Pipes Materials and Loads

Pipe Materials

Materials used for pipes:

Sewers are made from:

1- Concrete
2- Reinforced concrete
3- Vitrified clay
4- Asbestos cement
5- Cast iron (lined with cement).
6- Ductile iron (lined with cement).
7- Steel (lined with cement).
8- PVC, UPVC
9- GRB (fiber glass).

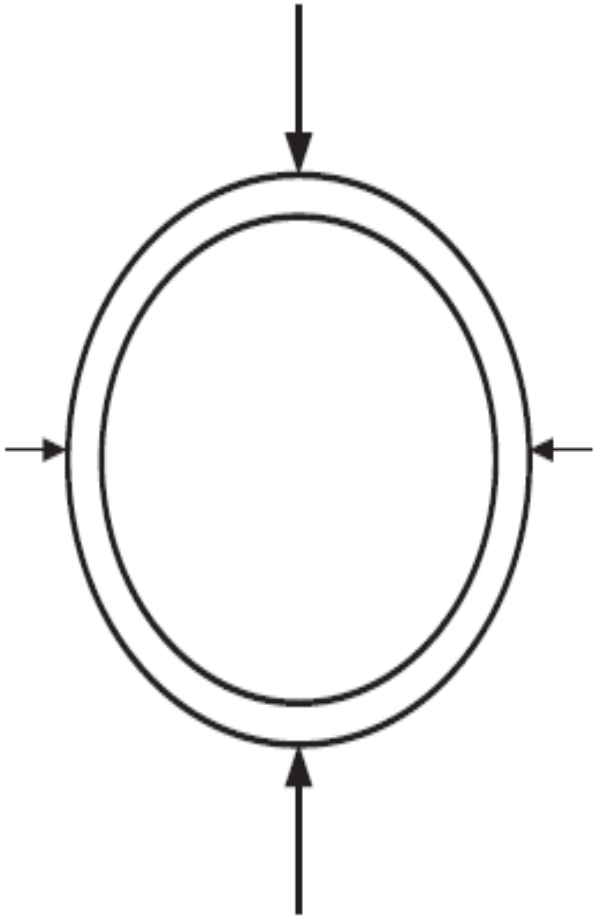
Factors effecting the selection of materials:

1- Chemical characteristics of wastewater and degree of resistance to acid, base, solvents,
2- Resistance to scour and flow (friction coefficient).
3- External forces and internal pressures.
4- Soil conditions.
5- Type of backfill
6- Useful life
7- Strength and water tightness of joints and effective control of infiltration and inflow.
8- Availability in diameter, length, and ease of installation.
9- Cast of construction and maintenance.

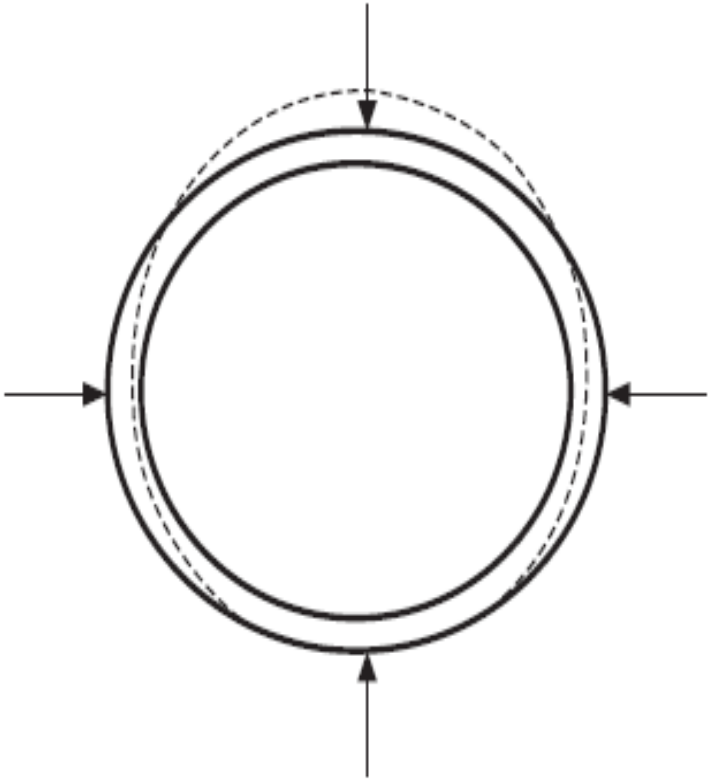
Pipe Materials classification

- Piping materials are generally placed in one of two classifications: **Rigid** or **Flexible**
- A flexible pipe has been defined as one that will deflect at least 2 percent without structural distress.
- Materials that do not meet this criterion are usually considered to be rigid.
- Concrete and clay pipes are examples of materials which are usually considered to be rigid.
- Steel and plastic pipes are usually considered to be flexible.

Rigid and flexible pipes loading and support



Rigid pipe – little deflection, soil load acts as line load with some horizontal support from active soil pressure



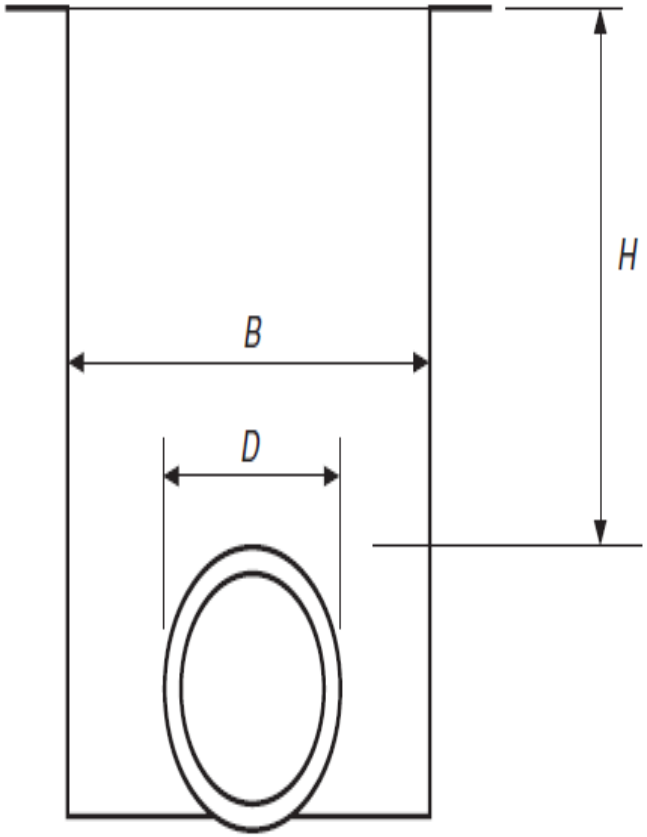
Flexible pipe – as pipe deflects, loads redistribute to provide more horizontal support from passive soil pressure

Loads on pipes

- In a buried sewer, stresses are induced by external loads and also by internal pressure in case of a pressure main.
- The external loads are of two categories
  - load due to backfill material
  - superimposed load (concentrated load and distributed load)

Loads on conduits due to backfill

- The load on rigid conduits in trench condition is given by the Marston's formula in the form



$$W = C_d \gamma B^2$$

Where W = load on the pipe (kg/m)

Cd = load coefficient

B = trench width (m)

γ = unit weight of backfill material

Cd is a function of the depth of cover (H), the width of the trench (H/B)

Table 1. weights of common filling materials

Materials	Weight (kg/m^3)
Dry sand	1600
Ordinary (Damp sand)	1840
Wet sand	1920
Damp clay	1920
Saturated clay	2080
Saturated top soil	1840
Sand and Damp soil	1600

Table 2. Values of Cd

Ratio H/B	Safe working values of C_d				
	Minimum possible without cohesion	Maximum for ordinary sand	Completely saturated Top Soil	Ordinary maximum for clay	Extreme maximum for clay
0.5	0.455	0.461	0.464	0.469	0.474
1.0	0.830	0.852	0.864	0.881	0.898
1.5	1.140	1.183	1.208	1.242	1.278
2.0	1.395	1.464	1.504	1.560	1.618
2.5	1.606	1.702	1.764	1.838	1.923
3.0	1.780	1.904	1.978	2.083	2.196
3.5	1.923	2.075	2.167	2.298	2.441
4.0	2.041	2.221	2.329	2.487	2.660
4.5	2.136	2.344	2.469	2.650	2.856
5.0	2.219	2.448	2.590	2.798	3.032
5.5	2.286	2.537	2.693	2.926	3.190
6.0	2.340	2.612	2.782	3.038	3.331
6.5	2.386	2.675	2.859	3.137	3.458

7.0	2.423	2.729	2.925	3.223	3.571
7.5	2.454	2.775	2.982	3.223	3.571
8.0	2.479	2.814	3.031	3.366	3.764
8.5	2.500	2.847	3.073	3.424	3.845
9.0	2.518	2.875	3.109	3.476	3.918
9.5	2.532	2.898	3.141	3.521	3.983
10.0	2.543	2.918	3.167	3.560	4.042
11.0	2.561	2.950	3.210	3.626	4.141
12.0	2.573	2.972	3.242	3.676	4.221
13.0	2.581	2.989	3.266	3.715	4.285
14.0	2.587	3.000	3.283	3.745	4.336
15.0	2.591	3.009	3.296	3.768	4.378
Very Great	2.599	3.030	3.333	3.846	4.548

Example:

- Determine the backfill load on 200 mm diameter stone ware pipe with a thickness of 16 mm laid in a trench to a width of 0.8 m in depth of 1.30 metre in ordinary sand soil.

Solution:

BC = D + 2t = 200 + 2x16 = 232mm

H=1.30-0.232=1.068 m

H/B =1.068/0.8=1.335

Cd= 1.05 (From Table 2)

γ = 1840 (From Table 1)

$W = C_d \gamma B^2$ =1.05 x 1840 x 0.8^2 = 1237 kg/m

Load on conduit due to super imposed loads

Concentrated Load:

- The formula for load due to super imposed concentrated load such as a truck wheel is given in the following formula

$W_{sc} = C_s (PF/L)$

W_{sc}= the load on the conduit in kg/m

P = the concentrated load in kg acting on the surface

F = the impact factor (1.0 for air field runways, 1.5 for highway traffic and air field taxi ways, 1.75 for railways traffic) and

Load on conduit due to super imposed loads

C_s= the load coefficient which is a function of

$$\frac{B_c}{2H} \quad \text{and} \quad \frac{L}{2H}$$

Where

H = the height of the top of the conduit to ground surface in m

B_c= the outside width of conduit in m and

L=the effective length of the conduit to which the load is transmitted in m

Values of C_s for various values of (B_c/2H) and (L/2H) are obtained from Table

Concentrated Superimposed Load

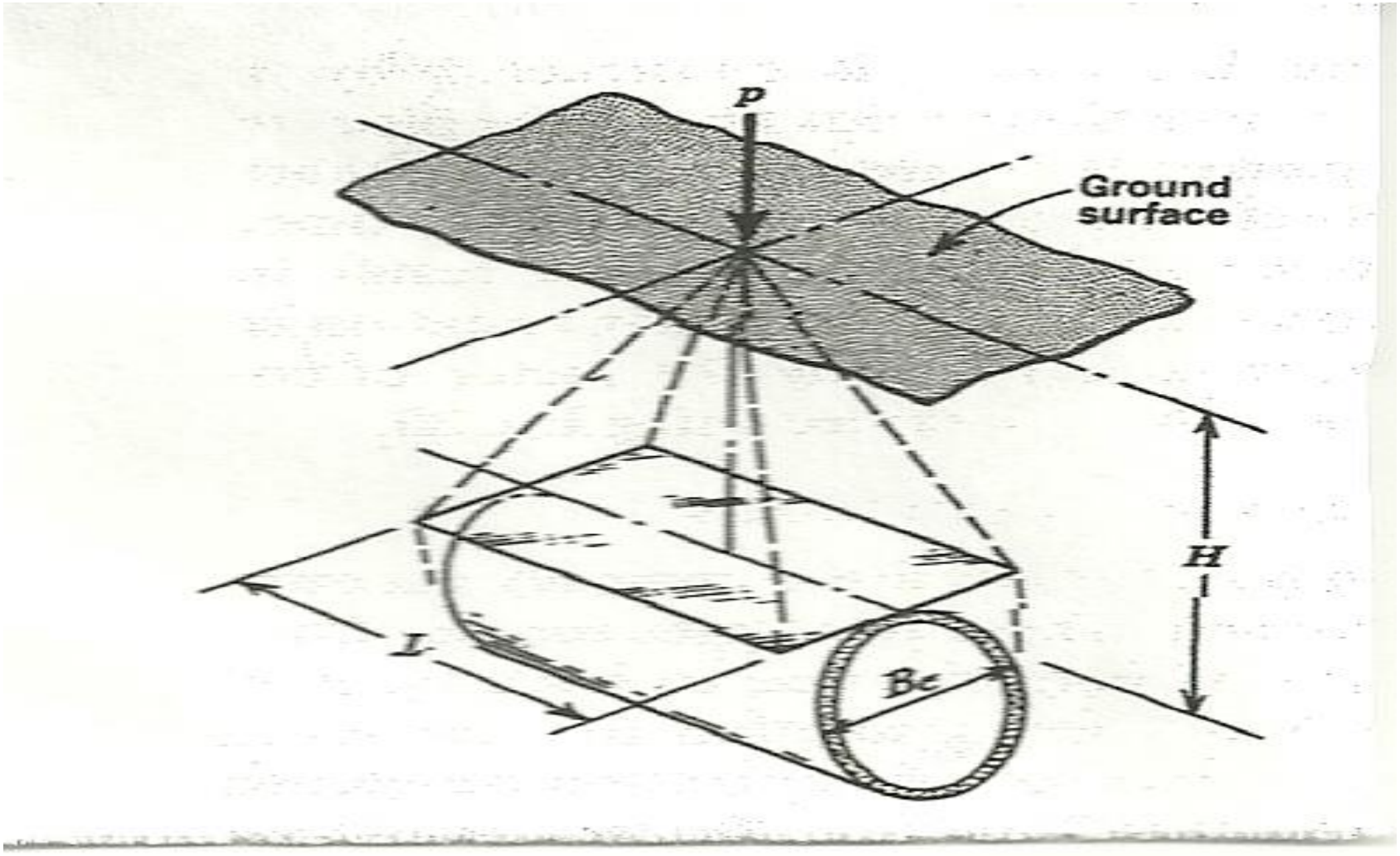


Table 3 Values of Load Coefficients

$\frac{D}{2H}$ or $\frac{B_c}{2H}$	$\frac{M}{2H}$ or $\frac{L}{2H}$													
	0.1	0.2	0.3	0.4	0.5	0.5	0.7	0.8	0.9	1.0	1.2	1.5	2.0	5.0
0.1	0.019	0.037	0.053	0.067	0.079	0.089	0.097	0.103	0.108	0.112	0.117	0.121	0.124	0.128
0.2	0.037	0.072	0.103	0.131	0.155	0.174	0.189	0.202	0.211	0.219	0.229	0.238	0.244	0.248
0.3	0.053	0.103	0.149	0.190	0.224	0.252	0.274	0.292	0.306	0.318	0.333	0.345	0.355	0.360
0.4	0.067	0.131	0.190	0.241	0.284	0.320	0.349	0.373	0.391	0.405	0.425	0.440	0.454	0.460
0.5	0.079	0.155	0.224	0.284	0.336	0.379	0.414	0.441	0.463	0.481	0.505	0.525	0.540	0.548
0.6	0.089	0.174	0.252	0.320	0.379	0.428	0.467	0.499	0.524	0.544	0.572	0.596	0.613	0.624
0.7	0.097	0.189	0.274	0.349	0.414	0.467	0.511	0.546	0.584	0.597	0.628	0.650	0.674	0.688
0.8	0.103	0.202	0.292	0.373	0.441	0.499	0.546	0.584	0.615	0.639	0.674	0.703	0.725	0.740
0.9	0.108	0.211	0.306	0.391	0.463	0.524	0.574	0.615	0.647	0.673	0.711	0.742	0.766	0.784
1.0	0.112	0.219	0.318	0.405	0.481	0.544	0.597	0.639	0.673	0.701	0.740	0.774	0.800	0.816
1.2	0.117	0.229	0.333	0.425	0.505	0.572	0.628	0.674	0.711	0.740	0.783	0.820	0.849	0.868
1.5	0.121	0.238	0.345	0.440	0.525	0.596	0.650	0.703	0.742	0.774	0.820	0.861	0.894	0.916
2.0	0.124	0.244	0.355	0.454	0.540	0.613	0.674	0.725	0.766	0.800	0.849	0.894	0.930	0.956

Example:

Determine the load on a 24-in diameter pipe under 3 ft of cover caused by a 10,000-lb truck wheel applied directly above the center of the pipe.

Assume the pipe section is 2.5 ft long; the wall thickness is 2 in.; and the impact factor is 1.5

B_c = 24+4 = 28 in. = 2.33 ft

L = 2.5 ft

H = 3.0 ft

$B_c/2H$ = 2.33/6 = 0.39

L/2H = 2.5/6 = 0.41

From Table 3, for $B_c/2H$ of 0.39 and L/2H of 0.41, the load coefficient = 0.240

Substituting the above values in equation $W_{sc} = C_s(PF/L)$

W_{sc} = 0.24 x {(10,000x1.5)/2.5} = 1,440 lb/ft

Load on conduit due to super imposed loads

Distributed load :

- For the case of distributed superimposed loads, the formula for load on conduit is given by

$$W_{sd} = C_s \, p \, F \, B_c$$

Where

W_{sd}= the load on the conduit in kg/m

.p = the intensity of the distributed load in kg/m^2

f = the impact factor

B_c= The width of the conduit in m

C_s = the load coefficient, a function of D/2H and L/2H from Table 3

H = the height of the top of conduit to the ground surface in m and

D and L are width and length in m respectively of the area over which the distributed load

Distributed Superimposed Load

