Recycled bedding and surround materials for gravity drains and sewers

Introduction

Below ground flexible drain and sewer pipes are typically installed with a granular bed and surround material. Granular material is often referred to as 'aggregate' in the wider construction industry. With suitable characteristics and when installed following industry best practice, it can provide long-term continuous structural support along the entire pipe length without causing damage to the pipe.

Granular materials can be natural, recycled (processed from demolition and construction materials) or secondary (industrial by-products e.g., slate or blast furnace slag) aggregates.

The guide is intended for use by developers who will be purchasing processed recycled aggregates for laying gravity drains and sewers in small to medium sized development sites.

The guide has been updated, February 2020, to include information on the use of unbound municipal incinerator bottom ash aggregate (IBAA).

Purchasing recycled aggregates

The BPF Pipes Group and its members recommend that recycled aggregates are always sourced from producers who are able to demonstrate that their product complies with BS EN 13242 and The Quality Protocol (or SEPA guidance) for the production of aggregates from inert waste.

Quick check list

- ✓ Specify processed recycled aggregates to "The Quality Protocol" and to BS EN 13242.
- ✓ Include additional requirements for highways or water sector use in your specification.
- ✓ Choose coarse aggregate in a size or grade for the pipe diameter being laid.
- ✓ Ask the producer to provide delivery documentation for every load of recycled aggregate despatched to demonstrate compliance with the protocol.
- ✓ Follow good practice for the transportation, storage and use of recycled aggregates in the protocol.

This guide explains how aggregates from **processed recycled materials** can be specified and used for pipe bedding and surround. It follows a Quality Protocol "*Aggregates from Inert Waste*" prepared by the EA / NIEA / WRAP for sourcing, processing and verifying that aggregates are suitable for use in this application. It does not address the use of as-dug material from the site.

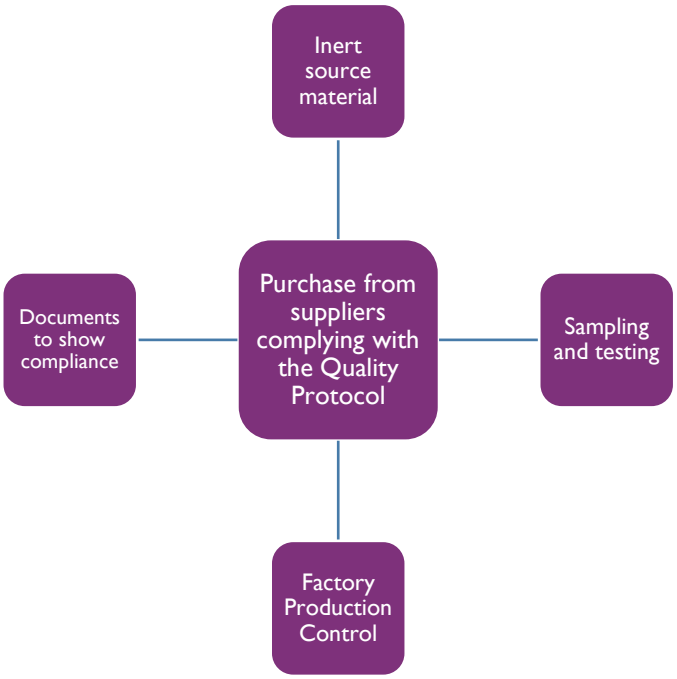
There are two key considerations when selecting recycled aggregate for pipe bedding and surround: the **environmental suitability** of material when used below the ground and the **engineering suitability** to provide continuous structural support to a pipe. This guide explains the important aspects of each of these for use with plastic pipes.

Contents

Terms used in this guide

Aggregate:	A granular material used in construction, which may be natural, recycled or manufactured
All-in Aggregate:	Grading comprises both fine and coarse aggregates
Coarse Aggregate:	Aggregate consisting of particle sizes ranging 4 mm to 80 mm
Fine Aggregate:	Aggregate consisting of particle sizes ranging 0 mm to 4 mm
Fines:	Particles less than 0.063 mm in size
Recycled aggregate:	Typically produced from demolition and construction materials
Secondary aggregate:	Typically produced from industrial by-products e.g. slate or blast furnace slag

Environmental considerations



Quality Protocol

The Environment Agency, Northern Ireland Environment Agency and WRAP (Waste & Resources Action Programme) have established a Quality Protocol "*Aggregates from Inert Waste*" for England, Wales and Northern Ireland. This document is referred to as 'The Quality Protocol' in this BPF Pipes Group guide.

It sets out the steps for the production of aggregates from inert waste and can be used by producers to demonstrate that the resulting aggregate is suitable for use within a designated market sector by conforming to British and sector standards for aggregates and does not pose a risk to human health and the environment.

The Quality Protocol can be accessed from the UK Government website: https://www.gov.uk/government/publications/quality-protocol-production-of-aggregates-from-inert-waste.

Scottish Environmental Protection Agency guidance on recycled aggregate is set out in a briefing note which can be accessed from the SEPA website: https://www.sepa.org.uk/media/162893/production-of-recycled-aggregates.pdf.

Source material

Under "The Quality Protocol", only source material considered to be inert waste (listed in Appendix C of the protocol) and accepted as suitable to produce recycled aggregate, as defined by the relevant environmental regulator (i.e. EA or NIEA), is used.

In addition, the source material should not be contaminated with dangerous substances, as defined within the List of Wastes (LoW) Regulations 2005 as applicable to the relevant UK nation.

Processing

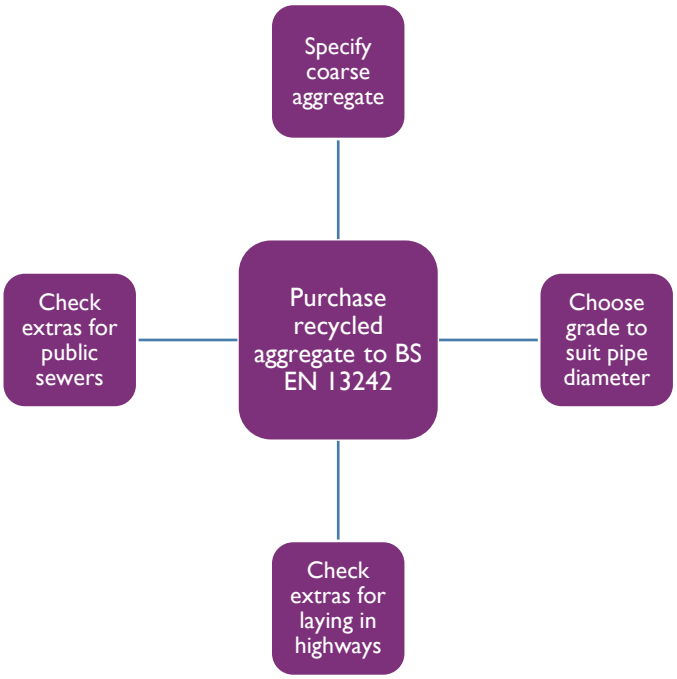
"The Quality Protocol" requires that source material is processed under a Factory Production Control system. It provides additional guidance on this aspect.

Verification

"The Quality Protocol" requires that the recycled aggregate is sampled and tested in accordance with the physical and chemical properties relevant to its end application. It provides additional guidance on these properties.

The producer needs to be able to provide all necessary documentation to demonstrate this. Section 3.3.2 of the protocol sets out the essential information which needs to be with every load of recycled aggregate despatched.

Engineering considerations



Materials Standard, BS EN 13242

For use as pipe bedding and surround, it is important that the developer selects products which meet the requirements of **BS EN 13242 "***Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction".*

Aggregates conforming to "The Quality Protocol" must comply with the requirements of the British Standard, so that developers purchasing to the protocol can be confident that the material is suitable for its intended application.

Note: All references to BS EN 13242 in this guidance relate to BS EN 13242: 2002 + A1: 2007.

In addition to the provisions of BS EN 13242, individual construction sectors have additional guidance for aggregates for bedding and surround. Further guidance for laying drains and sewers is given in key highway and water sector documents, see Table 1.

Table 1 Highway and Water Sector Guidance

Sector	Document
Highways	MCHW, Volume 1 (Specification for Highways Works), Series 500
Water Industry	WIS 4-08-02: Specification for Bedding and Sidefill Materials for Buried Pipelines. Amended by WIS 4-08-02A
	IGN 4-08-01: Bedding and Sidefill Materials including recycled aggregates for Buried Pipelines. Amended by IGN 4-08-01A
	BS EN 1610: Construction and testing of drains and sewers

Note: The use of unbound municipal incinerator bottom ash aggregate (IBAA) is permitted as pipe bedding, subject to the conditions determined by the Environment Agency in Regulatory Position Statement RPS 206 (Using unbound municipal IBAA in construction activities: RPS 206) and to meeting the requirements of BS EN 13242 and the sector guidance listed in Table 1 of this guide.

Materials Characteristics

The material characteristics detailed within BS EN 13242 may be generally divided into (a) grading limits and (b) physical / chemical properties.

Note: Not all the material characteristics detailed within BS EN 13242 are relevant to each end use.

Grading Limits

Aggregate for pipe bedding and surround is generally designated as 'Coarse' (G_c), 'Fine' (G_F) or 'All-in' (G_A).

'Coarse' designated material as defined in BS EN 13242 is preferred for pipe bedding and surround material as it provides the most robust and high-quality installation. Material can be defined by a single aggregate size or by grading limits, i.e. the range of aggregate particle sizes that are permitted. **The recommended size or grading limits of aggregate is determined by the pipe diameter, see Table 2.** This ensures that bedding and

surround material provides sufficient structural support whilst minimising the risk of damage to the pipe.

Table 2 Coarse Aggregate Grading

BS EN 13242 Coarse aggregate (Clause 4.3.2)		
Nominal pipe diameter, mm	Aggregate size, mm	
	Graded	Single sized
Not exceeding 140	-	4/10
Exceeding 140 but not exceeding 400	2/14 or 4/20	4/10, 6/10 or 10/20
Exceeding 400	2/14, 4/20 or 4/40	4/10, 6/14, 10/20 or 20/40

Notes:

- BS EN 1610 sets out maximum particle sizes for bedding of pipes. Reference to BS EN 1610 might be made in pipe manufacturer's installation guidance. BS EN 1610: 2015 permits slightly greater particle sizes, so aggregates specified to and complying with BS EN 13242 would comfortably meet the requirements of BS EN 1610: 2015.
- Whilst this BPF Pipes Group guidance specifically covers recycled bedding, the advice on aggregate size is the same for both new and recycled materials when installing plastic drain and sewer pipes.
- Proper crushing of recycled aggregate, in accordance with "The Quality Protocol", can virtually eliminate sharp edges. Therefore, the edge sharpness of processed aggregate is not a concern. Superficial scratches on the external surface of a plastic pipe for gravity (non-pressure) drains and sewers do not affect the system performance.

(More information on the grading limits is provided in the Annex to this guide).

Physical and Chemical Properties

"The Quality Protocol" only applies to those aggregates which are processed from inert waste and lists acceptable inert waste input materials.

After an initial screening to ensure that this is the case, there are a number of properties prescribed to ensure that a recycled aggregate for a specific end use is:

- consistent in quality and performance;
- easily handled and suitable for the intended application;
- sufficiently durable; and
- not a pollution risk to the surrounding soils, ground waters or risk to the health of those producing or using the material.

The properties deemed applicable to pipe bedding and surround vary between the highway and water sectors. The properties common to both sectors are set out below in Table 3, with additional requirements for highway and water sectors only in Tables 4 and 5 respectively.

(Further information on physical and chemical property requirements is provided in the Annex to this guide.)

Table 3 Common requirements

BS EN 13242, Physical Property Requirement	
Category	***Limit***
Category for general grading requirements	G_c 80-20
Category for tolerances at mid-size sieves	GT_{NR} (no requirements)
Category for maximum values of fines content	Crushed rock, recycled aggregate – f_4
Resistance to fragmentation	LA_{50}

Table 4 Additional 'highway only' requirements

BS EN 13242, Physical Property Requirement	
Category	***Limit***
Contain other materials	≤ 1% by mass (Class X) [Tested in accordance with Clause 710]
Water soluble sulphate content (as SO_3)	≤ 0.38% [Tested in accordance with BS EN 1744-1, Clause 10]

Table 5 Additional 'water industry' only requirements

BS EN 13242, Physical Property Requirement	
Category	***Limit***
Shape	FI_{20}
Durability - Water absorption - Magnesium sulphate soundness	 WA_{24} 2 MS_{18}
Resistance to wear	MS_{DE} 20
Acid soluble sulphate content - Other than air cooled blast-furnace slag - Air-cooled blast furnace slag	 $AS_{0.2}$ $AS_{1.0}$
Total sulphur - Other than air cooled blast-furnace slag - Air-cooled blast furnace slag	 ≤ 1% by mass ≤ 2% by mass
Volume stability of slag - Air cooled blast furnace slag - Steel slag	 Free from dicalcium silicate and iron disintegration V_5

References used in this guide

BS EN 933-3 Tests for geometrical properties of aggregates. Determination of particle shape. Flakiness index

BS EN 933-11 Tests for geometrical properties of aggregates. Classification test for the constituents of coarse recycled aggregate

BS EN 1097-1 Tests for mechanical and physical properties of aggregates. Determination of the resistance to wear (micro-Deval)

BS EN 1097-2 Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation

BS EN 1097-6 Tests for mechanical and physical properties of aggregates. Determination of particle density and water absorption

BS EN 1367-2 Tests for thermal and weathering properties of aggregates. Magnesium sulfate test

BS EN 1610 Construction and testing of drains and sewers

BS EN 1744-1 Tests for chemical properties of aggregates. Chemical analysis (2009+A1:2012)

BS EN 13242	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction (2002+A1:2007)
MCHW	Manual of Contract Documents for Highway Works. Volume 1 (Specification for Highways Works), Series 500
WIS 4-08-02	Specification for Bedding and Sidefill Materials for Buried Pipelines. Amended by WIS 4-08-02A
IGN 4-08-01	Bedding and Sidefill Materials including recycled aggregates for Buried Pipelines. Amended by IGN 4-08-01A

Annex - Using BS EN 13642 to select the right aggregates

Further detail is provided in this section on the grading and properties discussed above.

Grading (Geometrical) Requirements

Grading is a means of describing the range of particle sizes, including the distribution of these particle sizes, within a processed material.

A basic test in BS EN 13242 involves recording the percentage (by mass) of an aggregate sample that passes through a number of prescribed sieves, each sieve within the set decreasing in size.

Grade: The aggregate grade is defined by aggregate size, **d/D**

Where d (min) = lower sieve size [mm]
D (max) = upper sieve size [mm]

Grading Category: The grading category ($G_{\#}$) gives the maximum and minimum percentage limits of a coarse aggregate ($\#_C$) sample, passing at the upper and lower sieve sizes respectively, **G_c D/d**

Where D = min percentage (by mass) passing upper sieve size (**D**)
d = max percentage (by mass) passing lower sieve size (**d**)

For each of the aggregate grades listed in Table 2 of this guide, Table 6 summarises the sieve size and the corresponding percentage (by mass) limit for the aggregate sample passing through the corresponding sieve.

Fines content: A processed aggregate, particularly one which involves the crushing of material, typically generates very fine particles. BS EN 13242 classifies particles less than 0.063 mm in size as fines. The category for maximum values of fines content specifies a maximum percentage (by mass) limit of material that passes the 0.063 mm sieve i.e. f_4 denotes ≤ 4.0% (by mass) fines content.

It should be noted that fines from certain sources (i.e. clay), within an unbound aggregate, can increase the aggregates susceptibility to the effects of frost. The UK typically takes a pragmatic alternative approach to testing fines quality, by limiting the allowable fines content.

Table 6 Coarse aggregate geometrical limits

Grade	Graded			Single sized			
	2/14	**4/20**	**4/40**	**4/10**	**6/14**	**10/20**	**20/40**
Grading Category	**G_c85/15**			**G_c80/20**			
Sieve Size [mm]	**Percentage (by mass) passing sieve [%]**						
80			100				100
63			98 – 100				98 – 100
40		100	85 – 99			100	80 – 99
31.5	100	98 – 100			100	98 – 100	20 – 70
20	98 – 100	85 – 99	20 – 70	100	98 – 100	80 – 99	0 – 20
14	85 – 99			98 – 100	80 – 99	20 – 70	
10		20 – 70		80 – 99	20 – 70	0 – 20	0 – 5
6.3	20 – 70			20 – 70	0 – 20		
4		0 – 15	0 – 15	0 – 20		0 – 5	
2.8					0 – 5		
2	0 – 15	0 – 5	0 – 5	0 – 5			
1	0 – 5						
Notes: Recommended BS EN 13242:2002+A1:2007 aggregates; using sieve sizes within BS EN 13242 basic set plus set 2 range							

Physical Requirements

Physical properties, other that particle size, are prescribed to ensure that the aggregate specified for a specific end use application, is suitable and does not pose a pollution or health risk. The properties relevant to use for bedding and surround of pipes, summarised in Tables 3 - 5, are explained further below.

Shape: The shape of coarse aggregate particles is typically determined using the flakiness index, in accordance with BS EN 933-3. This is not widely used in the UK, due to the typical practice of specifying the end use, rather than the aggregate itself.

Resistance to fragmentation: This characteristic is a measure of how prone aggregate particles are to fragmentation. This is determined in accordance with BS EN 1097-2 and stated in terms of the Los Angeles coefficient. The test involves placing a 10/14mm sample of the aggregate within a steel drum containing similar sized steel balls, then rotating the drum at a prescribed speed and number of revolutions. The subsequent mass of the sample

aggregate retained on a 1.6mm sieve is then used to calculate the Los Angeles coefficient. The lower the declared number, the greater the materials resistance to fragmentation i.e. FI20 denotes a Los Angeles coefficient ≤ 20.

Durability: Weathering properties are typically grouped as durability characteristics; the specific tests required typically dictated by the proposed aggregate end use, aggregate source or expected site climate.

A key durability measure is resistance to freezing and thawing. Freeze-thaw resistance is typically determined by measuring an aggregates water absorption, in accordance with BS EN 1097-6. WA24 2 denotes an aggregate with a water absorption (by mass) ≤ 2%.

Where an aggregate has water absorption greater than 2%, it may still be considered to have acceptable freeze-thaw resistance, if also sufficiently resistant to chemical weathering. This is determined with a sulphate test in accordance with BS EN 1367-2, which assesses the behaviour of an aggregate sample when subjected to cycles of immersion in a magnesium sulphate solution and drying. Following the test, the aggregate sample is assigned a magnesium sulphate soundness category i.e. MS18 denoting a magnesium sulphate loss (by mass) ≤ 18%.

Resistance to wear: The resistance to wearing of a coarse aggregate, in particular the rubbing together of interlocking particles within an unbound pavement, is stated as a micro-Deval coefficient determined in accordance with BS EN 1097-1.

The test involves placing a 10/14mm sample of the aggregate within a steel drum containing steel balls and water, then rotating the drum at a prescribed speed and number of revolutions. The subsequent mass of the sample aggregate retained on a 1.6mm sieve, protected by a 8mm guard sieve, is then dried and used to calculate the micro-Deval coefficient (MSDE) i.e. MSDE 20 denotes a micro-Deval coefficient ≤ 20.

Contains other materials: The proportion of the constituent material contained within a recycled coarse aggregate is determined in accordance with BS EN 933-11; with a category declared according to the aggregates constituent material percentage (by mass) content. 'X' denotes 'other material' not covered within the standard categorisations, including cohesive materials such as clay, metals, wood, plastic and rubber.

Volume stability of slag: Determined in accordance with BS EN 1744-1, steel slag aggregate is deemed to be volumetrically stable if its classification is not greater than the prescribed value, which corresponds with the materials proposed end use, i.e. V5 denotes an expansion (by volume) ≤ 5%.

Water Soluble Sulphate or Oxidizable Sulphide Content: Problems with corrosion of buried galvanised steel structures and sulphate attack of buried concrete structures have been attributed to the presence of sulphides and sulphates within adjacent structural fill material. To mitigate the risk of sulphur compounds within structural fill, a number of tests and appropriate limiting values may be specified, when required.