# Technical details from TAG paper

## 4. Product

Bilcon Industries P/L manufactures a range of circular precast steel reinforced concrete pipes that are intended for non-pressure drainage or service duct sleeve applications in micro-tunnelled situations. Refer to Figure 2.

Please note Figure 2 shows lifting holes which are not permissible in AS/NZS 4058:2007 where pipes are required to be watertight. For handling purposes lifting anchors are normally embedded in the wall of the pipe but may be omitted if not required.

Bilcon Precast RCJP tech brochure could be accessed from the Useful link.

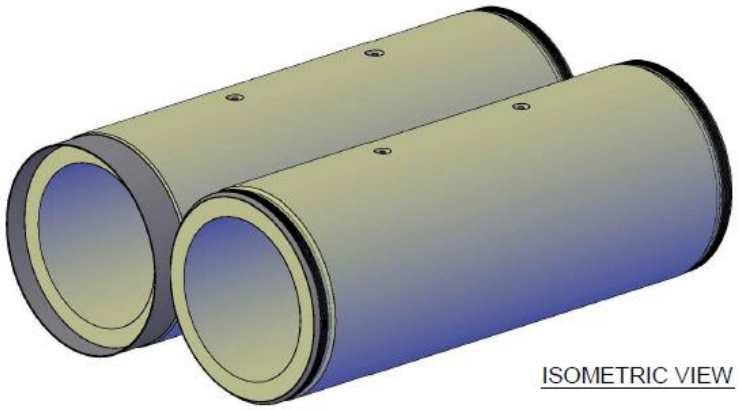



**Figure 2: Bilcon RCJP**

**TABLE 1: ATTRIBUTES OF PRECAST NON-PRESSURE CONCRETE JACKING PIPES**

| Attribute | Definition | Value |
|---|---|---|
| Size | DN (Nominal Diameter) | 300 - 3000 mm |
| Strength | Load Class | Class 2-10, 13-470 kN/m (Proof) |
| Pressure Rating | Watertightness | 90kPa |
| Joint selection | Elastomeric seal | |
| Joint types | Spigot-Socket | |
| Pipe Lengths | Effective Laying Length | Standard length 2000mm. Lengths may be customer specified to a maximum of 3050mm |
| Pipe Masses | Lifting Mass | 230kg – 22,500kg |

**TABLE 2: DIMENSIONS OF PRECAST NON-PRESSURE CONCRETE JACKING PIPES**

| Internal Dia. (mm) | External Dia. (mm) | Wall Thickness (mm) | Effective Length (mm) | Packer Thickness (mm) | Steel Collar Thickness (mm) | Weight (kg) | Max Jacking Load[2] (tonnes) | Collar Type |
|---|---|---|---|---|---|---|---|---|
| 300 | 450 | 75 | 2000 | 12 | 2 | 430 | 75 | F |
| 400 | 650 | 125 | 2000 | 12 | 2 | 990 | 204 | F |
| 450 | 650 | 100 | 2000 | 12 | 2 | 830 | 210 | F |
| 500 | 675 | 87.5 | 2000 | 12 | 2 | 775 | 147 | F |
| 500 | 730 | 115 | 2000 | 12 | 2 | 1,070 | 170 | F |
| 600 | 775 | 87.5 | 2000 | 12 | 2 | 910 | 173 | F |
| 600 | 875 | 137.5 | 2000 | 12 | 2 | 1,530 | 270 | F |
| 700 | 875 | 87.5 | 2000 | 12 | 2 | 1,040 | 199 | F |
| 700 | 960 | 130 | 2000 | 12 | 2 | 1,630 | 350 | F |
| 800 | 1052 | 126 | 2000 | 12 | 4 | 1,760 | 462 | F |
| 900 | 1140 | 120 | 2000[1] | 18 | 4 | 1,850 | 481 | F / B |
| 1000 | 1250 | 125 | 2000[1] | 18 | 4 | 2,125 | 558 | F / B |
| 1050 | 1300 | 125 | 2000[1] | 18 | 4 | 2,220 | 583 | F / B |
| 1200 | 1470 | 135 | 2000[1] | 18 | 4 | 2,720 | 727 | F / B |
| 1350 | 1600 | 125 | 2000[1] | 18 | 6 | 2,780 | 734 | B |
| 1500 | 1780 | 140 | 2000[1] | 18 | 6 | 3,470 | 935 | B |
| 1650 | 1950 | 150 | 2000[1] | 18 | 6 | 4,080 | 1,113 | B |
| 1800 | 2170 | 185 | 2000[1] | 18 | 6 | 5,540 | 1,559 | B |
| 2000 | 2410 | 205 | 2900 | 18 | 8 | 9,890 | 1,944 | B |
| 2100 | 2470 | 185 | 2900 | 18 | 8 | 9,245 | 1,797 | B |
| 2400 | 2810 | 205 | 2900 | 18 | 10 | 11,680 | 2,300 | B |
| 2500 | 3000 | 250 | 2900 | 18 | 10 | 15,035 | 3,020 | B |
| 3000 | 3500 | 250 | 2900 | 18 | 10 | 17,770 | 3,573 | B |

1. Also available in effective lengths of 2900mm
2. Max Jacking Loads calculated in accordance with BS EN 1916:2002 Annex B, with total safety factor of 3.33
3. The DN800 (960mm OD) pipe was used in Melbourne Airport Rail Link project as a sleeve to secure 337 OD MSCL watermain

### 4.1 Manufacturing Process

Bilcon pipes are manufactured either by horizontal centrifugal spinning or a vertical wet cast process. The horizontal centrifugal spinning process is used for the manufacture of thin walled pipes. Pipes of substantial wall thickness are manufactured by the vertical wet cast process where the compaction of the concrete is achieved with either self -compacting concrete or external form vibrators.

### 4.2 Materials

#### 4.2.1 Concrete

Bilcon batches its own ready-mix concrete as part of the manufacturing process of reinforced concrete pipe. It can vary the concrete mix design details or proportions to achieve specification criteria such as compressive strength, permeability, density or slump.

Ordinary Portland Cement (OPC), Sulphate-Resisting Cement (SRC), or Calcium Aluminate Cement (CAC) are available manufacturing options and should be specified by the purchaser to accommodate the environment and drain water quality.

### 4.2.2 Reinforcement

Bilcon concrete pipe reinforcement is in the form of circular cages concentric with the longitudinal axis of the pipe. A singular cage is used for DN 300 to DN 800 and a double cage is used for DN 900 to DN 3000. Further information, please refer to the detailed drawings.

#### **4.2.2.1** *Reinforcement cover*

The minimum concrete cover to the steel reinforcement is nominated in AS 4058:2007 and varies depending on method of manufacture and wall thickness. Additional cover can be provided where the proposed drain will be subjected to corrosion by salt water or other aggressive ground water.

### 4.2.3 Joints

Bilcon pipes are manufactured as double spigot joints (plain ended) where one end is fixed with an in-built Collar or Fixed-In Collar with elastomeric seal from factory which will be connected to the other pipe's spigot end fitted with an elastomeric seal, refer to Figure 2.

Jacking pipes from DN300 to DN800 are manufactured with a Fixed-In Collar and pipes from DN900 – DN3000 are manufactured with a Built-In collar. Both Collars are of 'flush type' meaning their OD is equal to the pipe OD, which make the trenchless installation easier.

Before joining two pipes, the Collars are attached with 'Chipboard Packing' as shown in Figure 3 not to allow either pipe ends to touch each other.

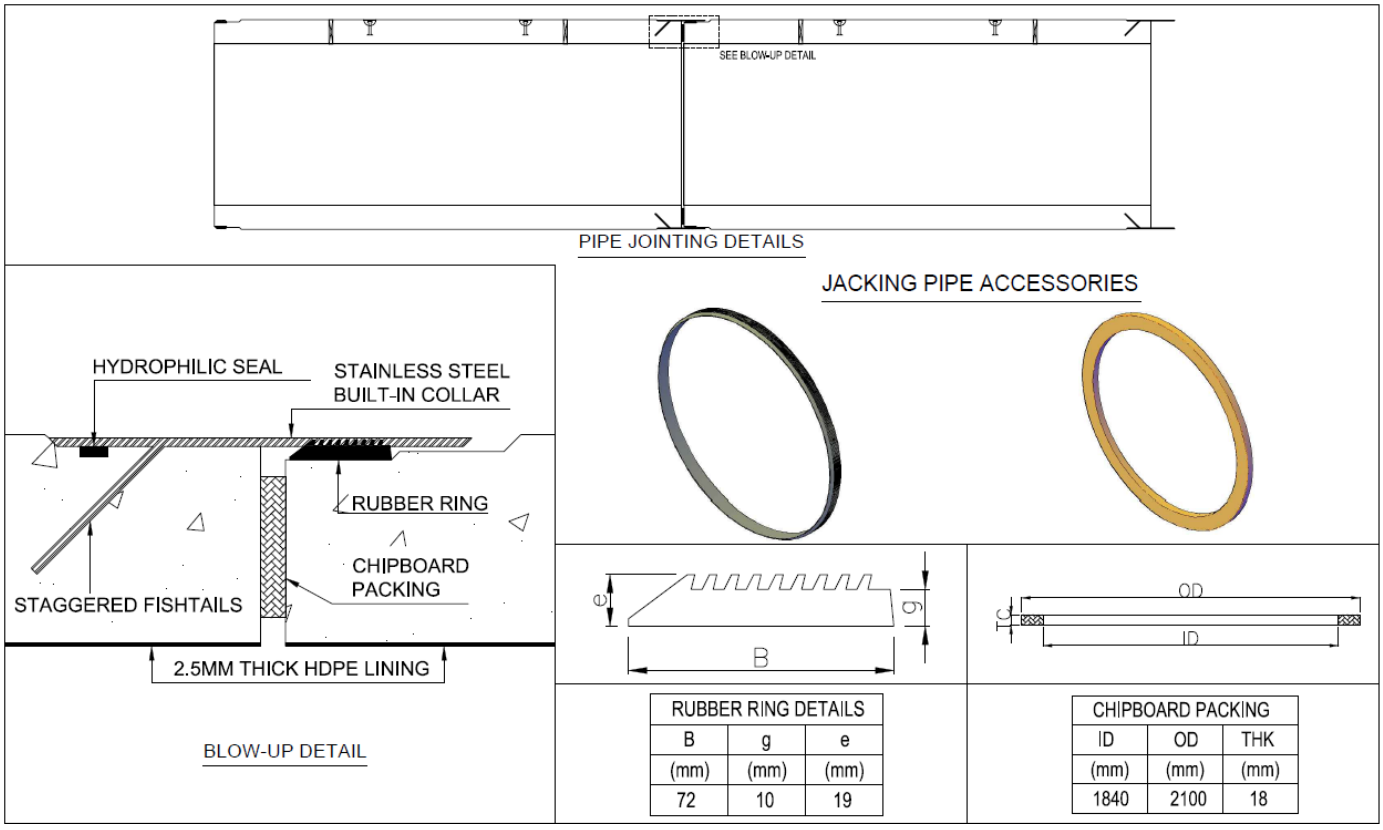
Bilcon Fixed-In Collar pipes are named as F Series Pipes and the Built-In collar pipes are named as B Series Pipes, like Humes S-Series and J-Series.

The collars are generally steel and made with mild steel or stainless steel grade SS316. These joint types are referred to as watertight joints and are designed to be flexible to accommodate deflection and movement of the joint. The mild steel collar comes with factory epoxy coating.


**Figure 2: Elastomeric seal fitted to spigot end**

**Figure 3: Chipboard Packing fixed to Collar end**

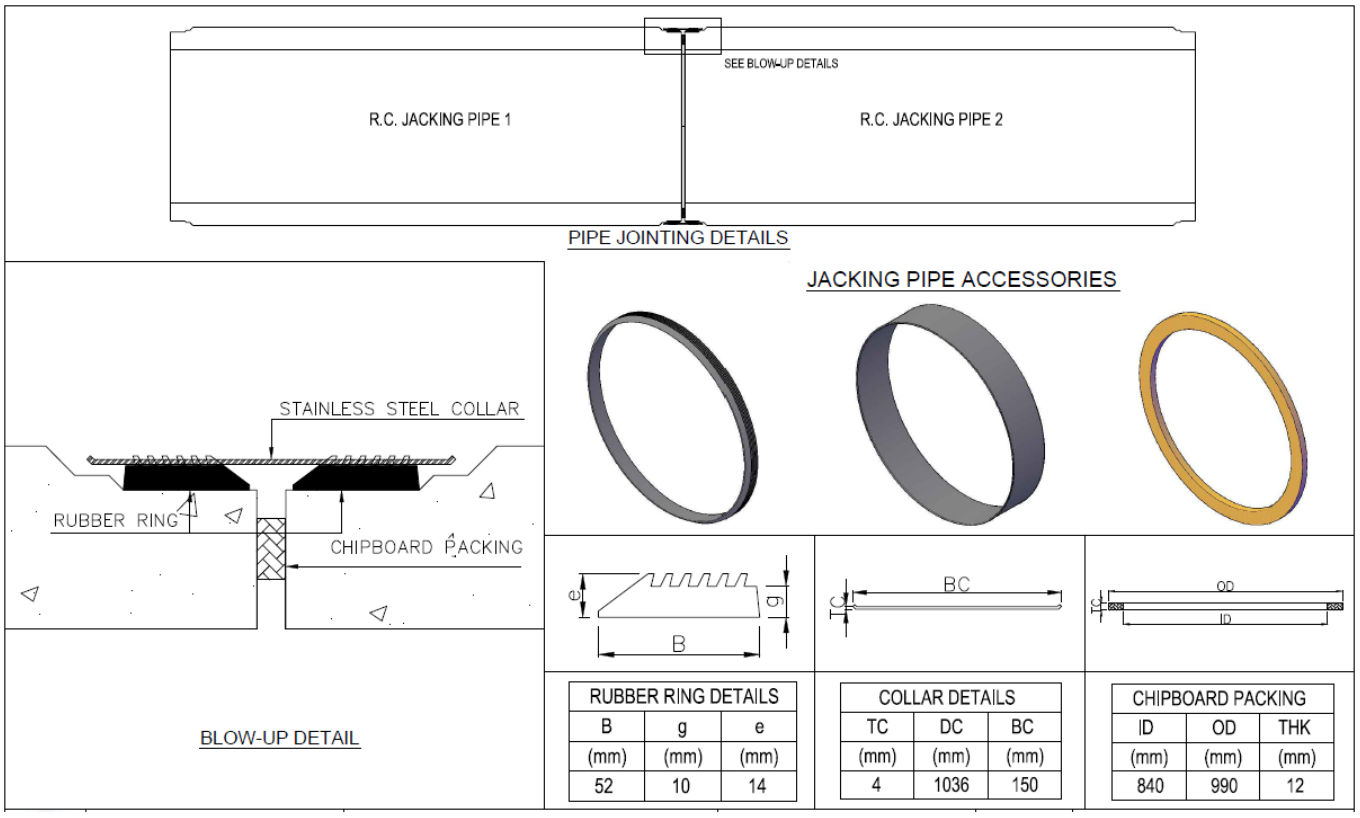
## Typical B-Series Detail




| RUBBER RING DETAILS | | |
|---|---|---|
| B | g | e |
| (mm) | (mm) | (mm) |
| 72 | 10 | 19 |

| CHIPBOARD PACKING | | |
|---|---|---|
| ID | OD | THK |
| (mm) | (mm) | (mm) |
| 1840 | 2100 | 18 |

## Typical F-Series Detail




| RUBBER RING DETAILS | | |
|---|---|---|
| B | g | e |
| (mm) | (mm) | (mm) |
| 52 | 10 | 14 |

| COLLAR DETAILS | | |
|---|---|---|
| TC | DC | BC |
| (mm) | (mm) | (mm) |
| 4 | 1036 | 150 |

| CHIPBOARD PACKING | | |
|---|---|---|
| ID | OD | THK |
| (mm) | (mm) | (mm) |
| 840 | 990 | 12 |

Detailed drawings of Bilcon RCJP details for DN500 x 2m x 87.5mm wall thickness could be accessed from the Useful link.

### 4.2.4 Joint material

The elastomeric seal rings are manufactured from natural rubber (NR50) in compliance with AS 1646. Seals are bagged, tagged and crated prior to storage at room temperature away from sunlight and sources of ozone, ready for despatch to site and installation.

### 4.2.5 Elastomeric joints

When pressure or watertightness classes are specified, elastomeric seal joints are the default joint type.

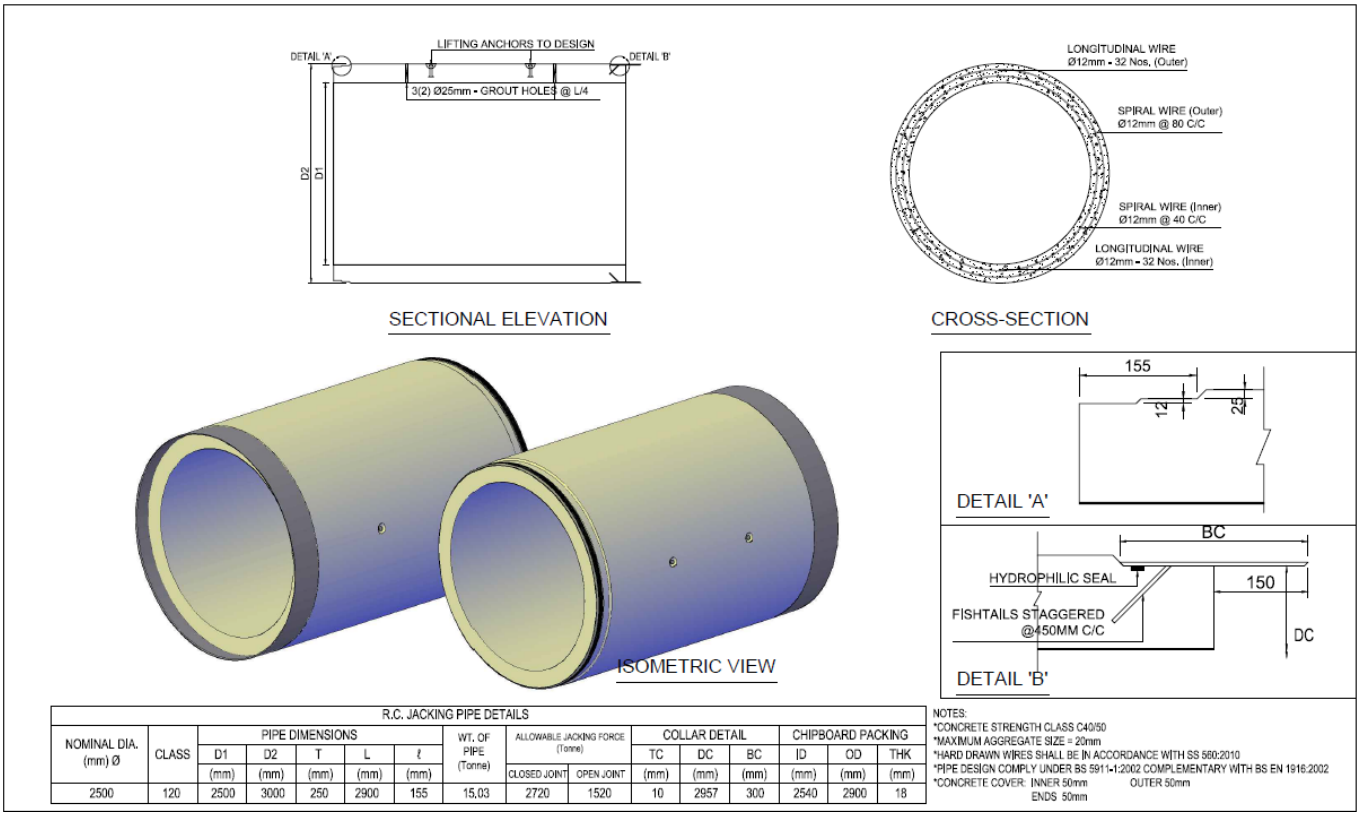
### 4.2.6 Deflection

The pipeline can be deflected at elastomeric seal joints. The deflection angle is up to 1.8° for sizes DN 300 up to DN 750 and up to 0.8° for sizes between DN 825 and DN 3000.

### 4.2.7 Fittings

The fittings consist of lifting anchors, steel collars, rubber rings and shipboard packers.

## Typical Pipe Properties




R.C. JACKING PIPE DETAILS

| NOMINAL DIA. (mm) Ø | CLASS | PIPE DIMENSIONS | | | | | WT. OF PIPE (Tonne) | ALLOWABLE JACKING FORCE (Tonne) | | COLLAR DETAIL | | | CHIPBOARD PACKING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D1 | D2 | T | L | ℓ | | CLOSED JOINT | OPEN JOINT | TC | DC | BC | ID | OD | THK |
| | | (mm) | (mm) | (mm) | (mm) | (mm) | | | | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) |
| 2500 | 120 | 2500 | 3000 | 250 | 2900 | 155 | 15.03 | 2720 | 1520 | 10 | 2957 | 300 | 2540 | 2900 | 18 |

NOTES:
*CONCRETE STRENGTH CLASS C40/50
*MAXIMUM AGGREGATE SIZE = 20mm
*HARD DRAWN WIRES SHALL BE IN ACCORDANCE WITH SS 560:2010
*PIPE DESIGN COMPLY UNDER BS 5911-1:2002 COMPLEMENTARY WITH BS EN 1916:2002
*CONCRETE COVER: INNER 50mm OUTER 50mm
ENDS 50mm

### 6.3 Proof load Vs Crushing Load in AS4058 and BS EN 1911 (complementary to BS EN 1916)

TUV SUV PSB Singapore has issued a Certificate of Conformity Ref. CLS1A 17 11 80522 007 to Bilcon RCJP complying with BS EN 5911.

The below Table 10 refers to Minimum Crushing Loads for strength class 120 concrete jacking pipes in accordance with BS 5911. The Proof Load is calculated 67% of this minimum crushing load.

Reference to Table 4.2 in AS4058 for Class 4 Concrete Jacking Pipes, the Proof Loads and Ultimate Loads are provided.

The below Summary Table compares both AS4058 Class 4 and BS 5911 (BS EN 1916) Class 120. When compared, we can conclude the Australian Standard is conservative compared to British Standard.

For Australian applications, Bilcon refers to Proof Load as referred in AS4058.

| Specification | PIPE DIAMETER | CLASS | Load Range Description | |
|---|---|---|---|---|
| AS4058 | | | Proof Test Load | Ultimate Test Load |
| | 600 | 4 | 52 | 78 |
| | 900 | 4 | 74 | 111 |
| | 1200 | 4 | 92 | 138 |
| BS/EN 5911 | | | Proof Load (Minimum Crushing Load x 0.67) | Minimum Crushing Load |
| | 600 | 120 | 48.24 | 72 |
| | 900 | 120 | 72.36 | 108 |
| | 1200 | 120 | 96.48 | 144 |

**Extract from BS 5911-1:2002** Concrete pipes and ancillary concrete products - Part 1: Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints (complementary to BS EN 1916:2002)

**Table 10 — Minimum crushing loads for strength class 120 jacking pipes**

| Nominal size<br>DN | Minimum crushing load, $F_n$<br>kN/m |
|---|---|
| 450 | 54 |
| 500 | 60 |
| 600 | 72 |
| 700 | 84 |
| 800 | 96 |
| 900 | 108 |
| 1000 | 120 |
| 1200 | 144 |
| 1400 | 168 |
| 1500 | 180 |
| 1600 | 192 |
| 1800 | 216 |
| 2000 | 240 |
| 2200 | 264 |
| 2500 | 300 |
| 2800 | 336 |
| 3000 | 360 |
| NOTE Table NA.5 of BS EN 1295-1:1998 recommends that the minimum value of safety factor for the structural design of reinforced pipelines should be increased from the normal 1.25 to 1.5 if, as is the case of BS EN 1916:2002, the proof load is 67 % of the minimum crushing load. | |

## TABLE 4.2

## TEST LOADS FOR LOAD CLASSES 2 TO 10 (CIRCUMFERENTIALLY REINFORCED CONCRETE PIPES)

| Pipe dia. | Proof or ultimate test load (see Note 1) kN/m | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Load Class (see Note 2) | | | | | | | | | | | |
| | Class 2 (X) | | Class 3 (Y) | | Class 4 (Z) | | Class 6 | | Class 8 | | Class 10 | |
| DN | Proof | Ult. | Proof | Ult. | Proof | Ult. | Proof | Ult. | Proof | Ult. | Proof | Ult. |
| 100 | 13 | 20 | 20 | 30 | 26 | 39 | — | — | — | — | — | — |
| 150 | 13 | 20 | 20 | 30 | 26 | 39 | — | — | — | — | — | — |
| 225 | 14 | 21 | 21 | 32 | 28 | 42 | — | — | — | — | — | — |
| 300 | 15 | 23 | 23 | 34 | 30 | 45 | 45 | 56 | 60 | 75 | 75 | 94 |
| 375 | 17 | 26 | 26 | 39 | 34 | 51 | 51 | 64 | 68 | 85 | 85 | 106 |
| 450 | 20 | 30 | 30 | 45 | 40 | 60 | 60 | 75 | 80 | 100 | 100 | 125 |
| 525 | 23 | 35 | 35 | 52 | 46 | 69 | 69 | 86 | 92 | 115 | 115 | 144 |
| 600 | 26 | 39 | 39 | 59 | 52 | 78 | 78 | 98 | 104 | 130 | 130 | 163 |
| 675 | 29 | 44 | 44 | 65 | 58 | 87 | 87 | 109 | 116 | 145 | 145 | 181 |
| 750 | 32 | 48 | 48 | 72 | 64 | 96 | 96 | 120 | 128 | 160 | 160 | 200 |
| 825 | 35 | 52 | 52 | 78 | 69 | 104 | 104 | 129 | 138 | 173 | 173 | 216 |
| 900 | 37 | 56 | 56 | 84 | 74 | 111 | 111 | 139 | 148 | 185 | 185 | 231 |
| 1050 | 42 | 63 | 63 | 95 | 84 | 126 | 126 | 158 | 168 | 210 | 210 | 263 |
| 1200 | 46 | 69 | 69 | 104 | 92 | 138 | 138 | 173 | 184 | 230 | 230 | 288 |
| 1350 | 50 | 75 | 75 | 113 | 100 | 150 | 150 | 188 | 200 | 250 | 250 | 313 |
| 1500 | 54 | 81 | 81 | 122 | 108 | 162 | 162 | 203 | 216 | 270 | 270 | 338 |
| 1650 | 58 | 87 | 87 | 131 | 116 | 174 | 174 | 218 | 232 | 290 | 290 | 363 |
| 1800 | 62 | 93 | 93 | 139 | 124 | 186 | 186 | 233 | 248 | 310 | 310 | 388 |
| 1950 | 66 | 99 | 99 | 149 | 132 | 198 | 198 | 248 | 264 | 330 | 330 | 413 |
| 2100 | 70 | 105 | 105 | 158 | 140 | 210 | 210 | 263 | 280 | 350 | 350 | 438 |
| 2400 | 78 | 117 | 117 | 176 | 156 | 234 | 234 | 293 | 312 | 390 | 390 | 488 |
| 2700 | 86 | 129 | 129 | 194 | 172 | 258 | 258 | 323 | 344 | 430 | 430 | 538 |
| 3000 | 94 | 141 | 141 | 212 | 188 | 282 | 282 | 353 | 376 | 470 | 470 | 588 |
| 3300 | 102 | 153 | 153 | 230 | 204 | 306 | — | — | — | — | — | — |
| 3600 | 110 | 165 | 165 | 248 | 220 | 330 | — | — | — | — | — | — |
| 3900 | 118 | 177 | 177 | 266 | 236 | 354 | — | — | — | — | — | — |
| 4200 | 126 | 189 | 189 | 284 | 252 | 378 | — | — | — | — | — | — |

NOTES:

1 The test load for a particular application should be determined in accordance with AS/NZS 3725.

2 The corresponding traditional alphabetical classes are shown in brackets (e.g., Class 4 = Class Z).

3 The proof load magnitude is proportional to the class number (e.g., Class 8 = Class 2 × 4).

4 Proof loads for intermediate classes may be obtained by linear interpolation between the closest tabulated values rounded upward to the nearest whole number, e.g., for a DN 300 size class pipe, the proof load for Class 7 is (45 + 60)/2 = 53 kN/m.

5 For pipe below Class 6, the ultimate load value is calculated to be 1.5 times the proof load and for Class 6 and above the ultimate load value is calculated to be 1.25 times the proof load.

## 9. Customer Reference

Since 1960's Bilcon precast concrete jacking pipes have been used in Singapore and Asia.

In Australia the following Govt and Private entities have used them.

| Item | Water Agency / Private Entity | Contractor | Year | Diameter | Length in metres |
|---|---|---|---|---|---|
| 1 | Greater Western Water, VIC | Laing O'Rourke | 2023 | DN300 | 154 |
| 2 | Greater Western Water, VIC | Laing O'Rourke | 2023 | DN800 | 140 |
| 3 | Water Corporation, WA | DM Civil (rail track) | 2019 | DN900 | 100 |
| 4 | Water Corporation, WA | Rob Carr (rail track) | 2018 | DN1200 | 126 |
| 5 | Manjimup Carpenters Dam, WA (Redd Moon Holdings) | GM Microtunneling | 2023 | DN500 | 204 |
| 6 | Larrakeyah Defence Precinct Work Package | Laing O'Rourke (DJ MacCormick Contractors P/L) | 2020 | DN1650 | 684 |

Till to-date there are no reported failures from the above installations.

Bilcon RCJP have been used by the following countries:

- Singapore
- Brunei
- India

## 10. Q&A during assessment of for use of DN800 (960 OD) x 2m Bilcon RCJP in Melbourne Airport Rail Link project

**Q1**: Confirm if annulus between carrier pipe and jacking pipe should be fully grouted with cementitious non-shrink grout as raised by GWW below

**A1**: GWW raise a sound argument for the back grouting of the annulus between the carrier and the encasing pipe. However, there are a few considerations that encourage the annulus to remain free from grout, this includes:

- Future accessibility of the pipe. Although the arrangement poses access difficulties, if the annulus remains grout free GWW are left with an asset with better O&M capabilities. This assumes that the construction team can install the arrangement as per MRWA-W-210. Note that construction will manage this closely with the GWW auditor.
- The encasing pipe is intended to be founded within Basalt. This reduces the risk of foreign material entering through a defect in the encasing pipe and damaging the carrier.

**Q2**: Confirm if lifting holes for the RCP jacking pipe should be treated with cementitious non-shrink grout prior to pipe jacking.

**A2**: It is assumed that the lifting lugs/holes designed by the pipe supplier are suitable for use and do not compromise in the allowable jacking force and pipe loading of the product. However, as the lifting lugs/holes may be subject to reduced reinforcement cover, the holes are recommended to be treated with cementitious non-shrink grout prior to pipe jacking.

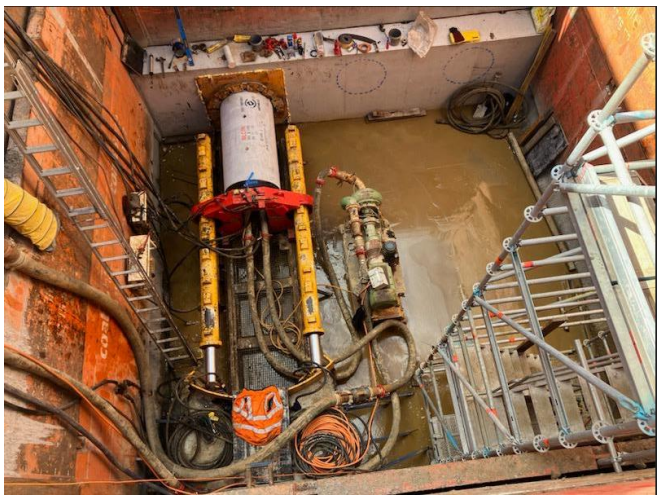



**Figure 3: Bilcon RCJP DN800 in Melbourne Airport Rail Link Project**