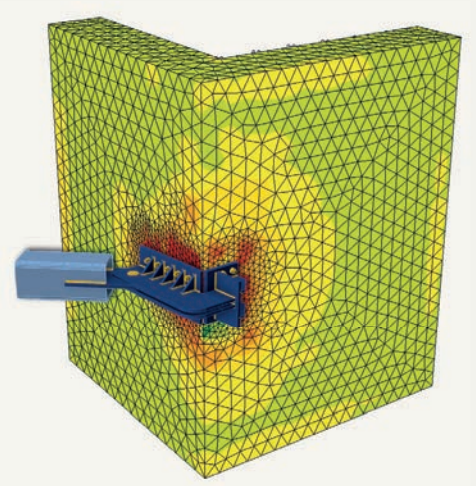
Continuing into the reinforced-concrete core

Checking the anchors alone does not show how their forces are transferred through the surrounding concrete.

A heavily loaded crane connection creates a 3D discontinuity region, where concentrated forces must spread around anchor groups, reinforcement, edges, corners and openings.

The anchorage model can therefore be transferred from IDEA StatiCa Connection into Detail 3D. The cast-in plate becomes a load-transfer device within a 3D reinforced-concrete model, allowing engineers to combine:

- →| headed studs and welded reinforcement
- →| multiple fastener types and anchorage groups
- →| straight, L-shaped and U-shaped bars
- →| wall reinforcement and additional local bars
- →| edges, corners, openings and combined loading.



The analysis shows how compression fields and reinforcement forces develop beyond the immediate anchorage zone. Engineers can then assess whether the existing reinforcement is sufficient, avoiding unnecessary supplementary bars that could create congestion in thin wall regions. They can also refine the anchorage arrangement or plate geometry where required.

One workflow for a continuous load path

The principal advantage is not simply the ability to perform more checks. It is the ability to follow the structural response across the different parts of the connection.

For a crane-support structure, the overall workflow can be divided into three connected stages:

1. Determine the governing crane actions

The global model establishes the governing reactions for the relevant crane configurations, slewing positions, wind conditions and construction stages.

2. Design the steel grillage connections

The forces are transferred into IDEA StatiCa Connection to verify the grillage nodes, splices, stiffeners, bolts, welds and connections to embedded plates.

3. Verify the transfer into the concrete

The cast-in plate, anchors and welded reinforcement are designed in Connection. Where required, the model continues into Detail 3D to analyse the surrounding reinforced concrete.

This approach connects the global structural concept with the detailed verification of its most critical interfaces.

Optimising the connection for construction

Crane-support structures must also be designed around how they will be fabricated, lifted, installed, used and eventually removed. IDEA StatiCa enables engineers to compare alternative connection arrangements and investigate questions such as:

- →| Can a difficult site weld be replaced by a bolted splice?
- →| Can plate thickness be reduced by introducing a more effective stiffener?
- →| Are all welds accessible for fabrication and inspection?
- →| Can the grillage be divided into practical lifting sections?
- →| Are the cast-in plates compatible with the core reinforcement and formwork?
- →| Would headed studs or welded reinforcement provide a better anchorage arrangement?
- →| Can anchor forces be distributed more evenly?
- →| Does the connection provide adequate stiffness as well as resistance?
- →| Can supplementary reinforcement be avoided?

Visual results identify the components governing the design, helping engineers refine the connection where changes make a meaningful difference.

Making ambitious structural ideas achievable

IDEA StatiCa provides engineers with a coordinated way to design and understand these critical details. Connection can be used for the complex steel joints and cast-in plates, while Detail 3D extends the assessment into the surrounding reinforced concrete.

For crane supports, transfer structures and other demanding steel-to-concrete interfaces, this creates a clearer route from an ambitious engineering concept to a detailed, verifiable and buildable solution.

The projects referenced in this article illustrate the engineering challenges associated with crane-support structures. Their inclusion does not suggest that IDEA StatiCa was used in their design.

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