# Designing with Stainless Steel Reinforcement

The revelation that stainless and carbon steels can be combined in concrete without requirements for isolation allows for designers freely to move from one steel type to the other. The mechanical properties of stainless steel are entirely compatable with carbon steel.

In practice, this means that stainless reinforcement follows all the criteria required of high tensile carbon steel. Stainless reinforcement conforms to BS8666. It has to pass the same mechanical tests as required of carbons steel set out in BS4449. The UK Highways Agency make it a requirement that all stainless rebar delivered to a UK Highways Agency site is UK CARES certified. This mirrors UK HA's existing requirements for carbon steel reinforcement. In practice, this means that most projects require CARES certification in the UK.

The impact of this interchangeability is that designers can consider where in the reinforced structure there is little risk of corrosion initiation of carbon steel. This should normally mean for a temperate environment that the bulk of the structural heavy steel will be carbon steel. This is set at depths which are proportional to the expected rate at which deleterious substances or rapid carbonation will start to have an harmful effect on the reinforcement - for example 120 years. The concrete will retain the passive alkaline environment of a good Portland Cement concrete mix at this level for the duration of the Service Life Design.

The stainless steel becomes the first line of defence allowing good traditional cover to be achieved between the carbon steel reinforcement and the surface of the concrete. The design and use of stainless and carbon steels becomes therefore the equivalent of using two shades of grey. The designer will assess levels of aggressive risk using tools now set out in the likes of EN206. Apply stainless selectively to comply with anticipated levels of aggressivity and design the rest of the reinforcement in carbon steel reinforcement at levels of low risk.

The depth to which steel reinforcement is incorporated into the design will be proportional for most applications to the rate of diffusion of deleterious particles and gradual reduction in the alkalinity of the concrete. The rate at which such particles travel by means of diffusion is related both to ambient temperature (for every 10°C rise in temperature the rate of diffusion approximately doubles) and other factors such as hydrostatic pressures – if applicable. By applying appropriate assessments to the design in this manner, we believe that the quantity of stainless steel required can be assessed with confidence. In a temperate climate as little as 2% of the carbon steel rebar need be replaced. The impact on the upfront cost of the project is not meaningful when compared to the costs saved over the service life of the structure. The long-term payback linked to removal of snagging defect costs and medium degradation of the reinforced structure with consequent maintenance costs should serve as powerful persuaders in Whole Life-Cycle cost analyses. Clearly, greater quantities of stainless reinforcement might be used if there is a pre-occupation with the cosmetic appearance of a structure.

The UK Highways Agency released in 2001 an important guide for the use of stainless steel reinforcement in concrete as it relates to Highways Agency structures. However, the importance of a Government body supporting the use of stainless is a significant step in the acceptance of the use of stainless steel. Unfortunately, the Advice Note, entitled BA84/02, pre-dated the recognition that stainless and carbon steels can be coupled in concrete without risk of galvanic reaction. Therefore, there is an ambivalent comment in the document regarding this issue. Regardless, the advantages to the document far outweigh any criticism. Importantly, there is recognition that cover can be reduced when using stainless reinforcement and crack widths can be increased.

Please also refer to Commonly used Stainless Alloys in UK.

It is important to note that time has not stood still since the release of BA84/02. The arrival of a new breed of stainless alloys for use in civil engineering will revolutionise what stainless steel is specified. It is now becoming dated and does not take into consideration the revisions to the British Standard BS6744:2001+A2:2009 which incorporates the onset of the new alloys.

These new alloys (Please refer to Lean Duplex Steels) will replace the austenitic stainless steels in nearly every civil

engineering application. However, as duplex alloys, they do not have the austenitic properties relating to continued strength at extreme temperatures and low magnetic permeability. The latter being generally best specified in Hot Rolled 316 in order to achieve lowest performance ratings.

And so we are reminded of a scene enacted thus:

ACT III SCENE I: France. Before Harfleur Castle – a fine and awesome looking edifice of some vintage with a hole in the wall.

Trumpets and sackbuts sound:

Enter KING HENRY avec entourage: EXETER, BEDFORD, GLOUCESTER, and Soldiers, with scaling-ladders and some busy looking fellows called enginieres:

KING HENRY V **"Once more unto the breach, dear friends, once more / Or close the wall up with our English dead!" (Pure William Shakespeare)**

What is less well documented by England's greatest bard is the dialogue between the King and the enginieres entailing the breach:

A man of French origin related by marriage to an English / Norman noble woman by name of Mouchelle was in heated debate with two others, namely, Atkinveryelder and Auld Arup (on a fact finding trip from the Norse countries). Each felt convinced that the English king should take their advice concerning the further opening of the breach during hostile engagement and the method of reconstruction following the assured victory – their ingenuity including a degree of miraculous foresight.

The enginieres had correctly surmised that until recently the breached area had appeared to be solid, had in fact shown the tell tale signs of rust marks (confused by some to be the ejection of daily ablutions down the side of the wall) and perceived therefore that a judicious prod from a battering ram would cause a catastrophic failure in the wall thereby creating the breach discussed in the Bard's fine utterances.

It transpired (and perhaps Mouchelle had inside knowledge on this matter) that the Harfleur wall had be reinforced by steel rather than resorting to the highly advanced and brilliant workmanship of northern Sheepfold types because it was viewed as being 'Too Expensive'. Well, we've all heard that before: an extra penny or pound spent today will save many pennies or pounds tomorrow.

As we know from the Bard's historical play, France was to rue the limited expenditure on civil engineering works. If only, their enginieres were oft heard saying 'after the fact', if only we had spent a little bit more money that miserable breach would never have happened. 'Twas Jacques who said, "do we really care, we won't be around in 30 years' time when it starts falling apart' Jacques had retired in the meantime to build castles from compacted sand on a strip of sun-drenched beach in Andalusia.

Sadly, once the victory had been celebrated, discounted cash flow analysis; a mistaken reliance on a too high rate of inflation; and unwise parsimony associated with periods of austerity following conflicts (also occasionally associated with periods of gross financial mismanagement by inept Governments), ensured that the miracle shiny metal concocted by Sir Berthier-Bryearleigh was never specified and was forgotten about until the early 1800s when a distant relative of the Baronet happened to be living in France stumbled on some chromium whilst riding a horse – but that's another story.

Some would say that we are no better today at helping ourselves to ensure that our structures do actually last. It is hoped that the more price stable duplexes will lead to a resurgence of interest and use in stainless steel for our national structures. Why fritter away money in repairs tomorrow when for a small extra cost you can get it right today? In times of projected austerity the need for intelligent specification that will not bankrupt and put at risk future generations should be of overriding importance.