A review of recent developments in concrete connection systems

Hervé Poveda of Ancon Building Products **provides an insight into modern methods of connection, enabling demand for faster and safer product installation to be met.**

There are increasing demands on the connections between structural concrete elements. Clients, contractors and engineers now insist on faster and safer product installation, as well as optimum design performance. The introduction of new design Standards, such as BS EN 1992:1-1 (Eurocode 2)[1], has also substantially increased the lap lengths for reinforcing bars, posing a new challenge to designers and product manufacturers.

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Re-bend reinforcement continuity boxes

Reinforcement continuity boxes were introduced to the construction market 25 years ago. Originally developed in continental Europe, their main advantage over the traditional construction joint featuring projecting reinforcing bars is that no drilling of formwork is required. They consist of pre-bent reinforcement, usually in the shape of U-bars, inserted in a steel casing and covered with a lid. Once the formwork for the first-phase concrete is struck, the box lid is removed and the bars are straightened using a special tool.

In recent years, improvements have been made to these systems, such as:

- Galvanised steel casings to improve durability.
- Ductile reinforcement grades (eg, B500C), to avoid the risk of bar breakage during the straightening process, particularly when installing large-diameter bars at cold temperatures.
- Heavy-duty plasticised cardboard lids as an alternative to steel lids, to reduce the risk of injury during removal.

Nevertheless, reinforcement continuity boxes still have limitations:

- Reinforcing bar diameters are limited to 16mm, as this is the largest bar size that can be safely pre-bent and straightened without risk.
- Access may be difficult, which can complicate the bar straightening process or sometimes make it impossible.
- The box geometry and dimensions restrict pull-out bar lengths, meaning that bar configurations required by new design codes such as Eurocode 2 cannot be accommodated.

Starter bars

To overcome the limitations of reinforcement continuity boxes, a starter bar system is often used. This comprises two components:

- A female reinforcing bar, fitted with a threaded coupler and installed in the first phase of the structure, eg, a core wall.
- A male reinforcing bar, threaded at one end to connect into the coupler of the female bar. This is installed in the second phase of the structure, eg, a slab or perpend wall connecting to the first phase.

The principal advantage of starter bars is that there is virtually no restriction on bar diameter or bar length, meaning that their use is fully compatible with new design Standards such as Eurocode 2. However, they

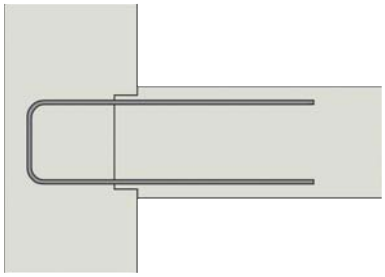

Figure 1: Typical connection.

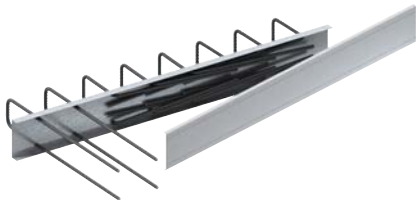

Figure 2: Typical reinforcement continuity box.

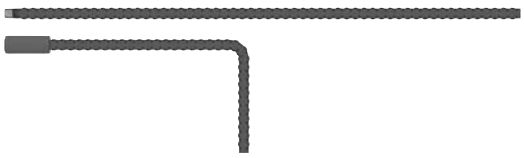

Figure 3: Starter bar system. Top – male component; bottom – female component.

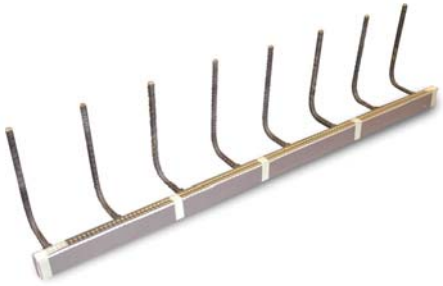

Figure 4: Coupler box, showing anchorage bar.

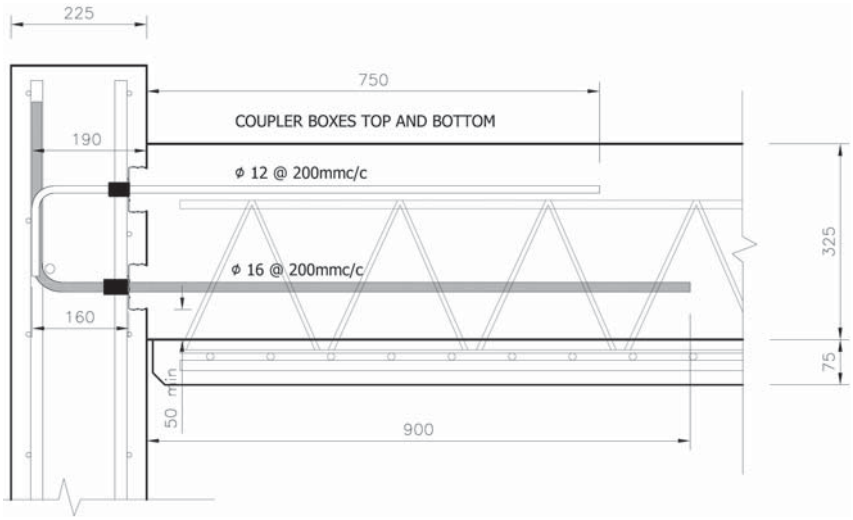

Figure 5 (right): Ancon coupler box, used in precast concrete off-site manufacture.

Figure 6: Ancon KSN Anchor.

Figure 7: KSN Anchor fixed to a standard timber carrier.

Figure 9: KSN Application – accommodates EC2 lap lengths.

are a step backwards when compared to reinforcement continuity boxes as far as speed of installation is concerned; female starter bars must be individually fixed within the reinforcement cage of the first phase, which can be a time-consuming process.

Coupler boxes

To accelerate the installation of starter bars, coupler boxes may be used. These consist of a series of female starter bars fitted to continuity boxes similar to those used with re-bend reinforcement systems. Compact reinforcing bar couplers must be used to ensure that the box depth and the female anchorage bar can be accommodated in the wall thickness.

Though originally developed for in-situ concrete construction, Ancon coupler boxes have recently been used with off-site construction, with the boxes installed in precast wall panels and the continuation bars installed on-site in the in-situ cast slabs. The application, for a large UK hospital construction project, is shown in detail in Figure 5.

In this specific case, coupler boxes were fixed within the precast wall panel reinforcement in just a fraction of the time required for conventional starter bars. This led to a substantial acceleration in the manufacture of the precast panels and the site programme. Another advantage of the system was that the bottom bars could be used in conjunction with latticed precast planks, which would not have been possible with re-bend reinforcement systems.

Though they present a number of advantages over re-bend continuity boxes and starter bars, coupler boxes still pose the problem of reinforcement congestion within first-phase concrete, due to awkward L-shaped anchor bars.

Threaded anchors

Pioneered in the Australian construction market where they have been successfully used for many years, threaded anchors are compact, reducing congestion in the wall. Again, the connection is made by threaded continuation bars, which mean EC2 lap lengths are easily accommodated. No on-site bar straightening is required.

When delivered to site, Ancon KSN Anchors are fixed to a timber carrier at the designed anchor spacing. The timber enables the installation of multiple anchors simultaneously and, when removed, the void left by the timber provides a shear key.

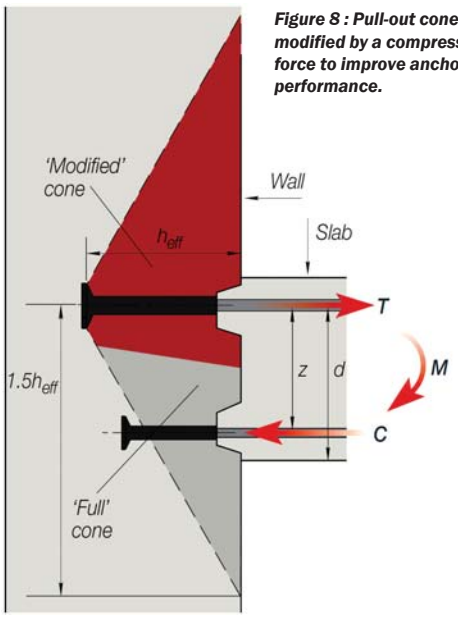

Figure 8 : Pull-out cone is modified by a compression force to improve anchor performance.

The KSN Anchor system has been comprehensively tested at Heriot Watt University. The test results demonstrate a significant enhancement in concrete cone pull-out capacity when the system is used in moment connections. This has enabled Ancon to offer relatively short anchor lengths which achieve the characteristic strength of the reinforcement.

The Ancon KSN was recently awarded 'Best Product in Show 2013' at the UK Concrete Show, NEC Birmingham.

Guarantee

In recent years, product designers and manufacturers have developed a number of systems to enable efficient connections between structural concrete components, for use with in-situ and precast construction.

New connection methods guarantee that the lap lengths required by the latest structural design Standards can be met, as well as offering faster, safer installation. ●

Reference

1. BRITISH STANDARDS INSTITUTION, BS EN 1992-1-1. *Eurocode 2. Design of concrete structures. General rules and rules for buildings*. BSI, London, 2004.