Steel Reinforced Spirally Wound PE Drainage and Sewer Pipes

(SANS 674:2008)
Pipe and pipe structure

The pipe is made from steel reinforced polyethylene profile that is formed by integrating HDPE with steel strips by means of an integration machine.

Fig.1 Profile structure

The profiles are spirally wound and then fusion-welded by HDPE melt at the profile edges which is overlapped by a winding and welding machine to form the pipe. The pipe is of spiral structure with concentric steel reinforced HDPE ribs, which are equidistantly distributed around the circumference of the pipe, extending vertically outward from the basic pipe body. In the pipe HDPE forms pipe bore and steel offers ring stiffness. The thickness and width of the steel strip is varied to make pipes of different diameters and/or different ring stiffness classes.

Fig.2 Pipe structure

Fig.3 SN12.5KN/m²; DN2000mm
## Pipe diameter & ring stiffness class

Table 1 Pipe dimension and ring stiffness class

<table>
<thead>
<tr>
<th>Nominal diameter DN. mm</th>
<th>Internal diameter ID. mm</th>
<th>Maximum outside diameter OMax. mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SN8 (kN/m²)</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>226</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
<td>326</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
<td>440</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
<td>540</td>
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<tr>
<td>600</td>
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<td>645</td>
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<tr>
<td>700</td>
<td>700</td>
<td>745</td>
</tr>
<tr>
<td>800</td>
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<td>853</td>
</tr>
<tr>
<td>900</td>
<td>900</td>
<td>964</td>
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<td>1200</td>
<td>1200</td>
<td>1274</td>
</tr>
<tr>
<td>1300</td>
<td>1300</td>
<td>1386</td>
</tr>
<tr>
<td>1400</td>
<td>1400</td>
<td>1488</td>
</tr>
<tr>
<td>1500</td>
<td>1500</td>
<td>1586</td>
</tr>
<tr>
<td>1600</td>
<td>1600</td>
<td>1694</td>
</tr>
<tr>
<td>1800</td>
<td>1800</td>
<td>1894</td>
</tr>
<tr>
<td>2000</td>
<td>2000</td>
<td>2106</td>
</tr>
<tr>
<td>2200</td>
<td>2200</td>
<td>2306</td>
</tr>
</tbody>
</table>

Notes:
1. SN stands for ring stiffness class of the pipe.
2. Weight per meter pipe is available upon request.

### SANS standard

Steel-reinforced spirally wound PE drainage and sewer pipes are manufactured according to South African national standard SANS 674:2008
Pipe characteristics and benefits

- Combination of two pipe materials results in excellent comprehensive properties at economical cost.

  The steel strip encased in polyethylene offers sufficient strength for the pipe to withstand soil and dynamic load. The basic material of the pipe body is polyethylene, which has been proved to have excellent anticorrosion resistance, hydraulic characteristics and proper flexibility. Stanway pipe represents the most reliable, safe and sound integration of the desirable properties of steel and polyethylene.

- High ring stiffness easily achieved at low pipe weight, which can be maintained over pipe lifespan.

  The elastic modulus of steel is more than 260 times that of polyethylene, and the density of the two materials differs by 7.9 times, so higher ring stiffness to weight ratio can be easily achieved in this pipe, especially for big diameters. HDPE is prone to creep, but steel does not creep at application temperatures of the pipe, so that this pipe, wherein the strength is provided by steel, has more stable long-term strength than other pipe materials.

- Light in weight

  Due to its unique structure and very high ring stiffness to weight ratio, this pipe is lighter than any other pure plastic pipe of equal ring stiffness. This means big cost saving in pipe handling and installation.

- Excellent corrosion resistance, and thus durable.

  Plastics are not subjected to galvanic corrosion, as are metals, since they are nonconductors. Polyethylene is a non-polar high-molecular-weight hydrocarbon. It is very resistant to chemicals and other media such as salts, acids, and alkalies. In this pipe, the steel strip is 100% completely enveloped in polyethylene, and as a result the pipe is also corrosion resistant to almost all chemicals.

- Excellent abrasion resistance

  Polyethylene has excellent abrasion resistance, which has been shown in laboratory tests to be three to five times longer than normal or fine-grained steel pipe at a typical velocity of under 15 meters. Thanks to this, the use of polyethylene pipe in the hydraulic transportation of solids through hydraulic systems is increasing mainly due to the economic advantages of operating this type of system. More and more polyethylene pipe is being used to transport granular or slurry solutions, such as sand, fly ash and coal.

- Good impact resistance

  Polyethylene is universally regarded as a high impact resistant thermoplastic material, even at low temperatures.

- Great resistance to abnormal stress

  Due to its high ring stiffness and proper axial flexibility, in case that soil settlement, groundwater floating, earthquake or excessive local load occurs, the pipe is able to relieve the excessive stress caused thereby through elastic deformation and consequently avoid leakage or damage at the joint or failure of the pipe.

- Pipe production nearby installation site easily achievable

  For pipes of DN200-1200mm pipe production nearby construction site is easily achievable thanks to noncomplexity in production process and easiness in reinstallation and transportation of production facilities.

- Simple installation saving much cost & labor

  The pipe is lightweight and does not need heavy lifting equipment at installation site; the pipe can be as long as up to 6-12 meters and use less joint; both joining methods are easy and convenient requiring simple tools and less labor efforts.

- Excellent flow characteristics

  The Manning’s n value of Stanway pipe is the same as that of pure HDPE structural wall pipe, i.e. 0.011, while the Manning’s n value of concrete is 0.013, so for same pipe size and under same application condition, Stanway pipe has 20% more transportation capacity than concrete pipe does.

- Long life expectancy

  The life expectancy of the pipe is expected to be 50 to 100 years, much longer than that of traditional metal and concrete pipes.

- “Zero pollution to the environment” achieved by leakfree joint

  Pipe joining by either of the two methods is leakfree, and does not pose threat to the surrounding environment when used for sewers.

- Does not cause secondary pollution

  When used for gravity transportation of drinking water from water source, this pipe does not cause secondary pollution as concrete or cast iron pipe does.
Raw materials
Polyethylene and steel strip are the only two materials used for making the pipes.

- HDPE80 for pipe extrusion is used to form pipe bore.

<table>
<thead>
<tr>
<th>Physical property</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (23°C)</td>
<td>g/cm³</td>
<td>0.93-0.965</td>
<td>ISO 1183</td>
</tr>
<tr>
<td>MFR(190°C/5kg)</td>
<td>g/10min</td>
<td>≤1.6</td>
<td>ISO 1133</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>%</td>
<td>&gt;350</td>
<td>ISO 527</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>Mpa</td>
<td>&gt;22</td>
<td>ISO 527</td>
</tr>
<tr>
<td>OIT (200°C)</td>
<td>min</td>
<td>≥20</td>
<td>ISO 10837</td>
</tr>
<tr>
<td>Carbon black, (mass)</td>
<td>%</td>
<td>2.5±0.5</td>
<td>ISO 11420</td>
</tr>
</tbody>
</table>

- Commercial quality (CR21) cold reduced carbon steel strip conforming to ISO6932 is used to make the reinforcing ribs.

Pipe manufacturing
For DN≤800mm, the pipe is made in two steps. In the first step, steel reinforced polyethylene profile is made by means of a one-step process, and then the profile is coiled onto a spooler; in the second step, the profiles are wound and welded into pipes.

For DN≥1300mm, the pipe production is continuous. Instead of being coiled onto a spooler, the profile, after cooled down, is continuously delivered into the winding and welding machine to form the pipe. The unique technology is developed by Starway, and has been patented in South Africa. Starway Machinery Manufacturing Co., Ltd is the owner of this proprietary technology.

For 900mm ≤DN≤1200mm, the pipe can be made by both methods.

![Pipe winding](image1)

![Fig. 11 Pipe winding](image2)

![Workshop](image3)

![Winding cages](image4)

- DN≤800mm pipe production flowchart
- Profile manufacturing process
- DN≥900mm pipe production flowchart
- (2) Pipe manufacturing process
Pipe jointing

--- Stainless steel clamp + rubber sleeve

This method is used for jointing of Dn800mm pipes. The jointing consists of three layers: the inner layer is a thin wall rubber sleeve which tightly enwraps the two pipe ends and securely seal the joint; the in-between is a layer of elastic foam rubber belt of certain thickness filling up the space between the inner and outer layers as well as transferring the clamping force of the clamps to the inner sleeve through its deformation; the outer layer is a stainless steel clamp, by adjusting the bolts of which the clamping force on the rubber belt can be adjusted to achieve tight seal, and the clamp can also increase the ring stiffness of the joint to some extent.

--- Electrofusion

This method is applicable to jointing of Dn800mm pipes using electrofusion belt as jointing element. The electrofusion belt is broad enough to offer enough fusion length. The belt thickness is bigger than the pipe thickness, and its length is bigger than the pipe perimeter. A heating wire circuit is preset in one side of the belt. Place the belt into pipe bore and use a PE belt holder to push the belt onto the inner pipe wall, as shown in the following figure. Apply current to the heating wire of the belt to make the inner pipe wall and the belt surface melt. During the heating process the belt and the pipe wall fuse together. After the fusion cools down, a secure connection is obtained. Specialty PE-belt holder and welding control unit have been developed, aiming at achieving a reliable and convenient jointing process.

Both jointing methods are proved to be secure, safe and 100% leakfree.
Pipe Testing

- Fig. 25 Ring stiffness test according to ISO9669
- SN8 DN300mm, SN=9.61
- SN8 DN400mm, SN=13.76
- Fig. 27 At-factory water test
- Fig. 26 Negative air pressure test according to SANS674
- Fig. 28 Bending test
- Fig. 28 Sand box test

Hydraulic design

- For full flow, the following figures shall be used for hydraulic design.

Fig. 30-1 Hydraulic design of ID200—1200mm pipes with full flow (n=0.01)
For partially filled pipes, the following table and the above figure shall be used for hydraulic calculations.

Velocity coefficient ($\beta^{0.667}$) and flow coefficient ($\alpha \cdot \beta^{0.667}$) at different filling level

<table>
<thead>
<tr>
<th>h/Di</th>
<th>$\theta$ (°)</th>
<th>$\theta$ (rad)</th>
<th>$\sin \theta$</th>
<th>$\alpha$</th>
<th>$\alpha$ ratio</th>
<th>$\beta$</th>
<th>$\beta^{0.667}$</th>
<th>Velocity coefficient</th>
<th>Flow coefficient</th>
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</thead>
<tbody>
<tr>
<td>1.000</td>
<td>360.0</td>
<td>6.2832</td>
<td>0.0000</td>
<td>0.7854</td>
<td>1.0000</td>
<td>0.2590</td>
<td>0.3967</td>
<td>1.0000</td>
<td>1.0000</td>
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<td>0.983</td>
<td>333.0</td>
<td>5.7959</td>
<td>-0.5000</td>
<td>0.7624</td>
<td>0.9952</td>
<td>0.2717</td>
<td>0.4193</td>
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<td>0.950</td>
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<td>-0.7548</td>
<td>0.7707</td>
<td>0.9813</td>
<td>0.2865</td>
<td>0.4344</td>
<td>1.0590</td>
<td>1.0745</td>
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<td>0.833</td>
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<td>5.2359</td>
<td>-0.8660</td>
<td>0.7627</td>
<td>0.9711</td>
<td>0.2913</td>
<td>0.4392</td>
<td>1.0701</td>
<td>1.0751</td>
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<td>0.900</td>
<td>288.3</td>
<td>4.9968</td>
<td>-0.9598</td>
<td>0.7446</td>
<td>0.9841</td>
<td>0.2980</td>
<td>0.4460</td>
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<td>1.0659</td>
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<td>0.854</td>
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<td>0.7114</td>
<td>0.9092</td>
<td>0.3031</td>
<td>0.4510</td>
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<td>0.910</td>
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<td>4.4784</td>
<td>-0.9228</td>
<td>0.6514</td>
<td>0.8676</td>
<td>0.3043</td>
<td>0.4522</td>
<td>1.1309</td>
<td>0.8900</td>
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<tr>
<td>0.750</td>
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<td>4.1887</td>
<td>-0.8660</td>
<td>0.6318</td>
<td>0.8044</td>
<td>0.3017</td>
<td>0.4497</td>
<td>1.1138</td>
<td>0.9119</td>
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<tr>
<td>0.700</td>
<td>227.2</td>
<td>3.9653</td>
<td>-0.7337</td>
<td>0.5874</td>
<td>0.7449</td>
<td>0.2963</td>
<td>0.4443</td>
<td>1.1200</td>
<td>0.8378</td>
</tr>
<tr>
<td>0.600</td>
<td>203.1</td>
<td>3.5447</td>
<td>-0.3023</td>
<td>0.4021</td>
<td>0.6266</td>
<td>0.2777</td>
<td>0.4255</td>
<td>1.0726</td>
<td>0.6721</td>
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<td>0.500</td>
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<td>0.5800</td>
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<td>0.400</td>
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<td>0.3923</td>
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<td>0.3734</td>
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<td>0.3578</td>
<td>0.9019</td>
<td>0.3358</td>
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<td>0.300</td>
<td>132.8</td>
<td>2.3177</td>
<td>0.7337</td>
<td>0.1889</td>
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<td>0.1708</td>
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<td>0.250</td>
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<td>2.0944</td>
<td>0.8860</td>
<td>0.1556</td>
<td>0.1986</td>
<td>0.1466</td>
<td>0.2779</td>
<td>0.7025</td>
<td>0.1370</td>
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<tr>
<td>0.200</td>
<td>106.2</td>
<td>1.8526</td>
<td>0.9603</td>
<td>0.1117</td>
<td>0.1422</td>
<td>0.1296</td>
<td>0.2438</td>
<td>0.6146</td>
<td>0.08740</td>
</tr>
<tr>
<td>0.150</td>
<td>91.1</td>
<td>1.5920</td>
<td>0.9998</td>
<td>0.0758</td>
<td>0.0940</td>
<td>0.0628</td>
<td>0.2048</td>
<td>0.5103</td>
<td>0.04923</td>
</tr>
<tr>
<td>0.147</td>
<td>90.0</td>
<td>1.5706</td>
<td>1.0000</td>
<td>0.0714</td>
<td>0.0909</td>
<td>0.0636</td>
<td>0.1990</td>
<td>0.5090</td>
<td>0.04627</td>
</tr>
<tr>
<td>0.100</td>
<td>73.7</td>
<td>1.2863</td>
<td>0.9598</td>
<td>0.0408</td>
<td>0.0520</td>
<td>0.0636</td>
<td>0.1990</td>
<td>0.4008</td>
<td>0.02084</td>
</tr>
</tbody>
</table>

Where:
- $W$ — water level in pipe (m)
- $D_i$ — pipe inside diameter (m)
- $h/D_i$ — water filling level in pipe
- $\alpha$ — ratio between value at different filling levels and value at full flow
- $\beta$ — ratio between value at different filling levels and value at full flow
- $\beta^{0.667}$ — coefficient (velocity ratio) — ratio between value at different filling levels and $\beta^{0.667}$ value at full flow.
- $\alpha \cdot \beta^{0.667}$ — coefficient (flow ratio) — ratio between value at different filling levels and $\alpha \cdot \beta^{0.667}$ value at full flow.

For hydraulic design of pipeline with full flow.

For hydraulic design of pipeline partially filled, firstly look up velocity coefficient ($\beta^{0.667}$) and flow coefficient ($\alpha \cdot \beta^{0.667}$) in Table 2, and then multiply them with the corresponding velocity and flow at full flow to obtain the velocity, and flow at partially filled level.
Structural design

● Structural actions on the pipe

(a) Characteristic value of permanent action on the pipe

The characteristic value of permanent action on the pipe shall be the characteristic value of vertical earth pressure on unit length of the pipe.

1. When the pipe is above ground water table, the characteristic value of permanent action on the pipe shall be calculated using the following formula:

\[ F_{SW, k} = r_s H_s D_1 \]

where:
- \( r_s \) — Characteristic value of vertical earth pressure on unit length of the pipe (kN/m);
- \( H_s \) — backfill depth between ground water table and design ground surface (m);
- \( D_1 \) — outside diameter of the pipe (m).

2. When the pipe is below ground water table, the characteristic value of permanent action on the pipe shall be calculated using the following formula:

\[ F_{SW, k} = r_s H_s D_1 + Y_{sw} (H_s - H_w) \]

where:
- \( r_s \) — Characteristic value of vertical earth pressure on unit length of the pipe (kN/m);
- \( Y_{sw} \) — combined gravity density of backfilling materials and groundwater, normally adopted as 20kN/m³;
- \( H_w \) — depth between pipe top and ground water table (m).

(b) Characteristic value of variable actions on the pipe

Variable actions on the pipe include live traffic load due to vehicles and static load due to aboveground stuff such as temporary constructions, sandpile, snow, etc. In calculation, either live traffic load or static load, whichever is greater, shall be used. It is not allowed to use the combination of both. Traffic load class shall be determined according to actual traffic condition.

The characteristic value of the traffic load on the pipe is calculated using the following formula. The quasi-permanent coefficient \( q_a \) for this load shall be adopted as 0.5.

1. The load transmitted to the pipe top in vertical direction by single wheel on the ground:

\[ q_a = \frac{N_a Q_a}{(a + 1.4H_s)(b + 1.4H_s)} \]

2. The overall load transmitted to the pipe top in vertical direction by two or more wheels of same row on the ground:

\[ q_a = \frac{N_a Q_a}{(a + 1.4H_s)(b + 1.4H_s)} \]

Fig. 33 Load distribution in lateral direction of the wheel

Fig. 34 Load distribution in driving direction of the wheel

Where:
- \( q_a \) — Characteristic value of vertical load per unit area transmitted by ground traffic to the pipe top (kN/m²);
- \( N_a \) — Quantity of wheels that exert load on the pipe;
- \( a \) — Length of touch area between the ground surface and single wheel (m);
- \( b \) — Width of touch area between the ground surface and single wheel (m);
- \( d \) — Distance between two adjacent wheels (m).

The dynamic coefficient \( \mu_d \) shall be adopted as 1.30 for traffic load, 1.25 for live load, 1.20 for fire load, 1.15 for explosion load, 1.05 for earthquake load, and 1.00 for other loads.

<table>
<thead>
<tr>
<th>Backfill depth above pipe top (m)</th>
<th>0.25</th>
<th>0.30</th>
<th>0.40</th>
<th>0.50</th>
<th>0.60</th>
<th>0.70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic coefficient ( \mu_d )</td>
<td>1.30</td>
<td>1.25</td>
<td>1.20</td>
<td>1.15</td>
<td>1.05</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The characteristic value of the static load due to aboveground stuff (other than the load due to vehicles) shall be adopted as 10kN/m², and the quasi-permanent coefficient \( q_a \) for this load shall be adopted as 0.5.

● Determination of vertical deformation of the pipe

Quasi-permanent combination of loads shall be used for this purpose.

When the pipe is buried and subject to external pressure, the vertical deformation of the pipe shall be calculated using the following formula:

\[ W_{z, max} = D_z \frac{K_d (F_{z, k} + g_a D_z)}{8S_t + 0.061E_d} \]

where:
- \( W_{z, max} \) — Maximum vertical deformation of the pipe subject to quasi-permanent combination of loads (m);
- \( K_d \) — Deformation factor of the pipe, as shown in the following table, which shall be selected according to the bedding angle \( \alpha \);
- \( D_z \) — Deformation lag factor, the value of which shall be within the range of 1.2~1.5, to be determined according to compaction density of two sides of the pipe;
Φ—— Quasi-permanent coefficient of variable load, adopted as 0.5;
Sp—— Pipe ring stiffness (kN/m²);
Ed—— Effective combined soil modulus, which shall be normally determined by test method.

Dynamic coefficient:

<table>
<thead>
<tr>
<th>Bending angle 2θ</th>
<th>20°</th>
<th>45°</th>
<th>60°</th>
<th>90°</th>
<th>120°</th>
<th>150°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deformation factor</td>
<td>0.109</td>
<td>0.105</td>
<td>0.102</td>
<td>0.096</td>
<td>0.089</td>
<td>0.083</td>
</tr>
</tbody>
</table>

When the pipe is buried and subject to external pressure, the vertical deformation of the pipe shall be less than 6%.
The vertical deformation ratio of the pipe shall be calculated using the following formula:

\[ \varepsilon = \frac{W_{fur}}{D_t} \times 100\% \]

Where \( \varepsilon \)—— Vertical deformation ratio of the pipe

● Determination of hoop cross-section strength of pipe

Fundamental combination of loads shall be used for this purpose.
The hoop cross-section strength of the pipe shall be calculated using the following formula.

\[ f_y \sigma \leq f_y \]

Where \( f_y \)—— Design value of hoop compressive strength of steel ribs (kN/m²);
\( \sigma \)—— Design value of compressive load of maximum hoop cross-section of steel ribs (kN/m²);
\( f_y \)—— Safety factor, 1.0 for sewer, 0.9 for storm water and 1.0 for mix of sewer and storm water;
\( \sigma \) shall be calculated using the following formula:

\[ \sigma = \frac{0.72K_yD_t}{f_y} \left( f_{pc,k} + \sigma_y D_t \right) \]

where \( K \)—— Load coefficient, when backfill depth H=0.8m, K=1.0, and when H=0.8m, K=0.85
\( f_{pc,k} \)—— Permanent load partial factor, adopted as 1.27
\( \sigma_y \)—— Variable load partial factor, adopted as 1.40
\( D_t \)—— Cross-section area of steel strips per meter pipe (m²/m)

● Determination of hoop cross-section stability of the pipe

Disadvantageous load effect combination shall be used for this purpose. In calculations, characteristic values shall be used for all actions. The hoop cross-section stability coefficient shall not be less than 2.0.
The following formula shall be used for calculation:

\[ \frac{F_{cr,k}}{F_{cr,k}} \geq K_s \]

where \( K_s \)—— Hoop cross-section stability resistance coefficient;
\( F_{cr,k} \)—— Disadvantageous load effect combination in vertical direction (kN/m);
\( F_{cr,k} \)—— Characteristic buckling pressure of the pipe.

The following formula shall be used for calculation of characteristic critical buckling pressure of the pipe:

\[ F_{cr,k} = 4 \sqrt{2EdS_d} \]

where \( Ed \)—— Effective combined soil modulus;
\( S_d \)—— Pipe ring stiffness.

● Determination of anti-floation capacity of the pipe

For pipes to be buried below groundwater level or surface water level, anti-floation capacity of the pipe shall be determined. For this purpose, characteristic values shall be used for both permanent load and variable load.
Anti-floating capacity of the pipe shall meet the following requirement:

\[ \sum F_{fik} \geq K_f F_{fik} \]

where \( \sum F_{fik} \)—— Combination of characteristic values of all permanent anti-floation loads;
\( F_{fik} \)—— Characteristic value of buoyant force;
\( K_f \)—— Anti-floation factor of the pipe, adopted as 1.1.

Fig 34 Difference between rigid and flexible pipe when subject to earth load
Storage, handling and transportation

**Storage**
The storage ground shall be flat & firm and the pipes shall be piled in proper order; the pipe stack shall be adequately wedged to prevent movement; the pipe layers/stack height shall comply with SANS 674 requirements, i.e. for pipes of diameter less than 2 m, the stack height shall not exceed 2 m, and for pipes of diameter larger than 2 m, the stack height shall not exceed the external diameter of the pipe; pipes of different sizes and different ring stiffness class shall be stacked separately; it shall be avoided to store the pipes under direct sunlight for overlong period; at site, the pipe shall be kept out of the way of construction traffic; items for pipe jointing shall be stored in warehouse.

**Handling**
Small size and light weight pipes may be handled by hand. Larger sizes shall be handled by machines. When handling the pipes with machinery, pliable strap or sling shall be used for lifting the pipes, and two support points shall be used; lifting points must be well spread and evenly spaced; don't use steel cable or chains to lift or transport the pipes; it is not allowed to pass the strap or sling through the pipe end to end. Adequate care shall be taken when handling the pipes; the pipes shall not be dropped off the truck, dragged along the ground or bumped against each other; heavy load on the pipes shall be avoided. Removal of any one pipe shall not cause shifting or rolling of any of the remaining pipes.

**Transportation**
Proper protection shall be made to both pipe ends during transportation; the vehicle bed shall be flat to the most likelihood; the pipes shall be directly placed on the vehicle bed and there shall be no cushions or the like inbetween; for large sizes, the pipes shall be properly wedged to prevent movement; the pile height shall be in accordance with relative state regulations governing traffic & transportation and standard requirement; pipes shall be transported on flat transport beds without sharp edges or other projections that might damage the pipes; rubbing of pipes during transport must be prevented, for instance by wrapping the pipes down; when pipes of different sizes are transported, the heaviest lengths shall be loaded underneath; if the pipes are transported nested inside one another the smaller pipes shall be removed first and piled separately.

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General requirements for pipe installation

- The pipes shall comply with SANS 674: 2008
- The installation site temperature shall be within the range of -20-40°C.
- The backfilling depth above pipe top shall not be less than 0.7m, and shall not be less than 1m in case the pipe passes under pavement or highway; normally the backfill depth shall not be greater than 6m.
- The pipeline shall be installed below frost line.
- Vertical deformation of the pipe shall not exceed 5%.
- Pipe ring stiffness class shall be selected according to actual condition. In case of normal foundation and the pipe is subject to normal truck road, SN4 (or greater) pipe shall be used; in case of soft foundation and the pipe is subject to heavy truck road, SN8 (or greater) pipe shall be used.
- Pipe laying and backfilling shall not be disturbed by groundwater. Pipe installation shall not start until the foundation strength meets the requirements.
- Conduit shall be used in case the pipeline passes below railway.
- Trench width, backfill materials and compaction density shall strictly fulfill the requirements given in the manufacturer’s technical manual. For DN450mm, the net space between trench wall and the pipe on each side shall be 300mm, and when DN > 450mm, the net space between trench wall and the pipe on each side shall be 500mm.
- Water tight and/or airtight test shall be carried out in accordance with SANS 1209.
- Acceptance inspection shall be carried out in accordance with applicable specifications or contract.

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![Fig.35 Correct pipe lifting method](image)

![Fig.36 Loading DN1200mm pipe to truck with forklift](image)

![Fig.37 Compaction density](image)
Backfill materials and compaction density

<table>
<thead>
<tr>
<th>Backfill</th>
<th>Optimum density (%)</th>
<th>Requirements for backfilling materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>95</td>
<td>Sand &amp; gravel, or graded crushed rock of less than 40mm</td>
</tr>
<tr>
<td>Bedding</td>
<td>85-90</td>
<td>Coarse or medium sand</td>
</tr>
<tr>
<td>30% Haunching</td>
<td>95</td>
<td>Coarse or medium sand</td>
</tr>
<tr>
<td>Initial backfill (line to 0.5m above pipe top)</td>
<td>85-95</td>
<td>Coarse sand, medium sand, rock screening, graded gravel of less than 40mm, or qualified native soil</td>
</tr>
<tr>
<td>Final backfill (From 0.5m above pipe top to the ground)</td>
<td>As per requirements for ground or road, but not less than 80</td>
<td>Native soil</td>
</tr>
</tbody>
</table>

Connection to manhole

Rigid connection is advised to be used when the pipeline is to be connected to brick or concrete manhole.

Starway pipe vs Concrete pipe

- **Pipe length**
  Standard length of Starway pipe is 6m, 9m and 12m. Longer pipe can be supplied as well, depending on transportation and/or on customer's request.
  As to concrete pipes, according to SANS 677:2003, "the recommended nominal effective length of pipes of diameter 300 mm and larger is 2.5 m, and manufacturers not yet producing pipes of length 2.5 m are advised to change to this length when replacing their moulds." At present, most manufacturers make concrete pipes 2.4 meters (8') long.
  It is obvious that using Starway pipes can save lots of joints, meaning great time and cost saving in pipe installation.

- **Flexibility**
  Concrete pipe is rigid. When soil settlement takes place or the trench bottom is unstable, the pipe will move. Because of pipe rigidity, the joints will move and gasket compression (plus the joint seal) will be affected. Sufficient joint movement can cause the effectiveness of the seal to fail. If localized loads exceed the pipe's structural limit, pipe wall failures (cracking) may occur. Either infiltration or exfiltration will result. If cracking continues, the rigid pipe may collapse.
  By contrast, Starway pipe is flexible in nature, and will deform when the trench bottom is unstable or soil settlement takes place. As such, joint area movement is minimized, reducing occurrences of seal failure. Besides, Starway pipe come in much longer lengths than concrete pipes, so there are fewer joints "at risk." Plus, electrofusion jointed Starway pipe is like joint-less and are therefore not subject to this problem.

- **Chemical resistance**
  HDPE has excellent chemical resistance to most industrial and domestic wastes, and is often used as a lining to rehabilitate concrete pipe or on new concrete pipe installations where high resistance to corrosion is required. Starway pipe uses HDPE as basic material. In the pipe the steel reinforcement is completely encased inside, so its chemical resistance is much better than concrete pipe. When electrofusion joint is used, the whole pipeline will have the same excellent corrosion resistance because the electrofusion belt is also made from HDPE.
  It is generally acknowledged that concrete is much less chemically resistant than HDPE. Concrete is vulnerable to hydrogen sulfide, which forms when solids in sanitary wastewater are unable to stay in suspension. This often occurs in collector sanitary sewers during periods of low flow.
  When the pipe uses gaskets for jointing, the gaskets are more vulnerable than the pipe material to chemical attack. This is a significant concern for concrete pipe systems, which have a gasket every 2.4 m. Electrofusion jointed Starway pipe system is not subject to gasket degradation.

- **Abrasion resistance**
  Abrasion resistance is a materials' ability to withstand mechanical erosion. Pipes used in drainage, sewer and stormwater applications requires significant abrasion resistance, since grit and suspended solids continuously impact on the pipe wall.
  HDPE ranks the first in abrasion resistance among pipe materials. It is generally accepted that HDPE is three to five times more abrasion resistant than concrete pipe. Besides the abrasion resistance of concrete pipe may be adversely affected by corrosion, therefore it can be concluded that Starway pipe is much superior to concrete pipe in respect of abrasion resistance.
AMANZI STARWAY (PTY) Ltd

Hydraulic characteristics
The Manning’s n value (0.01) of Starway pipe is the same as that of polyethylene-only structural wall pipe, while the Manning’s n value of concrete pipe is 0.013. After long term use, the flow resistance of concrete pipe may be even worse due to corrosion and abrasion, so reduction in flow capacity is anticipated, particularly in hostile environments. The flow capacity of Starway pipe in a gravity sewer or drainage application is 32% greater than comparable sized concrete pipe.

Pipe jointing
Two methods are used for jointing of Starway pipes; rubber sleeve combined with stainless steel clamp is used for DN1200mm pipes, which is simple and secure; electrofusion joint is used for DN900mm pipes, which characterizes in permanent reliability, zero leakage and same corrosion resistance, abrasion resistance and life expectancy as that of the pipe itself. The jointing element electrofusion belt is also made from HDPE. The joint made by means of this method is flexible in nature, so when pipe movement takes place due to soil settlement or groundwater fluctuation, the joint is able to respond accordingly to avoid damages from excessive stress.

Concrete pipes use gasketed precast bell and spigot connections or gasketed prefabricated steel male and female connections. Rigid in nature, concrete pipe is prone to move when soil settlement or groundwater fluctuations occur, and as a consequence, the pipe joint is weakened or even failed. Moreover, the anticorrosion and antiaging performance of the gasket and the anticorrosion performance of the prefabricated steel pipe end are not as good as the concrete pipe body, so the life expectancy of the joint is shorter than the pipe and the reliability of the joint will decrease with time. Finally, the chemical resistance of the gasket, which is inferior to pipe body, is also a big problem for concrete piping system which needs much more joints due to shorter standard pipe length.

Handling and transportation
Starway pipe is much lighter than concrete pipes, and consequently it is much easier to load, offload and transport the pipes. Two workers can lift a 6m-long ID500mm pipe without difficulty. Heavy lifting machinery cost can be saved when handling small and medium size Starway pipes.

Installation
Starway pipe has much longer pipe length (6-12m or even longer when transportation allows) and needs less joint, and the pipe jointing is much more convenient and quick than concrete pipe. Pipe cutting and end seating at site is very easy for Starway pipes. In addition, Starway pipe is much lighter in unit weight and does not need heavy lifting equipment. Due to these reasons, Starway pipe can save much time and cost in installation in comparison with concrete pipe.

Service life and cost
The service life of concrete pipe can be significantly reduced due to corrosion or abrasion. The situation may be even worse in severe conditions. Joint failure is often a big cause for reducing the effective useful life of a concrete pipe system. Theoretically the service life of Starway pipe can be as long as up to 100 years. To be conservative, the service life is designed as for at least 50 years. Although service life for both pipes must be carefully evaluated, concrete should never exceed the service life of Starway pipe.

Starway pipe has very good hydraulic characteristics, so smaller diameter Starway pipe can be used to fulfill same flow capacity requirement as bigger concrete pipe. Starway pipe has much longer pipe length, requiring much less joints. Handling and installation cost of Starway pipe is comparatively lower as well. In general, the total cost using Starway pipe is less than that using concrete pipe.

Starway pipe vs. PE structural wall pipes
There are many kinds of profile wall pure HDPE pipes available in the market. They are made either by one-step compressive extrusion process or by firstly extruding PE profiles (hollow inside or in the form of PE belt) and then winding and welding the profiles to form the pipe. All pipes use specially designed ribs or other reinforcing structures to increase pipe ring stiffness. A common disadvantage of these pipes is that all these pipes use POLYETHYLENE ONLY for pipe strength while the E-modulus of polyethylene is only 800-1000MPa. Compared with these pipes, Starway pipe uses less raw materials, saving manufacturing cost.

HDPE is prone to creeping over time, which may cause stress crack or seal failure at the joint, so the permanent mechanical strength and security of pure profile wall HDPE piping system may be adversely affected. But in Starway pipe, as the mechanical strength is provided by the steel reinforcement and creeping will not occur to steel under the pipe’s application condition, the permanent strength and service security of Starway piping system can be guaranteed.

Starway pipe vs. PVC drainage pipe

Pipe structure:
PVC drainage pipe fall into two categories: solid wall and profile wall. Both are produced through extrusion process. The pipe diameter of solid wall pipe is usually less than 400mm due to economic consideration. The profile walls are usually designed as corrugated, concentric straight rib reinforced or concentric T-rib reinforced.

Chemical resistance, abrasion resistance, hydraulic characteristic and installation
Using HDPE material as main pipe body, Starway pipe enjoys advantages over PVC pipe in terms of chemical resistance as well as abrasion resistance. The Manning’s n value of Starway pipe and PVC pipe are respectively 0.01 and 0.09. Starway pipe and PVC pipe have basically the same requirements for trenching, bedding, pipe laying and backfilling. However since Starway pipe is light in weight, it does not need heavy lifting equipment in handling, and because it is flexible in axial direction, it can be bent to a certain degree, which means more flexibility in installation.

Pipe jointing
PVC pipe is brittle in nature and can not be connected by welding method. PVC pipe usually uses gasketed socket-spigot connection. The gasket, exposing to the middle inside the pipe, is inferior to PVC in terms of corrosion resistance and aging resistance, and consequently the leakage likelihood at joint will increase over time. Besides, the tightness of the joint is also subject to adverse effect from thermal expansion and contraction of the pipe, soil settlement, and pipe deformation in axial direction that may be caused by groundwater fluctuation.

For DN100mm and smaller Starway pipe, rubber sleeve joint is proved to be reliable, secure and leakfree by both pressure test and engineering practice. DN900mm and larger Starway pipes can be joined by means of electrofusion welding. Theoretically this method can be regarded as jointless, which has been proved to be zero-leakage by nearly 50 years of engineering practice, and the chemical resistance and aging resistance of the joining element is the same as that of the pipe material. So Starway pipe is more reliable, secure and durable than PVC pipes.

Overall project cost
Generally the total cost of Starway drainage piping system is comparatively lower than that of PVC piping system due to the following reasons: first, profile costs of pipes can be transported to the site to make pipes nearby the site, saving great transportation cost; secondly, Starway pipe is light in weight and does not need heavy lifting equipment in installation site for handling, saving labor and time; and thirdly but most importantly, the pipe itself use less raw material in production than PVC pipe.
### Applications
- Irrigation works: irrigation pipes and water source pipelines
- Municipal engineering: buried drainage pipelines and sewers
- Building construction: stormwater pipelines, buried drainage pipeline, sewer and vent pipe
- Communication: communication cable conduit
- Industry: drainage pipelines
- Agriculture: irrigation pipelines for farmland, orchard, tea garden or woodland
- Roadway project: seepage or drainage pipelines for railway, pavement or highway projects
- Mines: vent pipe, drainage pipe or slurry transportation
- Gym and sports field: seepage or drainage pipelines of golf course, football pitch, etc.
- Seaports or airports: drainage pipelines or sewers
- Environmental protection: sewage collection & disposal in garbage treatment
- Stormwater detention and retention system
- Sea water transportation
- Culvert

### Chemical resistance

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Concentration</th>
<th>Resistance to corrosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric acid</td>
<td>tc</td>
<td>Good</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>10%</td>
<td>Good</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>25%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Hydrobromic acid</td>
<td>50%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>10%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Acrylic acid</td>
<td>100%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Aquasol</td>
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</tr>
<tr>
<td>Carbonic acid</td>
<td>100%</td>
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<tr>
<td>Boric acid</td>
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<td>Excellent</td>
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<td>Chromium trioxide</td>
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<tr>
<td>Phosphoric acid</td>
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<td>Excellent</td>
</tr>
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<td>Acetic acid</td>
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