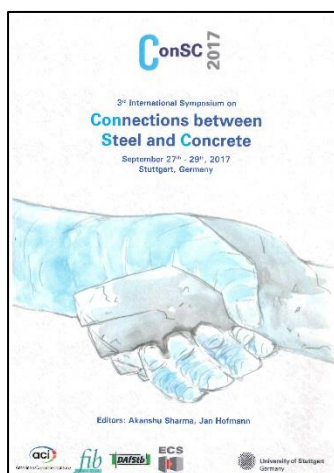


EC 2 adaptation to include steel to concrete connections.

As you may be aware from recent publications the release of EN 1992-4, or if you prefer EC 2-4, will include all types of post fixed or cast in anchors for connecting steel to concrete and more importantly it addresses how the concrete behaves locally around these products and includes models for checking the concrete capacity.



I have been involved in the field of post fixed anchor systems in the Irish market for the past 35 years. During that time, I have seen phenomenal developments in how anchors are produced, tested, regulated and incorporated into the design of a structure. In the same period, we saw the release of an Irish Code Of Practice for the design and installation of anchors and the release of BS 8539 Code of practice for the selection and installation of post-installed anchors in concrete and masonry. The release of EN 1992-4 will be the icing on the cake as it will contain everything included in the Irish and British codes and more.



I attended the 3rd International Symposium on connections between steel and concrete (Cons2017) in Stuttgart in September where it was confirmed that EN 1992-4 has been finished for some time but during the final edit the editors made grammatical changes that unintentionally impacted on the technical content by changing its meaning. This now requires all members of the working group to reconvene and rectify the changes. This they say will happen in early 2018 and there is no reason why the document won't be released by 2nd quarter of 2018.

While this document may already be known to some readers and will be state of the art with the inclusion of models on how to calculate concrete capacity for tension and shear connections, our experience has been that many engineers, contractors, suppliers and installers who work with the products have little knowledge of its content or origin.

EN 1992-4 is broadly the culmination of years of research by the Institute of construction materials (IWB) who have a long history within the university of Stuttgart and the material testing institute (MPA, University Stuttgart) founded at the end of the 19th century in 1884.

In 1984 a new professorship for fastening technology was established at the IWB and Professor Rolf Eligehausen became head of the department for fastening technology. The field of fastening technology developed very quickly and brought about research methods for different fastening systems such as headed studs, expansion anchors, bonded anchors and concrete screws.



In 1997 Prof Eligehausen set up a laboratory for the department that specialised in fastenings in concrete. By this time the IWB had become an important player on the global stage for fastening technology and much of their knowledge was used in the development of international standards and guidelines.

In 2009 prof Eligehausen was succeeded by prof Jan Hoffmann who continues to grow the knowledge and expertise of the department.

Between 1980 and today IWB have developed many test regimes to simulate anchor behaviour in cases where the concrete may be cracked, for fixings subjected to fire, seismic and dynamic applications, corrosion and long-term behaviour just to name a few. All these situations can now be included in the testing of an anchor system when it is being tested for a European Technical Assessment (ETA)

Over the 37-year timeframe the amount of testing and research has been extensive. Prof Eligehausen and his team also studied the failure behaviour of the concrete local to the connections and following experimental trials and tests they were able to develop design models to predict concrete failure for connections loaded in tension and in shear. These models were adopted by the European Organisation for Technical Approvals (EOTA) in their European Assessment Documents (EAD) and were also adopted by organisations like the International federation for structural concrete (FIB) and the European Engineered Construction Systems Association (ECS), the latter being the trade association for producers of cast in fastening products. This design method is commonly known as the “concrete capacity method” and forms the basis of the models that will be employed in EN 1992-4.

At an early stage in Prof Eligehausen’s research he identified the importance of including the product producers in the development of any standards and guidelines as, besides funding, they would be key players in communicating this information to the market. To this end he contacted Prof Artur Fischer of the fischer fixing company. Prof Fischer saw the importance of his company’s involvement and he started working with IWB in circa 1985. Soon afterwards companies like Hilti, Wurth, Halfen, Schock, Pfeifer, Jordhal and Peikko also became involved and are still involved today.

This impacted positively by ensuring that all products from the leading producers can be used with confidence as they have undergone rigorous testing to verify their suitability during the heavily regulated process to attain an ETA.

One area still to be investigated is the influence of supplementary reinforcement on the design resistance of any steel to concrete connection. This is not yet included in EN 1992-4, but it is something that will be included in later versions of the standard.

One would imagine that the presence of rebar in any concrete element must have a positive influence on the concrete capacity. However, the actual effect and its magnitude is still to be verified. Testing and research has already commenced in this area but as far as inclusion in the standards is concerned, this is something we will have to wait for.



In our experience, most engineers on the Irish market are using product selection software from the product manufacturers to determine the resistance capacity of connections. They are doing this without ever researching the EOTA documents, the product ETA or EN 1992-4. In many cases they are unaware of the fact that the producer's software is simply employing the models of EOTA or CEN (1992-4) to verify the concrete capacity for their connection detail. Having an understanding of EC 2-4 is vitally important to manage complex connections and allow for ingenuity and when required, engineering judgement, in cases where the actual situation falls outside the scope of the code. After all, true engineering should include the knowledge that enables the engineer to innovate and navigate new situations safely using first principles rather than just blindly following the book.

The lack of understanding among all duty holders is evident by the number of requests for site "proof tests" that we encounter. Personally, I am very supportive of site "preliminary tests" where the strength of a substrate is unknown and it is necessary to test several sample products to failure in order to verify the characteristic resistance and subsequently the design resistance of a product used in a substrate that may not be included in the ETA or referenced in any published data.

Proof testing can, in most cases, be futile as it proves nothing other than the interaction between the product and the concrete, something that is exhaustively covered in the ETA. BS 8539 has a section that mentions proof testing as a method to verify the quality of installation. In my opinion if there is a question over installation quality then the remedy must surely be to train the installers. If as an industry we continue to allow installation by persons in whom we have no confidence but are happy to check their work by means of site "proof testing" then I think we have missed the point and are attempting to cure the condition without ever addressing the cause.

We should also note the following with regard to on site proof testing:

90% of site "proof testing" is performed using a hand held tensile tester. 90% of these tests are performed on anchors with an ETA in new build concrete of excellent quality. Most of them are also applied to the anchor with the baseplate in position or with the bracket attached.

If we perform "proof tests" in the conditions described above, we need to consider the following. The design resistance of most connections will have been verified using the product software report. In most of these cases the concrete capacity will be decisive and will have a value based on the anchor group.

As stated in BS 8539 site "proof testing" is almost exclusively tensile testing as shear testing on site is very complex. When concrete failure occurs in tension it generally pulls a large cone of concrete out of the concrete local to the anchor group. To prove

concrete capacity, we need to use load spreader bridges to ensure we allow cone failure to develop. When we have no load spreader bridge or when the legs of the bridge are acting on an “in place” baseplate or bracket we are performing what is called a confined test. This does not allow cone failure to develop so it does not test the concrete capacity that is decisive in the report.



We are also only testing one anchor in the group. Even if cone failure could develop it is not representative of the group effect.

Also worth considering is the fact that we are generally applying a test action of 1.5 times the characteristic action. This will typically be lower than the internal tensile stress introduced in the anchor when applying the correct installation torque. This begs the question as to why we might apply a confined test load of 18 kN to an anchor that has already absorbed circa 30 kN during installation.

Finally, most engineers are now assuming that all anchor are located in the tension zone (cracked concrete). It is accepted that the resistance of the anchor will be lower when the concrete element is loaded, cracks appear, and the anchor is located in a crack. Most site tests are performed at construction stage and without the presence of the external forces that cause the concrete to deflect and crack. We could say that “proof testing” is performed mainly in concrete in its un-cracked state and verifies nothing about its expected performance in cracked concrete.

The Construction Fixing Association (CFA) who are the British and Irish trade association for the fixing industry are addressing this by promoting certified training for the installers. This way we can ensure that the anchors are correctly installed and will therefore provide the design resistance values as published in the ETA or in the software report.

It is the expressed opinion of the CFA that this is a much more fruitful use of time than performing meaningless “proof tests” to ironically verify that poorly installed anchors are acceptable. We at Masonry Fixing Services fully support this philosophy and we offer extensive installation training that covers the basic requirements to correctly install mechanical anchors, resin anchors and concrete screws. We do not support the theory that poorly installed anchors can be verified as fit for purpose after performing “proof tests”. If they are poorly installed they are wrong and this in our opinion amounts to gross error.



Should you have any questions on any of the content or any other aspects of EN 1992-4 please contact us on technical@masonryfixings.ie

You can also download our anchor software on <https://www.fischer-international.com/en/service/design-software-fixperience/download-fixperience>