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CPAA TECHNICAL NOTE

Radial Nibs, Spacers and Longitudinal reinforcement ends in Reinforced Concrete Pipe

Concrete Pipe Association of Australasia

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Purpose

This Technical Note sets out the reasons why corrosion of steel nibs, spacers and longitudinal reinforcement ends is not considered a durability issue for steel reinforced concrete pipe (SRCP), and how this is covered in AS/NZS 4058: 2007 (Clause 3.3.2).

Some specifiers are keen to nominate alternatives to mild steel such as stainless steel as well as caps to nibs. The issues around this are explained in this Technical Note. The important point is that minor corrosion of reinforcing steel such as nibs and longitudinal ends (none of which are part of the main circumferential structural reinforcing) is not a durability issue in SRCP.

Introduction

Cover to steel reinforcement in the manufacture of reinforced concrete pipes, is usually controlled by spacers, known as radial nibs or studs. These are either made from mild steel, stainless steel, or plastic and are attached to the perimeter of the reinforcement cage. The nibs or studs extend perpendicular to the cage and mould wall, ensuring that the design cover is maintained between the cage and the inner and outer surfaces of the pipe as shown in Figure 1.

In a vertical cast manufacturing process for reinforced concrete pipe, the reinforcement cage rests on the bottom of the mould. The ends of the longitudinals act as spacers or studs to maintain the design cover to the spiral/circumferential reinforcement at the end of the pipe. Longitudinals are in place to provide positional restraint to the spiral/circumferential (main) reinforcement during manufacture. They are not provided for any structural capacity in service and are therefore not important in terms of corrosion or durability.

The most widely used material for radial nibs is the same mild steel as that for the steel reinforcement cage. These types of nibs have been used for decades and have never been found to cause structural or durability issues that impact the service life of concrete pipe.

Similarly, plastic nibs have been used for decades, particularly in New Zealand, without structural or durability issues.

AS/NZS 4058: 2007 Precast concrete pipes (pressure and non-pressure) recognises that the exposed ends of steel nibs do not create a durability issue and specifically excludes cover requirements for radial nibs to circumferential reinforcement, end spacers and longitudinal reinforcement ends.

The following sections deal firstly with Steel Nibs, Spacers and Longitudinals, and secondly with Plastic Nibs, Spacers and Longitudinal Caps, along with a conclusion for each case.

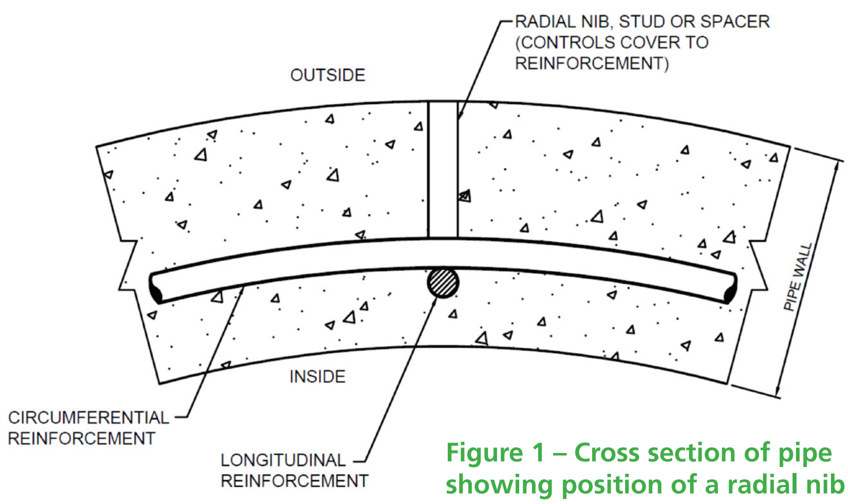

Figure 1 – Cross section of pipe showing position of a radial nib

Steel Nibs, Spacers and Longitudinals

Field investigations of long serving concrete pipelines in a variety of soil environments show that when exposed to aggressive ground waters, the nib rusts at the exposed tip. As the end of the nib oxidises, corrosion products build up over the nib tip and the dense oxide build up stifles further corrosion and reduces future corrosion rates. The small diameter of the nibs and longitudinals (limited to 10 mm Ø in AS/NZS 4058) reduces the potential volume of corrosion product, and as it has the freedom to expand out of the oxidised end, any corrosion does not lead to major spalling.

Figure 2 below illustrates a typical exposed longitudinal end.

Figure 3 shows a mild steel radial nib exposed for inspection on a 32 year-old pipe on the beach at Altona (Victoria) in the 1980's. There is no corrosion except at the normal concrete surface.

CORROSION MECHANISMS

Two mechanisms operate to encourage corrosion of a nib or stud at the exposed tip only.

Steel in concrete, when connected to bare steel in the soil (i.e. the exposed nib or stud tip in contact with the ground), sets up a galvanic couple and the resultant potential difference between the two causes the bare steel to become the anode and the steel in concrete the cathode.

At the anode, steel corrosion occurs:

$$Fe \longrightarrow Fe^{++} + 2e$$

At the cathode, oxygen and water are converted to hydroxyl ion, increasing the pore water pH:

$$O_2 + 2H_2O + 4e \longrightarrow 4\ OH^-$$

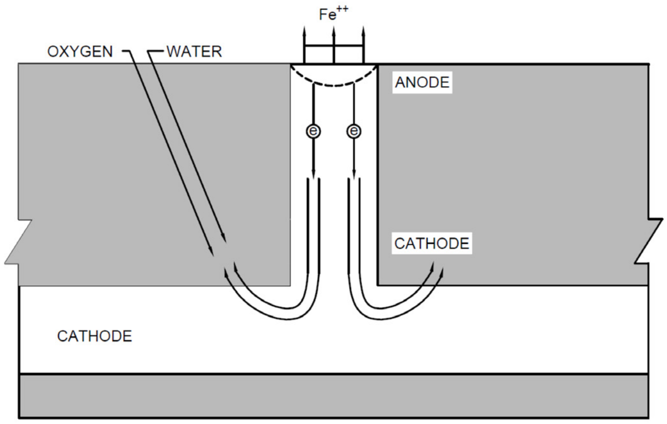

Figure 4 – Galvanic corrosion mechanism

The cathode in this instance is the steel reinforcing cage and the body of nibs combined, which results in a large surface area. The anode is the nib tip, which has a relatively small surface area. As such any corrosion which occurs at the stud tip can have an abnormally high rate. However, in the dense impermeable pipe concrete this rate is reduced considerably by the relatively high electrical resistivity of the covering concrete, and because oxygen diffusion to the cathodic steel is greatly restricted. In practice the corrosion rate is controlled by the

Figure 2 – Typical exposed longitudinal end

Figure 3 – Exposed steel nib in 32 year old pipe

diffusion of oxygen through the concrete to the steel reinforcement. In submerged or deeply buried concrete, oxygen diffusion to the structure itself is greatly reduced.

In addition to this "induced" corrosion mechanism, micro-cell corrosion can occur on the exposed stud tip. When oxygen diffusion rates restrict the induced corrosion rate, this process becomes the dominant cause of tip corrosion. Here, general rusting occurs just on the exposed steel surface as micro corrosion cells form under water droplets.

STUD CAPS

In the past some specifiers have required plastic or brass caps to be inserted over mild steel nibs or studs to protect them. Capping the nibs or studs with plastic caps has proven to be of no structural/durability value, but can be useful for improving the aesthetics of pipes or assisting with load class identification.

The use of brass caps would set up a galvanic couple with the mild steel that may accelerate corrosion.

CONCLUSION

Both field experience and corrosion theory support the use of mild steel studs in all but those cases where rust stains on the concrete surface are not acceptable for aesthetic reasons. Similarly, pipes which are cut or broken in two to make junctions, bends or short lengths will have exposed steel, particularly longitudinal reinforcement. It is very rare for corrosion of the exposed steel to penetrate sound concrete more than a few millimetres and no further corrosion should occur.

AS/NZS 4058 recognises the inert characteristics of studs on concrete pipe by stating that the concrete cover requirements do not apply to radial nibs, end spacers and longitudinal reinforcement ends.

Plastic Nibs, Spacers and Longitudinal Caps

Plastic spacers are widely used in concrete pipe and other precast products. The plastic spacers are fitted onto the steel reinforcement cage and extend to the inner or outer edge of the pipe wall to provide the design cover. These spacers are significantly smaller than those used in typical structural reinforced concrete members. They are intended to hold the reinforcement in place; not sustain the heavy loads that some in-situ concrete members endure. For this reason, they are specifically excluded from the scope of AS/NZS 2425 – Bar Chairs in Reinforced Concrete.

Plastic caps are also used sometimes on the end of the cage longitudinals to provide cover to the exposed steel ends.

The plastic nibs or caps are sometimes visible on the surface as shown in Figs 5 and 6 below.

Figure 5 Exposed plastic cap fitted to longitudinal reinforcement

Figure 6 Radial plastic nib

Sometimes a small amount of differential shrinkage occurs between the plastic nib and the cast concrete due to the curing temperatures required by the manufacturing process. This could theoretically lead to ingress of water and corrosion under the cap and at the base of the stud. Extensive field experience has shown that this does not result in corrosion of the steel reinforcing cages as in the presence of moisture autogenous occurs and seals any small gap arising from the differential shrinkage. In the case of aggressive environments, it may be appropriate to specify that these are not used, although in most cases it would be preferable to discuss the specific circumstances with the manufacturer.

Figure 7 below illustrates autogenous healing occurring between the start and the end of a New Zealand watertightness test carried out on a test pipeline comprising 4 pipes, in accordance with Clause D4.2 of AS/NZS 4058.

It is worth noting that the leakage in Figure 7 was only visible under a head of 9m pressure at the start of the watertightness test and has completely sealed by the end of the test. Typical gravity stormwater applications would operate under much lower working pressures, so this leakage is unlikely to occur.

CONCLUSION

Field experience has shown that the use of plastic nibs or spacers do not result in any durability issues when used in the manufacture of steel reinforced concrete pipe. The decision around the type of bar nib, stud or spacer to be used should rest with the manufacturer.

Fig 7 – Plastic radial nib – water seepage before and after NZ watertightness test.

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