calculations to verify that the pipe manufacturers' standard designs are structurally sound and cost-effective. The cost effectiveness of open cut excavation and micro-tunnel construction also has to be studied in these circumstances.

A2.2 Calculations for Pipe Structural Design

In many cases pipe manufacturer's technical catalogues will give tables of permissible cover for different bedding types and surface loading conditions. However, information is given in this Appendix to aid understanding of the reference information in order to enable:

a) calculations to be done where conditions occur outside the range of manufacturers' catalogues
b) the Consultant to verify manufacturers' pipe designs
c) the Consultant to carry out specific calculations where it may be possible to devise alternative, more cost-effective designs

The primary references for the calculations are BS EN 1295:2010 and BS 9295: 2010.

A2.2.1 Flexible Pipes (MDPE, HDPE, GRP, uPVC)

The primary source of strength for flexible pipes is the backfill at the sides of the pipe. It is very important that the material surrounding flexible pipes is carefully specified and properly compacted on site. Greater care is required in constructing flexible pipes than rigid or semi-rigid pipes.

It must be noted that GRP is a composite material which is manufactured in a range of stiffnesses. Additional factors must be taken into account in the pipe design for which reference to BS EN 1295 must be made.

The design method for flexible pipes is based around not exceeding the permissible ovalisation of the pipe, but with checks for other parameters.

The ovalisation formula below is based on Eqn. 23 in BS EN 1295:

$$\Delta = 100K_x (D_L P_e + P_s) / (8S + 0.061 E')$$

Where:

Δ = the pipe ovalisation (percent)
K_x = bedding factor or deflection coefficient
D_L = deflection lag factor
Pe = pressure from soil loading (kN/m^2)
Ps = surcharge pressure (kN/m^2)
S = pipe diametral stiffness (kN/m^2)
E' = modulus of soil reaction (kN/m^2)

Permissible Pipe Ovalisation (Δ)

Flexible pipes should be designed so that the ovalisation does not exceed the values below:

Permissible Pipe Ovalisation % for Different Pipe Materials		
GRP	**HDPE**	**uPVC**
3 (initial) 5 (long term)	6	5

Table A2-2 – Permissible Ovalisation