## THRUST BLOCKS

When an internal pressure is applied to a pipeline, unbalanced forces develop at all changes of size and direction in a pipeline.

Self restraining joints can be used in soft ground, steep inclines and in areas where there is a limited space.

One of the most common methods of providing resistance to thrust forces is the use of concrete thrust blocks.

Resistance is provided by transferring the thrust force to the soil through the larger bearing area of the block such that the resultant pressure against the soil does not exceed the horizontal bearing strength of the soil.

Design of thrust blocks entails determining the appropriate bearing area of the block for a particular set of conditions. The parameters involved in the design include pipe size, design pressure, angle of the bend (or configuration of the fitting involved), and the horizontal bearing strength of the soil.

The following are general criteria for bearing block design:

Bearing surface should, where possible, be placed against undisturbed soil. Where it is not possible, the fill between the bearing surface and undisturbed soil must be compacted to at least 90% Standard Proctor Density.

Block height (h) should be equal to or less than one-half the total depth to the bottom of the block, (Ht), but not less than the pipe diameter (D')

Block height (h) should be chosen such that the calculated block width (b) varies between one and two times the height.

The required bearing block area is: $$A_b = hb = \frac{T}{S_b}$$

Then, for a horizontal bend: $$b = \frac{2\,S_f\,PA\sin(\theta/2)}{h\,S_b}$$

**Where:**

- $S_f$ = Safety Factor (usually 1.5 for thrust block design)
- **P** = Maximum System Pressure (kg/cm$^2$)
- **A** = Cross-Section Area of the Pipe (cm$^2$)
- $\theta$ = Angle of the Bend (degrees)
- $S_b$ = Bearing Strength of the Soil (kg/m$^2$)
- **T** = Thrust Force (kg)
- **b** = Block Width (m)
- **h** = Block Height (m)

| Soil Type | Soil Bearing Strength $S_b$ kg/m$^2$ |
|---|---|
| Soft Clay | 4 800 |
| Silt | 7 300 |
| Sandy Silt | 14 600 |
| Sand | 19 400 |
| Sandy Clay | 29 200 |
| Hard Clay | 48 800 |

A similar approach may be used to design bearing blocks to resist the thrust forces at tees, dead ends, etc. Typical values for conservative horizontal bearing strengths of various soil types are listed in the adjacent Table.



Ductile Iron Pipe

## INDEX

## MANUFACTURING PROCESSES

KINGER Ductile Iron Pipe is manufactured as follows:

The process begins with the raw material which consists of steel scrap and iron ore being melted in an electric furnace or by the reduction of iron ore in a blast furnace.

Molten metal is first desulphered then further heated and processed in an induction furnace.

Magnesium is introduced to the molten metal to convert the graphite flakes to a spherodal form to produce Ductile Cast Iron.

The metal is transferred, after the Magnesium treatment, to the centrifugal spun casting machines to produce the pipe.

Molten metal is poured into a spinning horizontal mould. The centrifugal force from the spinning results in an even distribution of the metal around the inside surface of the mould. This method produced much smaller graphite flakes in a matrix of iron and improves the quality of the pipe substantially.

The perfectly spun and solidified pipes are then heat treated to achieve their required structure and mechanical properties.

After heat treatment, pipes are zinc coated externally.

Each pipe is then hydrostatically tested.

Cement mortar lining is centrifugally applied to the pipe internally and cured under controlled humidity and temperature conditions.

Pipes are finished with an external bitumen coating before being placed into stock or dispatched.

Pipe Drawn from Mould

Pipe Annealed

Hydraulic Testing

Bitumen Coating





## PROPERTIES & ADVANTAGES

KINGER Ductile Iron has exceptional inherent properties that make it highly suitable as a pressure pipe material. Properties include:

### High Resistance To Surge And Water Hammer

KINGER Ductile Iron has an inherent damping capacity and a high resistance to cyclic failure. In addition, the pipe is designed with a high safety factor, in excess of 3 times the pipe's operating pressure to allow for abnormal surge conditions.

### High Flow Capacities

The internal diameter of KINGER Ductile Iron pipe is larger than that of any other pipe material, for a given pipeline diameter. This coupled with the smooth mortar lining implies that KINGER Ductile Iron pipe provides the least resistance to flow ensuring a lower cost in power consumption across the **Life Cycle** of the system for equivalent flow when compared to other pipe materials.

### Resistance To Cathodic Corrosion

KINGER Ductile Iron pipe, because of its sealing system, ensures that every pipe length is insulated from the next with no continuity of current flow. This fact coupled with the pipe's standard coating and the material's natural resistance to corrosion, ensures decades of maintenance free operation without the need for cathodic protection in most soil conditions.

### Coatings And Linings

KINGER Ductile Iron pipe is supplied as standard with an active cement mortar lining to protect against the formation of iron compounds and to eliminate tuberculation. External protection as standard; is in the form of a zinc base coating and bitumen external coat. This method of coating and linings has proven their long term durability in thousands of applications.

KINGER Ductile Iron pipe is also available in a wide selection of alternative coatings to suit virtually every application.

### Jointing

KINGER Ductile Iron pipe makes use of a reliable spigot and socket joint with a dynamic sealing system which increases the integrity of the seal as the pressure increases. In addition, the jointing allows for angular deflection and excellent resistance to negative pressure conditions. The spigot and socket seal arrangement coupled with the robustness of the material, makes Ductile Iron pipe easy and quick to lay.

### A Semi Rigid Material

KINGER Ductile Iron pipe is considered a semi rigid material with sufficient strength and stiffness to make it less reliant upon pipe embedment for support. This factor minimises the need for imported bedding and surround and makes the laying of pipe more economical in comparison to flexible pipe materials.

### High Impact Resistance

KINGER Ductile Iron has, through practical testing and in many applications exhibited tremendous impact-resistance. The material's toughness makes it much less vulnerable to damage from improper handling or abnormal service conditions. In addition, it has proven its integrity in heavy traffic conditions with unstable soil environments, where other materials might fail due to the stresses caused by unusual superimposed external loading.

### High Tensile Strength

Ductile Iron has a tensile strength of 420 MPa, a high elongation (ductility) of 7-10%, a yield strength of 321 MPa and a high modulus of elasticity of 170 MPa. It is these factors that give the materials the ability to withstand severe stresses caused externally by shifting ground and heavy loads and internally by water pressure and water hammer.

## DIMENSIONS&PRESSURE RATINGS

KINGER Ductile Iron pipes are supplied in 6 metre lengths and in general conformance to ISO 2531 : 1998 or BS EN 545: 2002 standards. All pipes are internally mortar lined to ISO 4179 specifications, as standard. The nominal wall thickness of KINGERDuctile Iron pipe and fittings is calculated as a function of the nominal size (NB) utilising the following formula:

$e = K(0.5 + 0.001NB)$

**Where:**

K = A coefficient used for the determination of Class thickness and is selected from a series of whole numbers normally from 7 to 14

e = The nominal wall thickness of the pipe

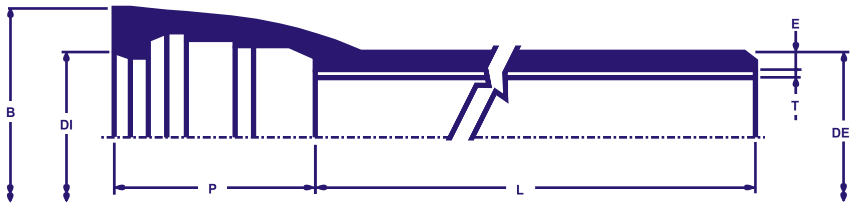
NB = The nominal bore of the pipe.

Class K9 has become the standard pressure class for water pipelines. The standard K9 wall thicknesses and operating pressures are given below:

**PFA** = Allowable Operating Pressure is the internal pressure, exclusive of surge, that a component can safely withstand in permanent service

**PMA** = Allowable Maximum Operating Pressure is the maximum internal pressure, including surge, that a component can safely withstand in service

**PEA** = Allowable Test Pressure is the maximum hydrostatic pressure that a newly installed component can withstand for a relatively short duration, when either fixed above ground level or laid and back-filled underground in order to measure the integrity and leak tightness of the pipe.




| DN mm | L Operating Length m | DE mm | DI mm | B mm | P mm | E mm | Standard Operating Pressure PFA | Maximum Operating Pressure PMA | Maximum Test Pressure PEA | T Nominal Thickness of Mortar Lining | Pipe Mass/Metre Pipe kg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **80** | 6 | 98 | 100.5 | 140 | 84 | 6 | 64 | 77 | 96 | 3 | 12.2 |
| **100** | 6 | 118 | 120.5 | 163 | 88 | 6 | 64 | 77 | 96 | 3 | 15.1 |
| **150** | 6 | 170 | 172.5 | 217 | 94 | 6 | 64 | 77 | 96 | 3 | 22.8 |
| **200** | 6 | 222 | 224.5 | 278 | 100 | 6.3 | 62 | 74 | 79 | 3 | 30.6 |
| **250** | 6 | 274 | 276.5 | 336 | 105 | 6.8 | 54 | 65 | 70 | 3 | 40.2 |
| **300** | 6 | 326 | 328.5 | 393 | 110 | 7.2 | 49 | 59 | 64 | 3 | 50.8 |
| **350** | 6 | 378 | 380.5 | 448 | 110 | 7.7 | 45 | 54 | 59 | 5 | 63.2 |
| **400** | 6 | 429 | 431.5 | 500 | 110 | 8.1 | 42 | 51 | 56 | 5 | 75.5 |
| **450** | 6 | 480 | 482.5 | 540 | 120 | 8.6 | 40 | 48 | 53 | 5 | 89.3 |
| **500** | 6 | 532 | 534.5 | 604 | 120 | 9 | 38 | 46 | 51 | 5 | 104.3 |
| **600** | 6 | 635 | 637.5 | 713 | 120 | 9.9 | 36 | 43 | 48 | 5 | 137.3 |
| **700** | 6 | 738 | 740.5 | 824 | 150 | 10.8 | 34 | 41 | 46 | 6 | 173.9 |
| **800** | 6 | 842 | 844.5 | 943 | 160 | 11.7 | 32 | 38 | 43 | 6 | 215.2 |
| **900** | 6 | 945 | 947.5 | 1052 | 175 | 12.6 | 31 | 37 | 42 | 6 | 260.2 |
| **1000** | 6 | 1048 | 1050.5 | 1158 | 185 | 13.5 | 30 | 36 | 41 | 6 | 309.3 |
| **1200** | 6 | 1255 | 1258.5 | 1377 | 215 | 15.3 | 28 | 34 | 39 | 6 | 420.1 |
| **1400** | 6 | 1462 | 1465.5 | 1610 | 239 | 17.1 | 28 | 33 | 38 | 6 | 547.2 |
| **1600** | 6 | 1668 | 1720 | 1874 | 160 | 18.9 | 27 | 32 | 37 | 6 | 690.3 |
| **1800** | 6 | 1875 | 127 | 2089 | 170 | 20.7 | 26 | 31 | 36 | 6 | 850.1 |





## COATINGS & LININGS

### Standard Coating

KINGER Ductile Iron pipe is supplied as standard with a metallic zinc coating which is sprayed onto the pipe surface and a finishing layer of bituminous paint in accordance to ISO 8179:1995 PART - 1. BS EN 545: 2002. BS 3416: Type 2 , is applied over the zinc coating.

The zinc coating with time, transforms into a dense impermeable protective barrier that has the ability to restore the continuity of the protective layer through the migration of zinc ions in areas where local damage may exist. The bitumen coating provides protection against cathodic corrosion and a suitable environment for the zinc coating to transform into an impermeable coating.

### Special Coatings

KINGER Ductile Iron pipes and fittings are supplied with the standard coating as outlined above may be buried in contact with the majority of soils. However should special soils and/or conditions such as soils with a low resistivity of less than 1500 ohms or soils with a low pH or, soils contaminated by certain wastes, organic or industrial effluent exist then, special coatings should be considered.

KINGER Ductile Iron may on request, be supplied with the following external coatings:

Polyurethane Coating
Epoxy Coating
Polyethylene Sleeves.

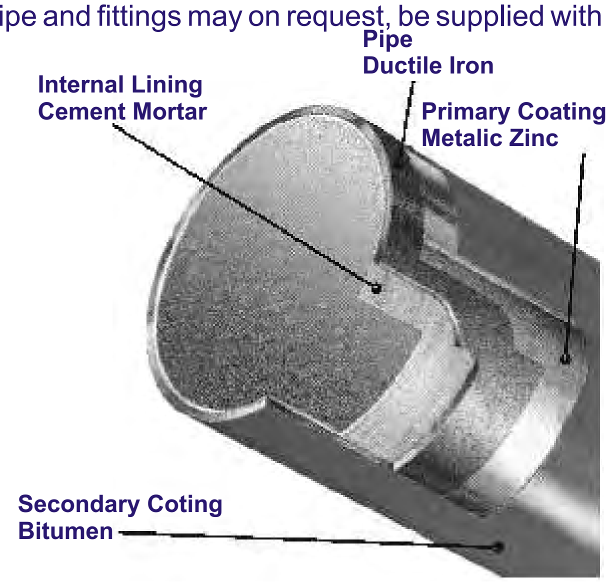
### Linings

KINGER Ductile Iron pipes are lined internally as standard with cement mortar which is centrifugally applied in accordance to ISO 4179 : 1985 and BS EN 545 : 1995. Centrifugally applied mortar provides a high level of mortar compactness, ensures good adherence to the metal and provides a smooth surface which reduces flow resistance.

As a corrosion protection, cement mortar lining is an added advantage to KINGER Ductile Iron pipes. The lining provides a physical as well as chemical barrier to corrosion of the iron wall. It eliminates red, rusty water and tuberculation. High Alumina cement lining is available for aggressive sewer applications and can handle fluid pH levels of 4 to 12.

Fittings are also supplied with an internal cement mortar lining. in accordance to BS EN 545 : 2002 and ISO 2531 : 1998. ProFlo Ductile Iron pipe and fittings may on request, be supplied with the following liners:

Polyurethane Lining
Epoxy Lining
Ceramic Epoxy Lining



## JOINTING

### Standard Joint

The spigot and socket push-on flexible joint is an extremely reliable joint, used extensively throughout the world on various pipe designs. Sealing in the KINGER Ductile Iron pipe design, is achieved by radial compression of the elastomer seal. Sealing is enhanced with an increase of pressure; this is due to the specific shape of the elastomer seal and the seal housing design and leads to the following benefits:

**Ease Of Installation/Rapid Installation**

Apart from normal anchoring precautions on bends and tees, no bolt tightening is necessary and the simple push on connection allows for rapid, low cost pipe laying even in wet conditions.

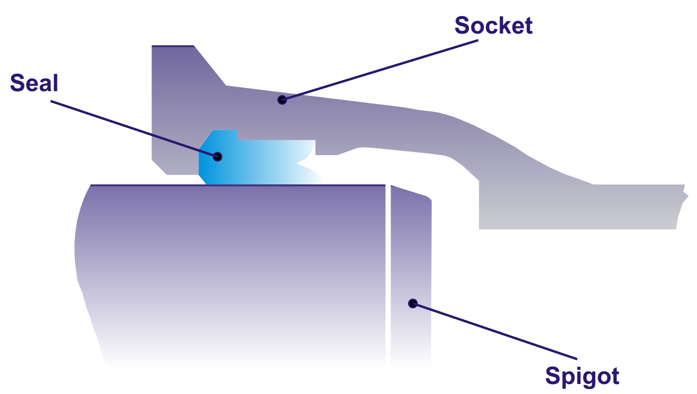
**Angular Deflection**

In addition, the flexibility of the joint allows for long radius bending without the need for additional fittings and, expansion and contraction is generously accommodated. Joint flexibility also provides an element of safety in poor and unstable ground conditions.

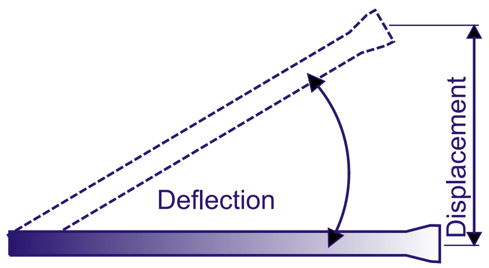
**Sealing Integrity**

A further benefit of the ProFlo Ductile Iron pipe sealing system is its resistance to low negative pressures, sealing integrity is therefore maintained regardless of the operating condition.

KINGER Ductile Iron pipe unless clearly specified is supplied as standard with elastomer seals and lubricants (SBR / EPDM) conforming Standards BS : EN 681- 1996 / ISO 4633 : 1996 / BS 2494 / 1990). The elastomer seal and lubricant shall in all cases be suitable for use with potable water as per BS 6920: 1996.




| DN | Maximum Deflection Degrees | Pipe End Displacement mm |
|---|---|---|
| 80 to 150 | 5° | 520 |
| 200 to 300 | 4° | 420 |
| 350 to 600 | 3° | 320 |
| 700 to 800 | 2° | 250 |
| 900 to 1200 | 1°30’ | 190 |







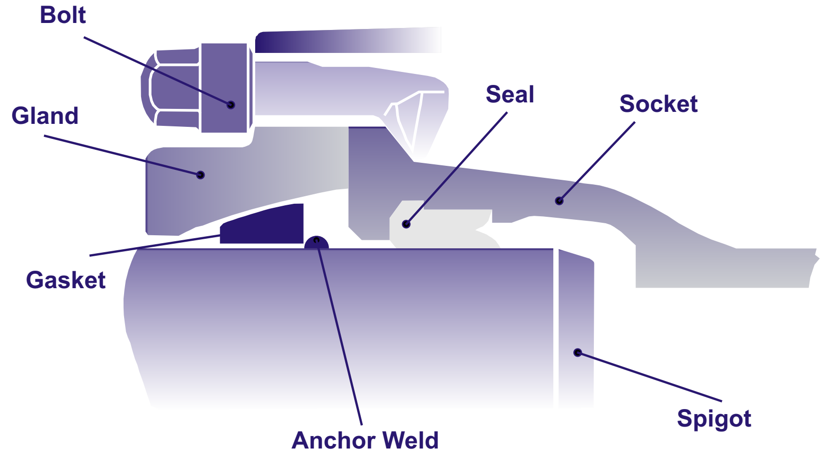

## JOINTING

### Restrained Joint

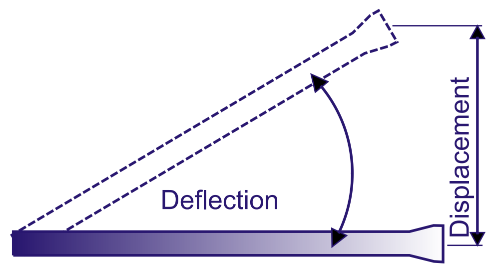
In some pipe laying conditions such as unstable ground conditions or extremely hilly terrains, axial pull-out forces are generated by internal pressure at cross-sectional and directional changes. Normal flexible jointing are incapable of withstanding such axial forces, unless used in conjunction with conventional thrust blocks.

An elegant solution that provides the benefit of the standard spigot and socket jointing arrangement, is in the form of a joint where the restraining mechanism is incorporated in the normal flexible spigot and socket which, offers the same degree of deflection as that of standard jointing.

Restraining joints are particularly useful in situations where the construction of anchor blocks are difficult such as congested areas because of their size or in low strength soils because of their weight.



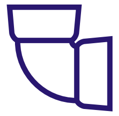
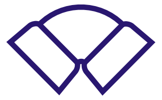
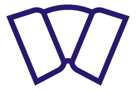
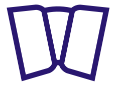
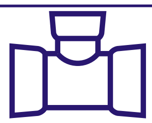
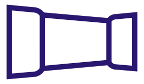
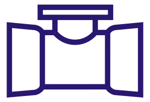
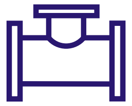

| DN | Maximum Deflection Degrees | Pipe End Displacement mm |
|---|---|---|
| 300 | 4° | 420 |
| 350 to 600 | 3° | 320 |
| 700 to 800 | 2° | 250 |
| 700 to 800 | 1°30’ | 190 |



## FITTINGS

KINGER Ductile Iron pipe can be supplied with a wide selection of fittings to suit most applications. Fittings without branches conform to class-K12. Ductile iron fittings with branches conform to class-K14. Refer to Page 5 for calculation of wall thickness.

Pressure ratings for ductile iron socket joint fittings (PFA, PMA & PEA) are equal to that of class K9 pipes. Fittings are supplied as standard with an internal cement mortar lining in accordance to BS EN 545 : 1995 and ISO 2531 : 1998.

| | Description | Nominal Sizes in mm |
|---|---|---|
|  | 90° Socketed Bends | DN80 To DN1800 |
|  | 45° Socketed Bends | DN80 To DN1800 |
|  | 22.5° Socketed Bends | DN80 To DN1800 |
|  | 11.25° Socketed Bends | DN80 To DN1800 |
|  | Socketed Tees | DN80 To DN1800 |
|  | Socketed Reducers | DN80 To DN1800 |
|  | Socketed Tees with Flanged Branch | DN80 To DN1800 |
|  | Flanged Tees | DN80 To DN1800 |
|  | 90° Flanged Bends | DN80 To DN1800 |
|  | 45° Flanged Bends | DN80 To DN1800 |
|  | 22.5o Flanged Bends | DN80 To DN1800 |
|  | 11.25° Flanged Bends | DN80 To DN1800 |





## DESIGNING WITH DUCTILE IRON

### Ductile Iron Properties

| | |
|---|---|
| Maximum Ultimate Tensile Strength | 420 MPa |
| Minimum Elongation | 5% for Fittings |
| Maximum Tension | 170 MPa |
| Maximum Compression | 180 MPa |
| Maximum Shear | 150 MPa |
| Maximum Bending Circumferential (pipe wall) | 250 MPa |
| Maximum Bending Longitudinal (pipe as a wall) | 200 MPa |
| Modulus of Elasticity | 170 gPa |
| Poisson's Ratio | 0.28 |
| Coefficient of Thermal Expansion | 20°C to 200°C)11 x $106^{-6}$ per °C |

### Hydraulic Performance

KINGER Ductile iron pipe is supplied as standard with a cement mortar lining and has a Hazen Williams factor of 140 and an effective Ks value when using the Colebrook White Equation of 0.03

### Semi Rigid Material

KINGER Ductile Iron Pipe is a semi rigid pipe material and its characteristics are such that it will withstand external loading through a combination of its inherent strength and the support from the pipe embedment. The pipe design method adopted to calculate pipe deflection is the Modified Iowa Spangler formula which is expressed as follows:

$$D = \frac{100K\,(Pe + Pt)}{8S + 0.061\,E'}$$

**Where:**

- D = Deflection (ovalisation) (%)
- **K** = Bedding Coefficient
- **Pe** = Earth Load (kN/m$^2$)
- **Pt** = Traffic Load (kN/m$^2$)
- **S** = Pipe Diametral Stiffness (kN/m$^2$)
- **E'** = Modulus of Soil Reaction (kN/m$^2$)

The degree of deflection increases with diameter but should be kept below the value that the internal cement mortar lining can withstand without cracking whit providing a minimum safety factor of 2 in respect of the ultimate bending stress in addition to ensuring a leak tight joint is maintained at all times.

| DN | Allowable Deflection % |
|---|---|
| 80 | 1.1 |
| 100 | 1.3 |
| 150 | 1.85 |
| 200 | 2.25 |
| 250 | 2.6 |
| 300 | 2.9 |
| 350 | 2.95 |
| 400 and above 3.0 | 3.0 |

## DESIGNING WITH DUCTILE IRON

### Earth Load - Pe

Pe is based on the prism load. The unit weight of soil in the absence of survey data is generally taken as being equal to 20 kN/$m^2$. Actual unit weight must be used if possible, especially if it is shown to be greater than 20 kN/$m^2$.

| DN | Narrow | Embankment |
|---|---|---|
| 80 to 200 | 1 | 1.8 |
| 250 | 1 | 1.7 |
| 300 | 1 | 1.6 |
| 350 | 1 | 1.5 |
| 400 to 450 | 1 | 1.4 |
| 500 to 600 | 1 | 1.3 |
| 700 and above | 1 | 1 |

**Pe = f yH**

**Where:**
**f** = Loading Factor
**y** = Unit Weight of Backfill (kN/$m^3$)
**H** = Height of Cover (m)

### Traffic load - Pt

The traffic load (Pt) is assumed to be uniformly distributed at the top of the pipe over a distance equal to the external diameter and is expressed as follows:

$$Pt = 40 \frac{B}{H}\left[1 - (2DN \times 10^{-4})\right]$$

**Where:**

**Pt** = Traffic Load (kN/$m^2$)
**B*** = Factor (0.5 to 2.0)
**H** = Height of cover (m)
**DN** = Nominal Diameter

**B*** = 0.5 for rural areas
= 0.75 for access roads
= 1.5 for main roads
= 2.0 for high traffic loads

### Pipe Stiffness

The stiffness factor is a measure of the pipe's ability to resist deflection (ovality).

| DN | Minimum Diametral Stiffness, S. kN/$m^2$ | DN | Minimum Diametral Stiffness, S. kN/$m^2$ |
|---|---|---|---|
| 80 | 1200 | 500 | 52 |
| 100 | 680 | 600 | 41 |
| 150 | 250 | 700 | 34 |
| 200 | 130 | 800 | 30 |
| 250 | 91 | 900 | 26 |
| 300 | 68 | 1000 | 24 |
| 350 | 67 | 1100 | 22 |
| 400 | 63 | 1200 | 20 |
| 450 | 61 | 1400 | 18 |

### Bedding Coefficient

The bedding coefficient (K) reflects the angle of support at the invert and the quality of the bedding and sidefill material and varies from 0.11 for bedding angle = 20° to 0.09 for bedding angle = 120°. A value of 20° corresponds to a ductile iron pipe simply laid on a trimmed flat bottom trench with excavations for the joints ( joint holes).





## DESIGNING WITH DUCTILE IRON

### Modulus of Soil Reaction

The modulus of soil reaction (E') is an empirical factor and is related to the degree of compaction applied to the pipe surround material on installation. Values have been established for various types of soil and vary from 0 to 20,000 kN/$m^2$. Low values correspond to the poorer soils with little or no compaction and the higher values to imported granular materials with compaction.

KINGER Ductile iron pipe in the smaller sizes can usually be laid in very poor soils (where E' is assumed to be zero) without the need to import granular material for the embedment. This advantage, compared with other materials, is due to the pipe having sufficient stiffness to withstand the imposed earth and traffic loads without support from the sidefill.

| Soil Type | Compaction | | | | |
|---|---|---|---|---|---|
| | Not Compacted | Loose | 85% | 90% | 95% |
| Gravel Stone | 5000 | 7000 | 20 000 | 30 000 | 50 000 |
| Sand 12% Fines | 1000 | 3000 | 7000 | 15000 | 20000 |
| Silts <50% | 0 | 1000 | 3000 | 5000 | 10000 |
| Clay LL <50% | 100 | 1000 | 1000 | 3000 | 7000 |

| Soil Type | Degree of Compaction | Thickness of Layer |
|---|---|---|
| Gravel/ Stone | 80 | 450 |
| | 85 | 450 |
| | 90 | 300 |
| | 95 | 300 |
| Sand 12% Fines | 80 | 450 |
| | 85 | 300 |
| | 90 | 300 |
| | 95 | 300 |
| Silt LL <50% | 80 | 450 |
| | 85 | 300 |
| | 90 | 150 |
| | 95 | 150 |
| Clay LL <50% | 80 | 450 |
| | 85 | 300 |
| | 90 | 150 |
| | 95 | 150 |

## KINGER - SELLING SOLUTIONS

KINGER products and services cover a broad range of industry needs, offering a total solution approach to customers. Products include valves, pipes, couplings, fittings and other related products.

KINGER is focused on satisfying the demand for pipeline systems, which will consistently perform in the most economical way, year after year across their entire ***Life Cycle***.

To perform as required, a pipeline system must be designed and specified to resist corrosion, surge and waterhammer, and external loads. Further, pipeline materials must be sourced from reputable manufacturers, handled and transported correctly and installed with due consideration of the pipe/ soil relationship.

KINGER services and products cover the entire spectrum of pipeline design, installation and operation ensuring that the most suited materials and complimentary components are selected relative to application, availability, initial cost and total cost of ownership.

## KINGER DUCTILE IRON PIPE

Ductile Iron pipe has for more than four decades, proven its strength, durability, and reliability for transporting raw and potable water, sewage, slurries, and process chemicals.

The material's high degree of dependability is due to its high strength, durability, and impact and corrosion resistance.

Installation of KINGER Ductile Iron pipe is simple and, once installed, is virtually maintenance-free.

The pipe is manufactured in 6 metre nominal laying lengths and in nominal bores of 80 to 2600mm. Standard pressure classes allow for working pressures of 20 bar and higher.
KINGER Ductile Iron is furnished with several different types of joints and a wide variety of standard fittings are available without special order. Cement mortar lining internally and zinc and bitumen coating externally is supplied as standard. Optional internal linings are also available for a wide range of special applications.



Ductile Iron Pipe

## OFFLOADING STACKING AND INSTALLATION

KINGER Ductile iron pipes and fittings are not susceptible to breakage by impact during handling but improper handling can result in damaged linings, coatings and sleeving. Damage to pipes and fittings may be caused by insecure loading, improper use of handling equipment, use of unsuitable handling equipment, incorrect stacking methods and impact between pipes.

### Offloading of Pipe

Off - loading should be carried out smoothly. Where pipes have been bundled, it is essential that the bundles be offloaded with slings around the complete bundle, using the correct lifting angle on the slings. It is essential that the bundles are not lifted by means of their retaining straps and that stacked bundles are lowered to the ground before the straps are cut. When cranes are used for off-loading individual pipes, slings or lifting beams with purpose designated padded hooks shall always be used.

### Stacking of Pipe

Pipes should be stacked on a base of raised wooden battens at least 100 mm thick x 225 mm wide. The battens should be positioned approximately 600 mm from each end of the pipe. The bottom layer of the pipes should be securely anchored. Pipe can be stacked in one of two ways namely:

### Square Stacking

Each tier of pipes is positioned with their axis at right angles to those of the preceding tier to form a stable and compact stack. The sockets of the pipes in each tier should be at the same end, except for the two end pipes which should be reversed to lock the tiers in position. Alternatively, the sockets of alternate pipes in each tier may be reversed. The pipes rest directly upon those beneath.

### Parallel Stacking

For this method of stacking two timber battens of sufficient strength should be placed across the pipes between each tier, approximately 600 mm from pipe ends. The sockets of pipes in each successive tier should be reversed and battens should be of sufficient thickness to avoid metal to metal contact. An adequate number of chocks should be wedged under the outer pipes of each tier and nailed to the timber bearers to ensure stability.

### Stacking Heights

For loose pipes the heights of stacks should be determined by consideration of the stresses on the lowest layer of pipes in the stack; the total height to which the crane can lift; and the facilities available to ensure stable stacking. It is recommend that:

DN80 up to DN200 not get stacked high than 12 pipe layers
DN250 to DN400 get stacked no higher than 8 pipe layers
DN450 to DN500 get stacked to 6 pipe layers
DN600 and DN700 get stacked to 4 pipe layers
DN800 and above no more than 2 pipe layers.

### Pipe Installation and Product Training

KINGER with every pipe order, provides a comprehensive Owner’s Manual which covers all aspects of ductile iron transport, installation and maintenance requirements. In addition, KINGER provides complete training on various aspects of component selection, pipeline design and installation.