## CROSS Safety Report

# Potential misapplication of shear enhancement in crane base design guidance

**This month's report raises concerns that a worked example in published guidance on crane base design applies shear enhancement in circumstances where it might not be appropriate.**

### Reporter's submission

A reporter highlights a concern regarding the design approach presented in Worked Example 3 of CIRIA C761 – *Tower crane foundation and tie design*, which addresses the design of a square piled tower crane base. They have used this example previously but, on more detailed review, now question whether the treatment of shear checks is always appropriate, particularly where the crane overturning load creates tension within the piles on one side of the base.

The worked example considers overturning in both diagonal and orthogonal directions and designs the concrete base as a beam in each direction for bending, beam shear, and punching shear. The guide identifies that diagonal overturning controls the beam shear check for the example geometry.

In assessing shear in this direction, the example checks two shear planes. One is adjacent to the crane leg and the other is adjacent to the pile. Both are located on the side of the base where the crane leg and corresponding pile reaction are in compression.

The guide notes that, where the distance between a pile and a point load on a pile cap is less than two times the effective depth, part of the shear force may be carried directly into the pile via strutting. The example therefore applies shear enhancement at these locations and concludes that the shear capacity is adequate.

Shear enhancement is the increase in shear capacity that occurs when a load applied near a support is carried partly to that support through a diagonal compression strut in the concrete, rather than entirely through normal beam shear action. This behaviour is often described as arching action.

The reporter observes that the example does not check the corresponding shear planes on the opposite side of the base, where overturning places the crane leg and pile reaction in tension. The guide states that the shear and punching shear related to tension pile loads are less onerous by inspection.

However, the reporter questions whether shear enhancement can be applied when both the crane leg point load and the pile reaction act in tension, because in this condition there would be no compression strut through the depth of the base. They consider that shear enhancement should only be used when a compression load is acting through the concrete such that part of the force can strut directly into the pile. The reporter's concern is illustrated in **Figure 1**.

Based on their own review, the reporter states that their calculations indicate the tension-side shear capacity adjacent to the pile could be substantially over utilised if shear enhancement is not applied. They are concerned that if this interpretation is correct, the worked example may be misleading.

They stress that clarity on this matter is important, given the reliance placed on this worked example within industry.

### Key learning outcomes

**For designers and reviewers of crane base designs:**

- →| Designers should carefully consider whether shear enhancement is appropriate, particularly where the formation of a compression strut may be inhibited by applied loads and reactions acting in tension
- →| All potential shear interfaces, including those on the tension side of piled crane bases under overturning, should be explicitly assessed
- →| Where the applicability of shear enhancement is uncertain or contentious, designing for full shear demand without enhancement may provide a more conservative solution
- →| Designers should not rely on copying worked examples without fully understanding and checking the assumptions, load paths, and applicability to the specific geometry and loading conditions being considered
- →| Over-reliance on standardised solutions or spreadsheet implementations derived from guidance examples can obscure engineering judgement and increase structural risk

The full CROSS Safety Report, including links to guidance mentioned, is available on the CROSS website (report ID: 1552) at **www.cross-safety.org/uk/safety-information/cross-safety-report/potential-misapplication-shear-enhancement-crane-1552**.

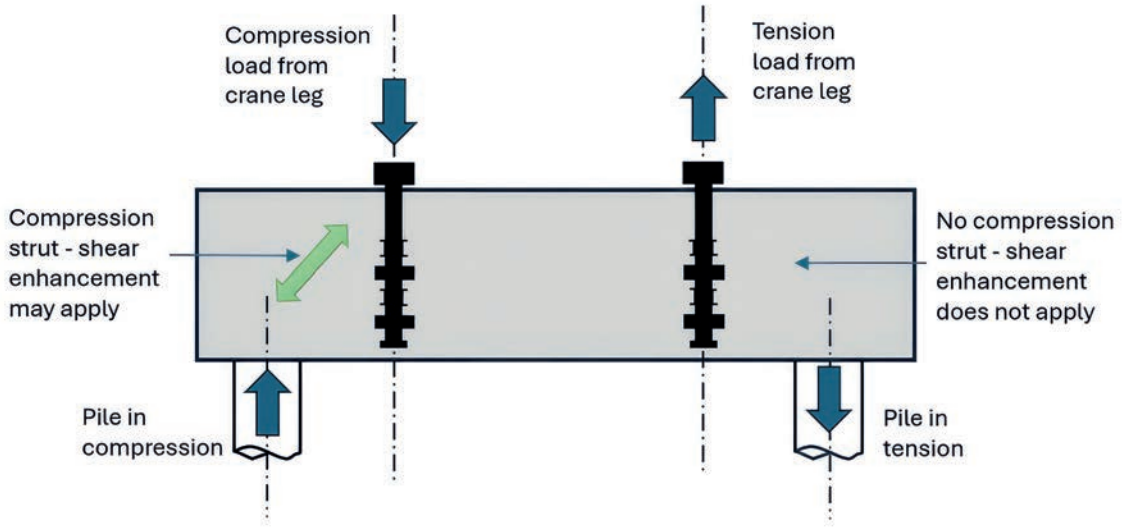


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**FIGURE 1:** Diagonal section through crane base illustrating reporter's concern

## Expert Panel comments

CIRIA C761 provides authoritative guidance on the design, installation, and maintenance of tower crane foundations and ties, emphasising safety and structural integrity. It is an important reference for designers and contractors, covering foundation types, geotechnical design, and independent checks to manage temporary works risk.

The reporter is thanked for raising this concern regarding Worked Example 3 within the guide. The Expert Panel considers the reporter's concern to be a valuable reminder of the importance of understanding the assumptions behind guidance documents and worked examples. These are intended to illustrate principles, but they are not a substitute for project-specific design checks. Designers should therefore remain alert to the limitations of any example and ensure that all load cases and, in this case, shear interfaces are assessed for the specific geometry and loading of their structure.

Members of the panel generally agree with the reporter's core point that shear enhancement cannot be applied in the CIRIA worked example when both the crane leg and the pile are in tension. In this situation no compression strut can form between the two locations based on the reinforcement detailing shown in the worked example.

Therefore, a designer should not rely on shear enhancement for the uplift condition. A simplified approach is to design the base to resist the full shear demand without enhancement. Although this approach may result in a deeper base and/or increased reinforcement, it offers practical advantages. It can lower the likelihood of errors during design, reduce dependence on intricate detailing, and make the reinforcement easier to fix on site, which collectively supports more reliable construction and improved structural safety.

Alternatively, a designer may undertake a strut and tie analysis. This will potentially optimise the solution, improve understanding of the required reinforcement detailing, and is aligned with established codified methods.

In addition to the reporter's concern, it is observed that Worked Example 3 in CIRIA C761, when assessing beam shear adjacent to the pile, assumes that the applied load acts in close proximity to the pile. Designers should be aware that this assumption may not align with the guidance given elsewhere in the CIRIA document or with the recommendations of PD 6687-2 and BS EN 1992-1-1.

Consideration should therefore be given to whether alternative assessment methods are more appropriate. An alternative approach to assessing shear in pile caps is set out in Technical Guidance Note (Level 2, Note 8): *Designing a pile-cap* **(www.istructe.org/journal/volumes/volume-91-(2013)/issue-12/technical-guidance-note-(level-2-no-8)-pile-cap)**.

Dealing with shear in deep sections adjacent to supports is a complex three-dimensional problem, there can be differences in expert opinion, and guidance develops over time. Readers would also benefit from understanding the guidance provided in the IStructE publication the *Design of transfer slabs* **(www.istructe.org/resources/guidance/design-of-transfer-slabs)**, together with the recommendations of BS EN 1992-1-1 and PD 6687-2.

The panel also notes a wider concern that aspects of structural design, including crane bases, are becoming increasingly standardised, with some designers relying solely on solutions or spreadsheets derived directly from worked examples. While this may streamline delivery, it can discourage engineering judgement and increase the risk that project-specific considerations are overlooked.

Crane foundations are generally single bespoke elements on projects that are safety critical and there are benefits to a simple approach to their design. Industry would benefit from an update to the guide that considers the issues presented in this report, the forthcoming second generation Eurocodes, latest developments in this area of design, and what is practical for industry.

An update also presents an opportunity to capture industry developments since the guide's initial publication, including cranked and tied tower cranes, internal and external climbing frames, and evolving chocking arrangements.

CROSS recommends that this report is brought to the attention of all those who undertake the design and construction of piled crane bases and further suggests that CIRIA consider providing additional clarification or expanded guidance in relation to Worked Example 3, to address the points highlighted in this report.