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Information and Guidance Note

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IMPORTED GRANULAR AND SELECTED AS-DUG BEDDING AND SIDEFILL MATERIALS FOR BURIED PIPELINES

1. INTRODUCTION

This information note provides guidance on choosing materials suitable for providing structural support to buried pipelines. Materials which fulfil this role are termed bedding and sidefill materials. This note deals both with granular materials brought to the site for these purposes and materials excavated in the course of the works which have been selected as suitable. These are termed imported granular materials and selected as-dug materials respectively. The guidance given below covers pressure and non-pressure pipelines, either sewers or water mains, of 100mm diameter and larger. All such pipelines require adequate structural support to ensure their long term performance. Figure 1 shows a typical trench configuration and illustrates some of the terminology adopted in this information note.

2. STRUCTURAL PERFORMANCE OF BURIED PIPELINES

Pipes used in the construction of buried pipelines can be divided into two main categories; rigid and flexible. A rigid pipe is designed to carry all the loads imposed upon it with minimal deformation. The bedding and sidefill material serves to enhance its load carrying capability. Clay and concrete pipes are typical of the products that fall into this category. A flexible pipe is designed to carry much less load than a rigid pipe, whilst deforming to some degree. The bedding and sidefill material provides most of its load carrying capability. Typical flexible pipe materials are uPVC and MDPE.

The pipe installation should be designed so that the pipeline will not suffer structural failure due to the loads acting on it. The design should take

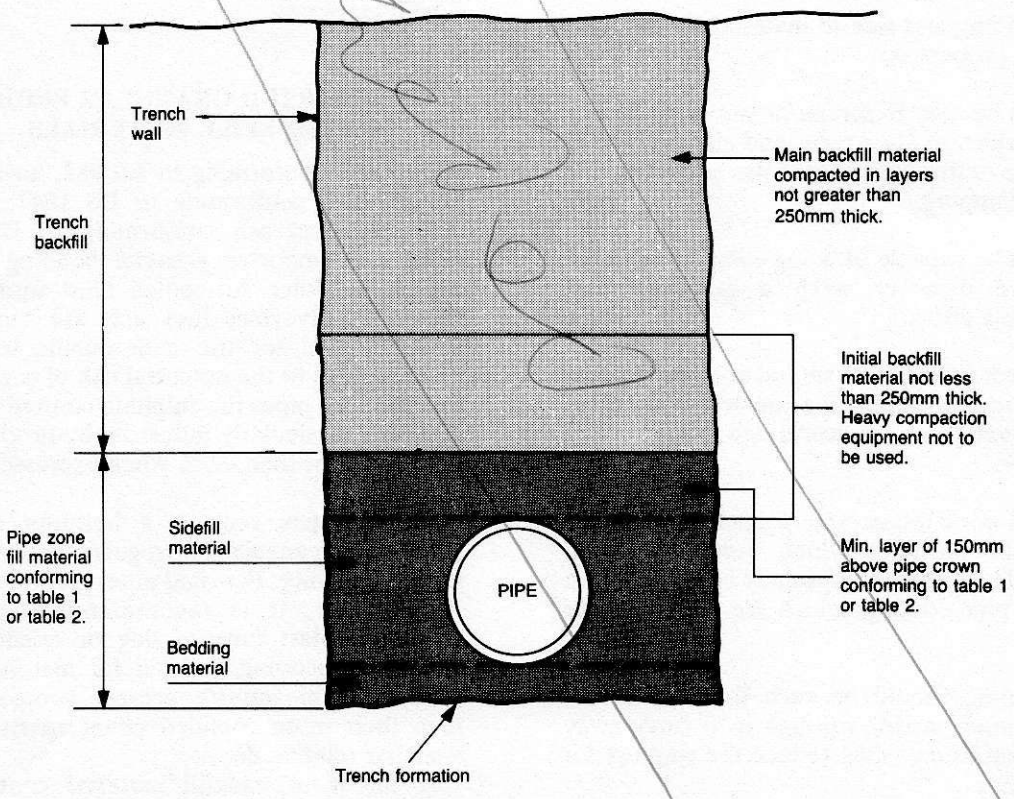

Figure 1 – Typical trench configurations

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account of the load applied to the pipe by the ground above it, traffic and other loads transmitted from the surface. The design should also take account of the standard of workmanship likely during laying. From consideration of these factors a suitable installation can be chosen and the necessary materials specified.

3. BEDDING AND SIDEFILL MATERIAL

The bedding and sidefill material, used to surround a pipe, may be selected as-dug material or imported granular material. The installation design may require the pipe to be fully surrounded with one of these materials. Alternatively both may be employed, for example, a granular bed may be placed below the pipe, with selected as-dug material used as sidefill.

For rigid pipes, the bedding material transfers the support reaction from the trench bottom to the pipeline. If this reaction is transferred uniformly and over a wide area, the load bearing capacity of the pipes is increased. The greater the extent of granular material around the pipe circumference the greater the pipe's load carrying capacity becomes.

Flexible pipes are incapable of carrying vertical imposed loads without the support of the bedding and sidefill material which transfers the loads from the backfill and ground surface to the native soil adjacent to the pipe. Whilst achieving this, the bedding and sidefill material must also control the deformation of the pipe under load in order to avoid overstress or buckling failure.

4. REQUIRED PROPERTIES

The ideal bedding and sidefill material should have the following properties:

(a) It should be easy to scrape or shovel to form a bed on which to lay a pipe, and also be easy to distribute uniformly beneath the haunches of a pipe by tamping.

(b) It should be capable of being compacted to the required density with a minimum of compactive effort.

(c) The largest particle size should not be excessive in relation to the pipeline diameter otherwise impact damage and concentrated point loading can occur.

(d) It should not contain large particles with sharp edges nor particles which break up when wetted. The former is especially important with pipes or pipe coatings which are susceptible to damage.

(e) The grading should be such that it will not permit water passing through it to carry away fine materials and thus reduce the support for the pipeline.

(f) Under wet conditions its grading should not permit fines from the native soil to infiltrate the bedding and sidefill material. In situations where this may occur consideration should be given to the use of a filter fabric.

(g) It should not cause corrosion or degradation of the pipes, fittings and jointing materials with which it is in contact.

(h) It should be sufficiently stable, when laid, to support the pipeline in the correct position both during and after laying. This is especially important with very heavy pipes.

(i) It should be chemically durable and not react with the soil or groundwater.

5. SELECTION OF SUITABLE BEDDING AND SIDEFILL MATERIALS

It will probably not be possible to satisfy all the required properties described in clause 4 and compromise will be necessary.

When selecting a suitable material consideration must be given to where and how the material is to be used, i.e.

(a) The chosen installation design, contract specification and expected level of site supervision.

(b) The size, weight and material of the pipes.

(c) The expected ground conditions.

Tables 1 to 3 and clauses 6 and 7 provide specific guidance on the selection of suitable bedding and sidefill materials.

6. IMPORTED GRANULAR BEDDING AND SIDEFILL MATERIALS

Aggregates conforming to BS 882, air-cooled blast furnace slag conforming to BS 1047, or sintered pulverized-fuel ash conforming to BS 3797 are suitable as imported granular bedding and sidefill materials (Note: Air-cooled blast furnace slag or sintered pulverized-fuel ash are currently not recommended for use with ductile iron or steel pipelines due to the potential risk of corrosion). For cementitious pipes the sulphate content of imported material, particularly industrial by-products, should not be greater than 0.3% when expressed as sulphur trioxide.

Heavy pipes require a bedding and sidefill material with angular or irregular shaped particles to provide stability. For rigid pipes greater than 500mm in diameter, it is recommended that angular air-cooled blast furnace slag or crushed rock be used as a bedding and sidefill material. Angular materials will require greater compactive effort than their more rounded counterparts to achieve a similar relative density.

If the main backfill material contains stones greater than the maximum size specified in Tables 1 and 2, it is recommended that the imported granular sidefill material be extended to 150mm above the pipe crown.

Table 1 - Granular bedding and sidefill materials for rigid pipes

Pipe Nominal Bore (DN)	Maximum Particle Size (mm)	Class of Bedding	Suitable Materials	
			Imported granular materials (Note a)	Maximum CF value for as-dug granular materials (Note b)
100	10	S	10mm nominal single-size	0.15
		B		0.30 (Note c)
		F		0.15
		N	Coarse, medium or fine sand	
Over 100 to 150	15	S	10 or 14mm nominal single-sized or 14mm to 5mm graded	0.15
		B		0.30 (Note c)
		F		0.15
		N	Coarse, medium or fine sand	
Over 150 to 500	20	S	10, 14 or 20mm nominal single-sized or 14mm to 5mm graded or 20mm to 5mm graded	0.15
		B		0.30 (Note c)
		F		0.15
		N	All-in aggregate or coarse, medium or fine sand	
Over 500 (Note d)	40	S	10, 14, 20 or 40mm nominal single-sized crushed rock or 14mm to 5mm graded or 20mm to 5mm graded or 40mm to 5mm graded	0.15
		B		0.30 (Note c)
		F		0.15
		N	All-in aggregate or coarse, medium or fine sand	

NOTES:

(a) Imported granular materials to include aggregates to BS 882, air-cooled blast furnace slag to BS 1047 and sintered pulverized-fuel ash to BS 3797.

(b) Compaction fraction value, see Appendix A.

(c) The higher the CF value for as-dug bedding and sidefill materials the greater the required effort for adequate compaction.

(d) Angular materials should be chosen to ensure sufficient support is provided to these heavier pipes. Crushed rock aggregates to BS 882 are recommended. Air-cooled blast furnace slag to BS 3797 or other granular materials may be used if they show a similar degree of angularity.

NOTE:

In wet soils the migration of fine soil particles with ground water into the voids of the bedding and sidefill material may be minimised by surrounding the granular material with filter fabric. Alternatively, the grading of the material may be selected so that it is self filtering with respect to the surrounding soil provided the other required properties are not impaired.

The classes of bedding listed in the above Table are fully described in Young and Trott 'Buried Rigid Pipes' and the Department of Transport document, 'Simplified tables of external loads on buried pipelines', WAA SWMC IGN No. 4-11-02 Revised bedding factors for vitrified clay drains and sewers.

Air-cooled blast furnace slag and sintered pulverized-fuel ash are not recommended for use with ductile iron or steel pipelines due to the potential risk of corrosion (see clause 6).

The sulphate content of bedding and sidefill materials for use with cementitious pipe should not be greater than 0.3% as sulphur trioxide.

7. SELECTED AS-DUG BEDDING AND SIDEFILL MATERIALS

Selected as-dug materials will normally be derived from the soil excavated from the pipe trench. Material excavated from trenches dug through land contaminated with domestic, building or industrial waste should not be used as bedding and sidefill material. Selected excavated materials should be readily compactible and be free from organic matter and combustible materials. Frozen soil should not be used. During selection, soil containing clay lumps larger than 75mm and stones larger than those permitted in Tables 1 or 2 as appropriate should be discarded.

All selected as-dug granular bedding and sidefill material should be evaluated using the Compaction Fraction Test, detailed in Appendix A. Materials are suitable if the values obtained do not exceed those given in Tables 1 or 2 for rigid and flexible pipes respectively.

Selected as-dug cohesive bedding and sidefill

Table 2 - Granular bedding and sidefill materials for flexible pipes

Nominal Size of Pipes (mm)	Maximum Particle Size (mm)	Suitable Materials	
		Imported granular materials (Note a)	Maximum CF value for as-dug granular materials (Note b)
100	10	10mm nominal single-size	0.15
Over 100 to 150	15	10 or 14mm nominal single-size or 14mm to 5mm graded	0.15
Over 150 to 300	20	10, 14 or 20mm nominal single-size or 14mm to 5mm graded or 20mm to 5mm graded	0.15
Over 300 to 600	20	14 or 20mm nominal single-size or 14mm to 5mm graded or 20mm to 5mm graded	0.15
Over 600	40	14, 20 or 40mm single-size or 14mm to 5mm graded or 20mm to 5mm graded or 40mm to 5mm graded	0.15

NOTES:

(a) Imported granular materials to include aggregates to BS 882, air-cooled blast furnace slag to BS 1047 and sintered pulverized-fuel ash to BS 3797.

(b) Compaction fraction value, see Appendix A.

(c) Material excavated from trenches dug through land contaminated with domestic, building or industrial waste should not be used as bedding or sidefill material (see clause 7).

material should be evaluated by referring to site investigation data and monitoring the excavated soil. Table 3 lists suitable as-dug cohesive bedding and sidefill materials.

8. SELECTED AS-DUG MAIN BACKFILL MATERIALS

Should the material excavated from the trench meet the specification laid down in clause 7 above, or, the requirements for 'Type B' material, laid down in clause 2.50.3 of the Civil Engineering Specification for the Water Industry, then it may be used as the main backfill material. Type B material should be free from stones greater than the maximum size permitted in Tables 1 and 2 to a level of 150mm above the pipeline crown.

Heavy compaction of the main backfill material should be avoided until the pipeline has minimum cover to the crown of 250mm, ref Figure 1. The main backfill material should be compacted in layers not greater than 250mm thick or in compliance with the local authority or contract specification. Special consideration should be given to this material if surface subsidence is a concern, for example under a main road.

9. REFERENCES

In this IGN reference has been made to the following documents:

O C YOUNG and J S TROTT. Buried rigid pipes; Structural design of pipelines.

WATER RESEARCH CENTRE. Guide to the Water Industry for the structural design of underground non-pressure uPVC Pipelines. WRc Engineering Report ER201E.

DEPARTMENT OF TRANSPORT. Simplified tables of external loads on buried pipelines.

WATER AUTHORITIES ASSOCIATION. Civil Engineering Specification for the Water Industry. 3rd Edition.

WAA Sewers and Water Mains Committee Information and Guidance Note No. 4-11-02 Revised bedding factors for vitrified clay drains and sewers.

BS 882 Specification for aggregates from natural sources for concrete.

BS 1047 Specification for air-cooled blastfurnace slag aggregate for use in construction.

BS 1377 Methods of test for soils for civil engineering purposes.

BS 3797 Lightweight aggregates for concrete. Part 2. Metric units.

BS 5930 Code of practice for site investigations.

See also

BS 5955 Code of practice for plastics pipework (thermoplastics materials) Part 6. Installation of unplasticised PVC pipework for gravity drains and sewers.

CP 312 Code of practice for plastics pipework (thermoplastics materials) Part 1. General principles and choice of material.

Table 3 - Suitable as-dug bedding and sidefill materials

Material		Modulus of Soil Reaction E′ (MN/m²)			
		Degree of compaction			
Description	British soil classification system group symbols	Uncompacted (Note a)	<85% std. Proctor	85% – 95% std. Proctor	>95% std. Proctor (Note b)
Gravel-single sized	GPu (Note c)	5	7	10	14
Gravel-graded	GW (Note d)	1	7	14	20
Sand and coarse grained soil with less than 12% fines	GP (Note e) SW (Note f) SP (Note g)	1	7	14	20
Coarse grained soil with more than 12% fines	GM (Note h) GC (Note i) SM (Note j)	*	3	7	14
Fine grained soil with medium to no plasticity and containing more than 25% coarse grained particles (LL < 50%) (Note q)	CL (Note k) ML (Note l) CI (Note m) MI (Note n) CL-ML (Note o) CI-MI (Note p)	*	1	3	7
Fine grained soil with medium to no plasticity and containing less than 25% coarse grained particles (LL < 50%) (Note r)	CL (Note k) ML (Note l) CI (Note m) MI (Note n) CL-ML (Note o) CI-MI (Note p)	*	1	3	7 (Note s)

Guidance for appropriate trench widths for flexible pipe is given in WRc Report ER201 E.

* No reliable modulus values for these uncompacted materials.

NOTES:

(a) For any situation where bedding and sidefill trench material must be placed and compacted within temporary trench supports, the value chosen for E′ should be that associated with uncompacted material.

(b) BS 1377 Test 12, 'Determination of the dry density/ moisture content relationship (2.5kg rammer method)', is used to determine the Standard Proctor Density.

(c) Poorly graded uniform gravel.

(d) Well graded gravel.

(e) Poorly graded gravel.

(f) Well graded sand.

(g) Poorly graded sand.

(h) Very silty gravel.

(i) Very clayey gravel.

(j) Very silty sand.

(k) Clays with low plasticity.

(l) Silts with low plasticity.

(m) Clays with intermediate plasticity.

(n) Silts with intermediate plasticity.

(o) Mixtures of ML and CL.

(p) Mixtures of MI and CI.

(q) Clays and silts, with a liquid limit less than 50% and an appreciable fraction passing the 75 μm BS test sieve, with more than 25% coarse grained particles.

(r) As note q with less than 25% coarse grained particles.

(s) Modulus of soil reaction (E′) values are only applicable to flexible pipe design.

APPENDIX A – COMPACTION FRACTION TEST FOR GRANULAR MATERIAL

A.1 APPARATUS

A1.1 Open-ended cylinder

Approximately 250mm long and 150mm (+ 10mm – 5mm) internal diameter (150mm diameter pipe is suitable).

A1.2 Metal rammer

Metal rammer with striking face approximately 40mm diameter and weighing 0.8kg to 1.3kg.

A1.3 Rule

A.2 METHOD

Obtain a representative* sample more than sufficient to fill the cylinder (about 10kg). It is important that the moisture content of the sample should not differ from the bulk of material at the time of its use in the trench.

Place the cylinder on a firm flat surface and gently pour the sample material into it, loosely and without tamping. Strike off the top surface level with the top of cylinder and remove all surplus spilled material. Lift the cylinder up clear of its contents and place on a fresh area of flat surface. Place about one quarter of the material back in the cylinder and tamp vigorously until no further compaction can be obtained. Repeat with the second quarter, tamping as before, and so on for the third and fourth quarters, tamping the final surface as level as possible.

A.3 DETERMINATION OF COMPACTION FRACTION

The Compaction Fraction value is determined as follows:

Measure from the top of the cylinder to the surface of the compacted material. This distance divided by the height of the cylinder gives the compaction of the material under test.

* To obtain a representative sample about 50kg of the proposed material should be heaped on a clean surface and divided with the spade down the middle into two halves. One of these should then be similarly divided, and so on until the required mass of sample is left.