What to do when prestressing in cold weather

by Paul Uno

The art of prestressing was first put into real form by innovators such as Eugene Freyssinet in the early 1900s. His most significant early bridge was the Pont le Veurdre in France, built in 1911, which was unfortunately destroyed during World War II. Following this event Freyssinet wrote: "I have always loved it more than any other of my bridges, and of all that the war has destroyed, it is the only one whose ruin has caused me real grief."

Today we have achieved greater spans and thinner members using prestressing than Freyssinet could ever have imagined, primarily due to higher grades of steel and concrete. With today's low relaxation steel strand at an ultimate tensile strength (UTS) of 1870MPa, which is around three times higher than conventional reinforcing steel; and concrete grades in the range 50MPa to 100MPa (three to five times higher than in the 1920s), designers and engineers are able to produce aesthetically pleasing structures that have very light weight-to-span ratios.

In considering the difference between prestressed and post-tensioned systems, prestressed elements usually come in the form of precast units such as rail track sleepers, bridge beams or more commonly hollow core precast floor and wall panels. The latter are cast on beds up to 170m long where 12.7mm steel strands (formed from seven individual wires) have been tensioned earlier to about 85% of their 184kN breaking load. A machine then traverses along this bed placing, vibrating and tamping a very low water-cement ratio concrete mix over these strands (and the tubes that form the hollows). Once the appropriate transfer strength has been reached, the panels are then saw-cut and removed from the casting beds.

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Post-tensioning is where the same prestressing strands are tensioned after the concrete has been placed. Post-tensioning ducts are profiled on site (usually parabolic draping) and steel strands are then fed through these thin metal ducts. Concrete of grade 32MPa and higher is then poured around the ducts and the projecting cables at the dead ends (these are where the seven wires that form the strand are opened to form what are called onions, thereby anchoring the cable into the concrete matrix).

The next day the prestressing strands are tensioned to an initial force about 25% of the total jacking force which equates to 46kN for 12.7mm strands. This is done to control any shrinkage cracking that may occur during the first 24h. The concrete must have a minimum compressive strength of 7MPa or else crushing of the concrete may occur during stressing.

Once the concrete has reached a minimum air-cured compressive strength of 22MPa, the final force is applied to the strand (usually about 85% of the UTS