Recycled and stabilised materials in trench reinstatement

Annual trench arisings from gas and water asset renewals are in the order of 4.8 million tonnes per year. Recycling and the efficient use of materials can both minimise waste going to landfill and reduce demands on primary aggregate. This guidance covers the recovery and recycling of trench arisings (with or without hydraulic binders), and the use of recycled aggregates within trench reinstatement works.
Executive summary

Water and gas capital and maintenance trench works generate around 4.8 million tonnes of arisings across Great Britain, equivalent to 4.5% of the national construction, demolition and excavation wastes (WRAP, 2005a). Waste generation in this sector is significant and environmental pressures to recover arisings and to use recycled materials is increasing.

The overall principles behind encouraging recycling are to:

- **Minimise:**
  - materials going to landfill
  - demands on primary resources
  - material transportation distances

- **Maximise:**
  - recovery and recycling of materials

Specific provision is given for the use of recycled aggregates and hydraulically bound materials, and re-use of trench arisings, within the second edition of the specification for the reinstatement of openings in highways (SROH), HAUC (2002).

Wide experience with these materials already exists, both within the utility reinstatement sector and the wider highway engineering community.

Exemplar information and case study evidence focusing on recycling of trench arisings is presented in this guidance document (section 3) to encourage both acceptance and uptake. The information is aimed at local authorities, utility companies and their supply chain.
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Glossary

General:

HAUC
Highway Authorities and Utilities Committee.

Subgrade
The made ground or naturally occurring soil that is found below roads and footways.

SHW

SROH

NRSWA

Waste
Any substance or object that the holder discards, intends to discard or is required to discard. As defined in the Waste Framework Directive (European Directive 2006/12/EC).

Product
Material which is deemed to be ‘recovered’ by the reprocessing of waste and no longer a waste.

Process:

Improvement
Drying out of soil/material by absorption and/or evaporation, results in the reduction in the water content

Modification
Physico-chemical reactions between lime and clay minerals occur within a few days and change the soil’s plasticity

Recycling
Reprocessing of wastes, either into the same application (closed-loop recycling) or a different application (open loop recycling).

Re-use
Putting materials to another use, without any additional processing, after they have fulfilled their original function.

Recovery
The point at which a waste becomes a product via recycling or re-use (reclaimed).

Stabilisation
Incorporation of hydraulic binders into materials thereby turning unsuitable or marginal materials into suitable construction materials.

Materials:

Aggregate
Granular material used in construction. Aggregate may be natural, secondary or recycled.
ARM
Alternative reinstatement materials.

GSB1 (granular subbase 1)
The term GSB1 is specific to the SROH. The material specification for the reinstatement of openings in highways which is equivalent to SHW clause 803 Type 1 unbound mixture.

Hydraulic binder
Material (or a combination of materials) that sets and hardens by hydraulic reaction. This includes cement, fly ash, lime and processed blastfurnace slag and factory produced hydraulic road binders.

Recycled aggregate
Aggregate derived from the processing of inert material previously used in construction.

Secondary aggregate
Aggregates derived from by-products of other industrial processes and which have not been previously used in construction.

Foamed concrete
Lightweight material produced by incorporating preformed foam into a base mix of cement paste using specially designed mixing plant. Entrapped air bubbles reduce the density of the base mix and have a strong plasticising effect on it. The foamed concrete is initially free flowing but rapidly hardens (WRAP, 2005)

SMF (Stabilised material for fill)
The term SMF is specific to the SROH. It comprises an ad-hoc grouping of materials including processed, improved, modified or hydraulically bound materials (including stabilised). SMF can be derived from any source, including virgin materials and are not necessarily bound. Source and process are not specific to SMFs and they are instead defined by a set of compositional and performance requirements.

SMR (Structural material for reinstatement)
The term SMR is specific to the SROH. It comprises a material grouping generally falling within the hydraulically bound materials family, including specific materials such as foamed concrete. Broadly defined as a material that includes “cementitious, chemical, hydraulic binder or are inherently self-cementing” (HAUC, 2002). They are generally differentiated from SMFs by superior performance.

Trench arising
Materials excavated from a trench.

Application:

Apparatus surround
Selected fine fill material to protect utility apparatus.

Backfill
General fill up to the underside of the pavement structure.

Subbase
A layer of the pavement foundation supporting the upper pavement layers.

Base
Layer of bound material over the subbase.

Binder
Layer of bound material, (cement-bound or asphalt-bound) underlying the surfacing layer.
Recycled and stabilised materials in trench reinstatement

Water and gas capital and maintenance trench works generate around 4.8 million tonnes of arisings across Great Britain, equivalent to 4.5% of the national construction, demolition and excavation wastes (WRAP, 2005a). Waste generation in this sector is significant and environmental pressures to recover arisings and to use recycled materials is increasing.

Recycling plays a central role in the efficient use of materials and can be undertaken with confidence.

1.0 Scope of guidance document

1.1 Background

Local authorities, utility companies, contractors and material suppliers all have an important role to play in the efficient use of materials associated with utility maintenance or capital works. The generation of arisings is significant and the adoption of sustainable construction processes during trench excavation, material supply chain and reinstatement works has a number of clear environmental benefits.

This guidance document aims to promote and encourage recycling by providing evidence of material use and guidance on where additional information can be found. It is written for all parties involved in the process, including contractors, material suppliers and local authorities that have duties of inspection and material approval.

1.2 Materials flow

Recycled aggregates are aggregates derived from the reprocessing of inert material previously used in construction. This includes processed trench arisings (covering as dug soils, aggregate, asphalt and/or concrete), Recycled Concrete Aggregate (RCA), Recycled Asphalt Planings (RAP) and Recycled Aggregate (RA). Secondary aggregates (such as recycled glass and incinerator bottom ash aggregate) can also be used in place of primary reinstatement materials. A simplified materials flow for trench reinstatement works is shown in Figure 1, showing standard and good practice.

![Diagram of simplified materials flow highlighting good practice](image-url)

**Figure 1** Recycling with confidence – simplified materials flow highlighting good practice
The overall principles behind encouraging recycling are to:

- **Minimise:**
  - materials going to landfill
  - demands on primary resources
  - material transportation distances

- **Maximise:**
  - recovery and recycling of materials

### 1.2.1 On site re-use or recycling of trench arisings

The most efficient use of materials is the on-site re-use or recycling of excavation arisings to reinstate trenches, as this system will minimise transportation distances. However, quality control and satisfactory husbandry of the trench arisings are fundamental factors controlling the optimum potential for re-use of trench arisings, as intermixing of materials during excavation will lower the potential for re-use. As such, this closed loop approach is most appropriate in verges and unmade ground, where defects are not an issue.

Unsuitable material (for example, trench arisings too wet to allow adequate compaction) can be recycled via the mixing of hydraulic binders on site, primarily for small works. However, practicalities (storage space, time, weather and achievable level of quality control) often mean it is necessary to remove excavated material from site, regardless of suitability for re-use or on-site recycling.

Encouraging the use of recycled aggregates and hub recycling (involving transportation of trench arising to a central recycling plant and transporting recycled reinstatement materials back to site) is, therefore, the main focus of this guidance document for achieving efficient use of materials. Other initiatives, such as trenchless technology, location of services away from roads into verges or footpaths and ‘first time’ reinstatement also have an important role to play, but are not covered in detail in this document.

### 1.2.2 Recycling of trench arisings

Hub recycling is the recovery and recycling of trench arisings at central recycling depots (permanent or temporary) with the capability to process and stockpile trench arisings. This is particularly applicable to areas where utility companies are undertaking capital and maintenance works. Mobile recycling plant capable of processing trench arisings are readily available. Such plant may be established in site compounds or located at local recycling centres where trench arisings can be stockpiled, further reducing haulage distances.

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Mobile plant for recycling trench arisings (courtesy of SMR UK Ltd)
Recycled and stabilised materials in trench reinstatement

The unsuitability of these trench arisings for direct re-use typically relates to their relatively high content of cohesive fine soils. Therefore, a number of recycling processes include the addition of hydraulic binders. The resultant quality controlled products would, as a minimum, have equivalent performance to their unbound alternatives. In fact, many of the hydraulically bound materials (including stabilised soils) should be expected to have superior performance to their unbound equivalent.

Other sources of recycled aggregates and use in other applications

Recycled aggregates are widely available from a variety of sources (other than trench arisings), including construction, demolition and highway maintenance. Supply can be direct from quality managed recycling facilities on demolition sites or suitably equipped recycling centres. Recycled aggregates readily feed into the materials flow as a direct replacement for imported primary materials. Conversely, dependent on local supply and demand, trench arisings can and have been recycled and utilised in alternative construction applications.

You can permit and encourage recycling with confidence

Recycling and the use of recycled aggregates is both encouraged and widely accepted within the construction industry. Established uses for recycled aggregates include pavement quality concrete, asphalt, pavement foundations, bedding sands, pipe surrounds, fill materials, block paving and drainage media.

Specific provisions covering the majority of applications are given within the main material specifications; specification for highway works (SHW) and specification for the reinstatement of openings in highways (SROH), and local authority highway guidance (WRAP 2005b).

The Quality Protocol for the production of aggregate from inert waste (WRAP, 2004, 2005c and 2005d) has established a quality management scheme for aggregate processing to aggregate standards and a defined recovery process. This provides confidence to the local authority, utility company and contractor that the recovered aggregate conforms to standards that are common to both recycled and primary aggregates and is no longer a waste.
1.4 Acceptance of recycled aggregate

Recycled aggregates that are used in unbound or bound applications (including Type 1 subbase, and within concrete and asphalt) are not classed as alternative reinstatement materials (ARMs), and are assessed on the basis of the compositional and physical requirements within the specification (SROH).

Recycled aggregates have specific provision for use within the SHW specification, including SHW series:
- 500 drainage and service ducts (including pipe bedding and surround)
- 600 earthworks (fill)
- 800 unbound, cement and other hydraulically bound subbase mixtures (including unbound subbase mixtures)
- 900 bituminous bound materials
- 1000 concrete materials (including foamed concrete and pavement quality concrete)

Hydraulically bound materials are covered by series 800 of the SHW. These materials are open to the use of both recycled aggregates (including stabilised soils) and hydraulic binders that could also be derived from recycled sources. This family of materials is currently covered by alternative reinstatement materials (ARMs) within the SROH and require verification of the laboratory determined performance by site trials. However, a number of proprietary techniques specific to the recycling of trench arisings have already been extensively trialled. Therefore, case study evidence and guidance on likely equivalence in performance has been drawn together to assist practitioners. Certain case by case aspects may need consideration (such as the influence of local geology on arisings or reinstatement options). However, verification of performance criteria can often be drawn from pre-existing site trials, and confidence gained by ensuring adoption of quality control procedures and control testing.
The sustainability benefits of recycling include environmental, social and economic aspects. These benefits are reflected in the policies adopted by central Government and most local authorities. Pressures to minimise the volume of trench arisings going to landfill and the use of primary resources will increase. Local authorities, utility companies, contractors and material suppliers all have a fundamental role to play.

2.0 Strategic objectives

Recycling is an important aspect of sustainable construction. This is recognised by the Government's Sustainable Development Strategy which includes core indicators measuring the use of recycled aggregates.

Targets associated with recycling are already part of many local authority's strategic objectives. In the case of utility trench works, involvement tends to be limited to material approval, with the priority being to ensure that the standard of the pavement (roads or footpaths) is maintained and to minimise disruption to the public. The use of quality controlled recycled aggregates does not conflict with these priorities. In addition, many hydraulically bound or flowable materials have superior technical and/or practical qualities compared to those of unbound primary materials. In addition, a positive policy of considering recycled aggregates on a 'fit for purpose basis' can be used to demonstrate best practice towards local authority sustainability objectives and it also encourages their potential social, environmental and economic benefits.

Many companies seeking or already holding ISO14001 accreditation (the International Standard for Environmental Management Systems) have recycling targets, and use the measurement of key performance indicators, such as the diversion of materials from landfill or maximising the recycling of arisings, for tracking performance within their supply chain. The benefits of undertaking these measurements are that they can readily be incorporated as good practice indicators and be used as part of a range of measures to track the industry's progress and commitment to sustainable development.

Exemplar – Measuring sustainable development within the water industry

The water companies sustainability indicators include the amounts of aggregate used, recycled aggregate procured and excavated material diverted from landfill. These figures are compiled to allow the measurement of progress towards sustainable development, as well as highlighting areas for further improvement.

It is reported that the water industry used well over 1.8 million tonnes of aggregate, of which 14% was procured from recycled sources, and 61% of aggregate arising from capital and network projects were re-used or recycled in 2005/2006.

Excavated materials are accounted for separately and include rocks, soil, old pipes and so on. The mass of excavated materials produced in 2005/2006 over the full range of construction and maintenance activities undertaken by the water industry totalled in excess of 4.3 million tonnes, of which 43% was diverted from landfill.

Source: UK water industry sustainability indicators (2005-2006)
2.1 Environmental benefits

Clear environmental advantages are associated with recycling of arisings from utility works. These include:
- conservation of finite resources
- reduction in material going to landfill
- the potential for reduced energy consumption
- the potential for reduced emissions from haulage

2.2 Social benefits

Social benefits can include:
- increased local employment
- business development opportunities
- reduced disruption from minimised haulage movements

2.3 Economic benefits

The economic benefits related to recycling of arisings from utility works are only readily assessed on a case by case basis. At worst the material should be cost neutral; however, local conditions could mean:
- recycled aggregates could cost less
- reduced waste disposal costs
- recycling may become a new revenue system
- reduced haulage
- value of social and community gains

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**Exemplar – Clyde Street in Glasgow**

3,900 tonnes of trench arisings were excavated during the replacement of a gas main at Clyde Street Glasgow. 50% of the trench arisings were recovered and recycled for use as SHW Type 1 subbase and Type B pipe bedding.

The benefits of this recycling operation were direct costs savings associated with recycling versus landfill and material purchase costs and reduced haulage (due to the proximity of the recycling centre). Reduced transportation also had other indirect benefits including reduced air emissions, noise and traffic on roads. Transporting to a local site also resulted in fewer delays in the site works because the trucks could do a faster turnaround.

Increasing amounts of recycled materials within their reinstatement works was beneficial to the contractor achieving and maintaining their ISO 14001 accreditation.

Source: www.aggregain.org.uk
A range of materials are used during utility trench reinstatements. These include structural pavement layers (including asphalt and concrete), pavement foundation layers (primarily subbase), trench backfill, and pipe bedding and surround. The incorporation of recycled aggregates into asphalt and concrete are both well established and publicised. The focus of this section is, therefore, on recycling trench arisings and the use of recycled aggregates in unbound and hydraulically bound applications.

Imported primary aggregates have been used traditionally to replace excavated materials, which are often intermixed and taken off site. There is now a range of recycled reinstatement materials and processes available to avoid such waste. Capital investment and research has resulted in a widespread availability of recycled aggregates and greater confidence in their end use. This includes specific provision within SROH, developments to highway specifications and guidance documents, development of the Quality Protocol for recycled aggregates, guidance on soil stabilisation and trials of proprietary products.

The type of reinstatement materials acceptable for use in trench reinstatement depends on the location of the excavation and application (section 4).

### 3.0 Material performance and history of use

#### 3.1 Unbound materials

Recycled aggregates can readily be used in an unbound application. In the context of this guidance, the term recycled aggregate includes three main sources:
- selected trench arisings suitable for re-use
- processed and/or treated trench arisings made suitable for re-use
- aggregate derived from the processing of inert material previously used in construction (not specifically from trench arisings)

All the above materials may potentially be used as backfill and/or subbase depending on the class of material and road category (section 4).

It is important to obtain recycled aggregates from a quality controlled source. A Quality Protocol has been developed for the production of the recycled aggregates (WRAP, 2004, 2005c or 2005d) is a requirement for recycled aggregates within clause 710 of the specification for highway works (SHW). One of the aims of the protocol is to provide purchasers with a quality managed product to common aggregate standards and it can be found at www.wrap.org.uk/ construction. Part of the requirements for recycled aggregate is that it shall be tested in accordance with Clause 710 of the SHW and the content of all foreign materials (including wood, plastic and metal) shall not exceed 1% by mass.

The SHW specifically permits the following recycled aggregates for use within Type 1 subbase (SHW 800 Clause 803); Recycled Concrete Aggregate (RCA), Recycled Aggregate (RA) and Recycled Asphalt Planings (RAP). An
upper limit of 50% by mass is placed on RAP content. This material is equivalent to GSB1 (granular subbase) as specified within the SROH.

Acceptable backfill materials (section 4.4), whether primary or recycled are classified with the SROH as either:

- **Class A** – Graded granular mixtures (including Type 1 and Type 2 subbase, respectively SHW series 800 Clause 803 and 804)
- **Class B** – Granular mixtures
- **Class C** – Cohesive/granular mixtures
- **Class D** – Cohesive mixtures

Unacceptable material is categorised as Class E. However, this material may be improved by processing (drying or re-grading) or by addition of a suitable hydraulic binder (section 3.2).

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**Exemplar - source of information**

Numerous case studies exist to demonstrate the application of recycled aggregates within unbound applications. Guidance on the type of recycled content permitted and environmental considerations are available online at: [http://www.aggregain.org.uk/specifier/index.html](http://www.aggregain.org.uk/specifier/index.html).

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### 3.2 Hydraulically bound materials

Hydraulically bound materials cover a wide range of products, including stabilised and cement bound materials. Classification is dependent on the material treated (type of soil or aggregate), the mixing process employed, hydraulic binders used and end performance requirements.

The basic concept is that the combination of the soil and/or aggregate and the hydraulic binder alters the strength, durability and volume stability of the material being treated. Stabilisation specifically refers to the combination of soil with hydraulic binder(s), typically including cement, to produce a stiff durable paving material.

The specification for the reinstatement of openings in highways (SROH) groups stabilised materials and other hydraulically bound materials as ARMs. However, soil stabilisation is a well established construction technique. There are many well documented successful applications in recent history, including at the Millennium Dome, Heathrow Airport Terminal 5 and Manchester Airport Runway 2, and it has been endorsed by the Highways Agency since the 1960’s. The added advantage of techniques such as soil stabilisation, is that the treatment can render unsuitable material (for example wet mixed trench arisings) into a durable stiff bound material. The potential for superior performance, for example in comparison to SHW series 800 Type 1 subbase, is recognised within both the SROH and SHW (section 3.4).

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In situ stabilisation to form pavement foundation

There are a variety of binders available including cement, pulverised fuel ash (PFA), ground granulated blastfurnace slag (GGBS), and lime. The specialist recycling companies processing trench arisings tend to use proprietary products. Dependent on the hydraulic binder type, percentage of hydraulic binder additions and recycling process, the material could be fast setting or hardening, or be sufficiently slow setting to enable off-site mixing and delivery to site. No aggregates are specifically precluded as a component of hydraulically bound mixtures by the SHW. The resultant end performance of the material is dependent on several factors, including aggregate type, water addition, compaction and how well the materials are mixed.
Soil stabilisation should not be confused with improvement or modification of a material:

- **Improvement** – drying out by absorption and/or evaporation, results in the reduction in the soil moisture content
- **Modification** – physico-chemical reactions between lime and clay minerals occur within a few days and change the soil’s plasticity
- **Stabilisation** – includes chemical reactions which result in the formation of cementing agents which increase mixture strength and durability

Ex situ stabilisation of trench arisings (courtesy of SMR UK Ltd)

**Exemplar – North Popley Development, Hampshire**

Preliminary infrastructure works were carried out at the North Popley development site, near Basingstoke, by Mildren Construction Ltd (main contractor), Envirosoil Ltd (stabilisation), Bardon Aggregates (surfacing) and Foster Yeoman Limited (cold recycled bitumen bound material) for Hampshire County Council, to provide an access road and services across the site.

Chalk excavated from the trenches was treated ex situ prior to use as backfill material. In addition, the subgrade chalk was in situ stabilised by the addition of 2% ordinary cement to form a cement bound subbase for the access road and footways. The use of stabilisation significantly reduced lorry movements and associated disruption on the narrow local access roads. In total, over 1000 m³ of chalk that would have been sent to landfill and replaced with imported aggregates was retained on site.

In addition, the asphalt pavement for the access road was constructed using a 250 mm layer of Foamix®. The cold recycled bitumen bound material contained recycled asphalt planings derived from maintenance works on the A325 at Alice Holt. Foamix® is laid cold, resulting in energy savings compared with conventional hot asphalt. The total amount of Foamix used in the access road was 300 m³.

Environmental benefits include decreased use of primary aggregates, successful recycling of asphalt planings from another site and diversion of material from landfill, along with reduced lorry movements and energy consumption.

Source: Hampshire County Council www3.hants.gov.uk

Hydraulically bound materials fall under three material groups within the SROH.

### 3.2.1 Cement bound material (CBM3)

CBM3 is permitted for use within the permanent reinstatement of composite and certain modular roads (section 4). This product is not an alternative reinstatement material (ARM) and does not require a trial prior to use.

It is an aggregate based hydraulically bound material (specifically bound with cement) for which the specification has been superseded (pre November 2004 SHW 1000 series). Guidance on the current SHW 800 series (post November 2004) equivalent hydraulically bound material (including aggregate requirements) is available from the aggregain specifier (http://www.aggregain.org.uk/specifier).
3.2.2 Stabilised materials for fill (SMF)

Stabilised materials for fill (SMF) comprise an ad-hoc grouping of materials including processed, improved, modified or hydraulically bound materials (including stabilised). This product is classified as an ARM.

SMF can be derived from any source, including primary aggregates and are not necessarily stabilised (in terms of the accepted definition within highway engineering). Source and process are not specific to SMFs and they are instead defined by a set of performance requirements (section 3.4).

3.2.3 Structural materials for reinstatement (SMR)

Material grouping which generally falls within the hydraulically bound materials family and are classified as ARMs. Broadly defined as a material that includes “a cementiceous, chemical, hydraulic binder or are inherently self-cementing” (HAUC, 2002). The group is divided into the following three sub categories:

- Foamed concretes for reinstatements (FCRs)
- Flowable SMRs (FSMRs)
- Non flowable SMRs (NFSMRs)

FCRs use cement or proprietary binders, generally as prescribed mixes or foaming process, while FSMRs comprise any type and/or combination of aggregates and binders, both are flowable and should not require compaction. NFSMRs like the FSMRs can comprise any type and/or combination of aggregates and binders but are not flowable so require in-situ compaction.

Exempler – Trial of ‘Trenchmix’ by Wrekin Construction Ltd

In 2002, the construction of a public sewer in rural Worcestershire by Wrekin Construction Ltd used ‘Trenchmix’, a mixture of recycled fines, PFA and a small amount of lime, to reinstate a 35 m long, 2.6 m deep and 0.6 m wide section of trench in Eardiston. The area was selected for the trial because it was subject to a large array of axel loading (cars, vans and heavy goods vehicles).

The ‘Trenchmix’ was supplied by Shropshire Recycling Services from their Bridgnorth depot and was produced in a mixing plant supplied and operated by Wrekin Construction Ltd. In total, 148 tonnes of ‘Trenchmix’ was delivered and stored within the site compound until required. A 110 mm layer of road base was then laid directly onto the ‘Trenchmix’ (in two layers), followed by 60 mm/40 mm thick layers of Binder Course/Wearing Course. Operators compacted the ‘Trenchmix’ in 200 mm layers and found it comparable in workability to the unbound equivalent.

Since completion no problems have been reported and performance has been noted as good.

Source: www.ukqaa.org.uk

3.2.4 Foamed concrete (FCR)

Foamed concrete is deemed to be approved for use (HAUC 2002), and is consequently the most commonly used ARM. As such it is the only ARM detailed in the practical guide to reinstatements (HAUC 2006). Foamed concrete was initially recommended in the Horne report (1985) for use in highway reinstatement works and was specified as a backfill material in the New Road and Street Works Act in 1991.

The beneficial characteristics of foamed concrete include:

- Ease of application due to self compacting and self levelling properties
- Lightweight and easy to excavate due to air voids introduced in foam
- Early strength gain – ability to re-surface 12 – 18 hours after placement
- Good load distribution, preventing the direct transmission of axial loads to the services
A study conducted by Jones et al (2005) showed that foamed concrete can easily accommodate a wide range of recycled aggregates to replace primary aggregates. The performance of the recycled aggregates within foamed concrete (in terms of consistency and strength development) was comparable with or, in some cases better than, that of equivalent primary aggregate foamed concretes. The recycled aggregates suitable for use in foamed concrete include Recycled Aggregate (RA), Recycled Concrete Aggregate (RCA), incinerator bottom ash aggregate (IBAA), fly ash (also known as pulverized fuel ash), blastfurnace slag and china clay sand. These recycled aggregates can be used as a constituent of foamed concrete if they comply with the specification (SHW).

Exemplar – Use of foamed concrete containing recycled aggregate

Foamed concrete containing recycled aggregate produced from demolition arisings has been used to reinstate trenches across the east midlands. The foamed concrete was supplied by Douglas Multicrete and the reinstatement undertaken by McNicholas on behalf of Transco.

Source: www.aggregain.org.uk.

3.3 Equivalence between unbound and hydraulically bound materials

The specification for the reinstatement of openings in highways (SROH) permits several types of unbound and hydraulically bound materials. The specification requirements for each type are outlined in section 4.0. They comprise both compositional and physical requirements.

Confidence in a material’s end performance, and incorporation into the permitted reinstatement options, is generally determined on the basis of an assumed or measured California bearing ratio (CBR). The main issues with comparing likely performance of these materials, based upon laboratory testing, is that the CBR test is understood to only be an indirect measure of performance. Therefore, any assessment is likely to be indicative.

The stabilised materials for fill (SMF) group of materials permits a relatively broad range of performance, with the soaked CBR range falling from 2% to in excess of 30% (SROH). Empirical evidence and established practice indicates that:

- the soaked CBR range between 2% to in excess of 30% covers a wide range of performance (including durability)
- soaked CBR values below 15% are likely to be associated with an improved or modified material
- a minimum mean soaked CBR values of 15% (with no single value below 8%) is the typical requirement for SHW clays stabilised to a capping standard (HA74 and SHW series 600)
- subbase applications typically require an ultimate soaked CBR in excess of 50% (Britpave, 2004), however, values of in excess of 30% have been satisfactorily used

Performance at the superior end of the hydraulically bound materials is determined by compressive cube strength ($R_c$ reported in MPa or N/mm²). These materials are grouped as SMRs, and include foamed concrete, granular stabilised soils and aggregate based hydraulically bound materials.

The pavement design guidance associated with the SHW now permits a performance specification route for designing pavement foundations. Although this route is currently not directly applicable to the SROH, research considering the performance measurement of materials, what design values can be assumed and associated revisions to the SHW have been drawn upon to produce an indicative hierarchy of materials (Figure 2).
SMF(S) and SMR hydraulically bound materials have some degree of overlap. The benefit of producing materials with a soaked CBR in excess of 30% is that they can be used as a replacement for GSB1 (section 3.1) for subbase applications (section 4). In general terms, hydraulically bound materials offer a potential advantage over their unbound counterparts, lending themselves to use as structural layers. This has been recognised within the revision to the highways agency pavement foundation guidance, where the potentially superior performance of hydraulically bound material layers can now be factored into the overall pavement design, allowing for reductions in overlying structural layers and/or reductions in the thickness of subbase layers.

Exemplars – Performance of HBMs within pavement foundations

Research within the TRL pavement test facility has shown that a HBM subbase layer (stabilised cohesive soil) could be up to 60% thinner than the unbound granular subbase.

Source: TRL report 248.

Resistance to frost heave is a durability requirement of materials, which are not considered to be insulated or at sufficient depth for this not to be an issue. Hydraulically bound materials are advantageous since research has shown that:

- Hydraulically bound materials with a compressive strength over 3 MPa can be considered resistant to frost heave
- Hydraulically bound materials with a CBR in the range of 15-50% are likely to pass the unbound material test requirement (in terms of maximum recorded heave during laboratory testing); however, the material may no longer be intact

Sources for further information are given in Section 6.0. Specific guidance on the identification (in terms of local geology) and stabilisation of sulphate bearing clays is contained within the highway agency advice note HA74.
3.4 Case Study 1 – Reinstatement with recycled trench arisings in Camden

Contractor Barhale Construction Plc. are currently using Trenchmod® to process and recycle the excavated material for reinstatement. One example is a recent project at Mansfield Road, Camden, under the North London Capital Works framework contract for Thames Water Utilities. Trench arisings were taken to the Trenchmod® plant located on a Thames Water site at Lea Bridge, Hackney. The processed material was then transported back via 8-wheel tipper lorries as and when required. This process reduces the amount of material sent to landfill and demand on primary resources, along with reduced haulage distances, yielding both environmental and economic benefits.

Background

Trenchmod® has been used in maintenance excavations since January 2000, it was developed by Keanes Environmental Ltd to process trench arisings (both soil and aggregate) so that the material complies with Highways and Utilities Committee (HAUC, 2002) requirements for trench reinstatement. The process comprises the use of a patented machine to grade the trench arisings and blend an active powder. The machine is computerised and provides a report on the constituents used and tonnages produced, furthermore, the processed material is then tested for compliance with regulations, to confirm the material has been produced to a quality assured standard.

The machine can process and recycle approximately 500 tonnes per day, but requires locating at a depot that has sufficient space for stockpiling arisings and covered storage for the processed material, as well as a place to park and operate the plant and associated equipment. The Trenchmod® process is registered with the Environment Agency as exempt from waste management licensing (under Paragraph 13, the manufacture from waste of a soil / aggregate material).

Technical Data

After modification, the material may be stored for up to two months before being used to backfill a trench, where it should be compacted in ‘lifts’ according to the HAUC Specification. Once compacted, the material forms a block similar to weak concrete, which can subsequently be saw cut when required. The 90 day compressive strength testing has yielded results in excess of 2 N/mm² and the clegg hammer results are above 19 (30% CBR) in accordance with HAUC specification.

The performance history of the product and previous Utility companies usage has led to an outright conditional acceptance from the London Borough of Camden, where Trenchmod® may be used as backfill/Type 1 subbase alternative.

Benefits

The use of Trenchmod® helps protect the natural environment by reducing the need for primary materials, transportation of quarried material and eliminating the need to landfill trench arisings, resulting in both environmental and economic benefits.
3.5 Case Study 2 – Reinstate using recycled trench arisings in Devon

SMR Soil Stabiliser has been used by South West Water on approximately 100,000 reinstatements within the footways and carriageways of Devon, since its introduction in 1999. SMR Soil Stabiliser was initially approved for footway reinstatement where its successful use, and further trials in carriageways, led to Devon County Council extending the approval to South West Water to include reinstatement of Type 3 & 4 roads, up to and including roadbase levels.

The use of SMR Soil Stabiliser facilitates the re-use of trench arisings for reinstatement, eliminating the need for imported backfill material and the need to remove spoil to landfill. This ties in with Devon County Council’s development process which seeks to ensure the maximum use of locally available aggregates as well as recycled materials so as to minimise overall environmental impact.

Background

Devon County Council is responsible for the maintenance of the largest road network in the UK, 12,820 km of roads and 2895 km of footways. The Council has a Sustainable Transport Policy to encourage more walking and the use of public transport, and the Local Transport Plan 2006-2011 is building on the current use of recycled materials in highway maintenance operations to achieve maximum utility value from recycled and secondary aggregates. This is partly achieved by the use of SMR Soil Stabiliser to recycle arisings for trench reinstatement.

Technical data

SMR Soil Stabiliser is a proprietary product that was introduced to the market by Exeter based SMR (UK) Ltd. The powder is mixed dry with selected excavated material (SEM) to produce a stabilised material, classified as a Non Flowable Structural Material for Reinstatement (NFSMR) in accordance with Appendix A9 of SROH, New Roads & Street Works Act 1991 (HAUC 2002).

Numerous laboratory and field tests have been conducted on the reinstatement material including California bearing ratio (CBR), compressive strength testing and frost heave susceptibility tests. In addition, air void testing of the wearing course applied onto SMR stabilised reinstatements have been conducted. In all of the tests, the SMR stabilised reinstatements outperformed control reinstatements using SHW Type 1 subbase (GSB1).

Benefits

Recycling of trench arisings by mixing in SMR Soil Stabiliser has both environmental and economic benefits. Over the seven years that SMR Soil Stabiliser has been used in Devon approximately 200,000 tonnes of primary aggregate have been preserved, resulting in around 400,000 tonnes of material movements being avoided, reducing both pollution and disruption to the road going public.
3.6 Case Study 3 – Alternative application of Trenchmod® for redevelopment in Enfield

Developers St James homes are currently using Trenchmod® for an alternative application. The redevelopment of a former water treatment works at Innova Park, Enfield, required the removal or modification of 30,000 tonnes of inert and non hazardous material. The material has been modified with Trenchmod® to be used as subbase across the 9.83 acre site, in preparation for the planned residential development. This has resulted in landfill diversion, reduced haulage movements and the associated economic benefits.

Background

St James homes were originally established as a joint venture between Thames Water and The Berkeley Group Holdings Plc in 1996, to transform disused sites into sustainable and attractive developments. Trenchmod® was developed by Keanes Environmental Ltd to process trench arisings (both soil and aggregate) and has been used in maintenance excavations since January 2000.

The process comprises the use of a patented machine to grade the excavated material and blend an active powder. The machine is computerised and provides a report on the constituents used and tonnages produced, furthermore, the processed material is then tested for compliance with regulations, to confirm the material has been produced to a quality assured standard.

Technical data

The machine can process and recycle approximately 500 tonnes per day, but requires locating at a depot that has sufficient space for stockpiling arisings and covered storage for the processed material, as well as a place to park and operate the plant and associated equipment. The Trenchmod® process is registered with the Environment Agency as exempt from waste management licensing (under Paragraph 13, the manufacture from waste of a soil / aggregate material).

After modification, the material may be stored for up to two months before being used to backfill a trench, where it should be compacted in ‘lifts’ according to the HAUC Specification. Once compacted the material forms a block similar to weak concrete, which can subsequently be saw cut. The 90 day compressive strength testing has yielded results in excess of 2 N/mm² and the clegg hammer results are above 19 (30% CBR) in accordance with HAUC specification.

Benefits

The use of Trenchmod® resulted in both environmental and economic benefits including the diversion of 30,000 tonnes of material from landfill. The related economic benefits, the combined saving of reducing material taken to landfill and the importation of quarried stone, was in the region of £0.6 million. The use of an on-site processing plant also reduced the amount of lorry movements to and from site resulting in a reduction of emissions and disruption to local residents.
3.7 Case Study 4 – Stabilised trench arisings used in Type 2 Roads in Hampshire

Morrison Construction conducted an approval trial using SMR Soil Stabiliser to recycle trench arisings into a Type 2 carriageway. Trench work along the A27 at Sarisbury Green, Hampshire has been conducted to install a 400 mm gas pipe for Southern Gas Networks. Hampshire County Council approve the use of SMR soil stabiliser for footway reinstatement and following a successful trial on the A27, the material has been approved for Type 2, 3 and 4 roads across Hampshire.

The excavated trench arisings were processed at a nearby site and the SMR stabilised material transported back to the site when required for reinstatement. The recycling of trench arisings reduces the requirement for landfill and primary aggregates, minimising the overall environmental impact.

Background

SMR (UK) Ltd launched SMR soil stabiliser in 1999. Since its introduction it has been accepted for use by 160 highway authorities, mainly for use in footways and Type 3 and 4 roads. Following a successful trial in Hampshire, on a Type 2 road, Morrison Construction have been given conditional approval by Hampshire County Council for the use of stabilised recycled arisings as structural material for reinstatement (SMR) on Type 2 roads.

Technical data

SMR (UK) Ltd provide training on the use of their proprietary product and processing plant. The excavated soil was processed off site, oversize material (>75 mm) was screened out, and the remaining suitable material was mixed with SMR soil stabiliser to produce a high quality reinstatement material. The material is currently classed as a non flowable stabilised material (NFSMR) in accordance with Appendix A9 HAUC 2002. The stabilised material has an average shelf life of 4 to 5 days, depending on moisture content and storage conditions and may be used for backfill, subbase and base layers.

The amount of powder used depends on the quality of the trench arisings, and is normally in the range of 1.25 to 2.5% addition. The machine provides a consistent mix, thereby ensuring a high degree of quality control. The resulting recycled stabilised material has a compressive strength value in excess of 2 N/mm² and a California bearing ratio (CBR) in the region of 30%.

SMR soil stabiliser may be mixed manually for small excavations or larger volumes may be mixed with the use of mobile plant, such as the ‘Screen Machine Might2’ plant, which can process 30 - 40 tonnes per hour and the Screen Machine Achiever which can process up to 150 tonnes per hour. Recent developments include Live Heads and Stockpiling Conveyors for both models. The resultant product is a high quality reinstatement material marketed as SMR Premix’d, which can outperform SHW Type 1 subbase.

Benefits

The recycling of trench arisings by mixing in SMR soil stabiliser has both environmental and economic benefits. Including the amount of material movements avoided, reducing both pollution and disruption to the road going public.
3.8 Case Study 5 – Flowable cement bound excavated material for reinstatement

Cement Bound Excavated Material (CBEM) has been developed to reinstate trenches in a variety of roads in West Yorkshire, from lightly constructed, lightly trafficked roads such as Thorn Grove, Rothwell to heavily constructed, heavily trafficked roads such as the A639 at Methley.

Background

United Utilities and Advantica have conducted research and field trials since 1997, to develop a family of stabilised reinstatement materials known as cement bound excavated material (CBEM). The production of CBEM has grown and a recycling facility was set up at Sheepscar, Leeds in 2004, with assistance from WRAP. The facility is now operated by United Utilities, to process excavated material and produce a consistent, flowable, self compacting reinstatement material (CBEM 3), which is used to reinstate trenches throughout West Yorkshire namely; City of Leeds, City of Bradford, Wakefield Metropolitan Borough and Kirklees Metropolitan Borough.

The plant can process the entire range of excavated materials including soft clays, thus, 100% recovery can be achieved. Acceptable material is stored in a covered bay where clay soils are allowed to dry out and unsuitable objects (pipes etc) removed manually. The material is separated into three size ranges, (fine, coarse and oversize) by a vibrating screener and the oversize material is processed by a Neuenhauser twister. CBEM 3 is delivered and mixed on site using an Armcon volumetric mixing unit. The compact plant is designed to operate on a quick turnaround of materials; therefore, stockpiles are kept to a minimum.

The requisite ratio of fine and coarse fractions are combined to a suitable grading and stored in a hopper the cement and water are stored separately on the truck. The components are combined in a bowl at the end of the chassis and mixed in the Archimedes screw section of the volumetric mixer. The flowable CBEM 3 is ejected from the upper end of the screw and poured down an adjustable chute into the trench. The mixing technique facilitates accurate batching, avoiding the requirement for disposal of excess material.

Technical data

The fine fraction (0 – 20 mm) conforms to the gas industry specification for fine fill and can be used as pipe surround. The coarse fraction (20 – 40 mm) can be used as aggregate or combined with the requisite amount of fine material and cement to create CBEM 3, of which there are two mix designs (a standard mix to cover most applications and a stronger mix for use as a base course in Type 1 and 2 roads). Both mix designs are used under trial agreements, in accordance with HAUC, 2002, which have been signed by Leeds, Bradford, Kirklees and Wakefield. The cube strength of the ‘standard mix’ exceeds the required 90 day strength of 2 N/mm² (HAUC, 2002) and the ‘strong mix’ achieves the 90 day target strength of 4 N/mm².

Benefits

No surface movement and no failures have been reported at any of the sites where the material has been used.

In addition, to the environmental benefits associated with recycling and reduced lorry movements, the flowable, self compacting nature of CBEM 3 negates the requirement for manual compaction, so operators are not exposed to vibrating power tools, mitigating the risk of hand arm vibration syndrome.
The type of reinstatement materials acceptable for use in trench reinstatement depends on the location of the excavation (including verges, footways and category of road) and placement of reinstatement materials (layer in pavement). The material specifications and road categories are set out in SROH and summarised in this section.

4.0 Specification and compliance

4.1 Road categories

The second edition of SROH saw the introduction of an additional road category (Type 0) to cover especially heavily trafficked roads (Figure 3) resulting in five road categories plus footways, verges and unmade ground. Each category has its own performance criteria for the materials used in each structural layer.

<table>
<thead>
<tr>
<th>Type</th>
<th>Traffic Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&gt; 30 to 125 msa</td>
</tr>
<tr>
<td>1</td>
<td>&gt; 10 to 30 msa</td>
</tr>
<tr>
<td>2</td>
<td>&gt; 2.5 to 10 msa</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 0.5 to 2.5 msa</td>
</tr>
<tr>
<td>4</td>
<td>&lt; 0.5 msa</td>
</tr>
</tbody>
</table>

Figure 3 HAUC, 2002 Clause S1.3 Road Categories Key: msa = millions of standard axles

4.2 Pavement (structural) layers

There are four main types of road construction detailed in the SROH; flexible, composite, modular and rigid. All the designs have structural layers in common, namely base course, subbase and subgrade. The presence of the capping layer is dependent on the quality of the subgrade. Where underground apparatus is installed the capping and subgrade is replaced by pipe surround and backfill; the overlying structural layers are then constructed according to the design of the surrounding pavement.

Flexible and composite roads generally have an asphalt surface course supported by an asphalt binder course. Below these layers there would usually be further base course (asphalt in the case of flexible, and concrete in the case of composite), over a subbase layer. In situations where the underlying soils are weak, there may also be a capping layer to help spread the load. Finally, the original soil and rock, known as the subgrade, provides the foundation to the overlying pavement. Modular roads are similar to flexible and composite roads, except that the
asphalt layer is replaced by paving blocks bedded on sand or similar fine aggregate. Rigid roads are defined by their use of a solid concrete slab which may or may not have an asphalt surfacing. The concrete slab is supported by subbase, and like the flexible and composite road designs the presence of a capping layer depends on the subgrade.

The structural reinstatement of trenches, including material selection, is governed by the road type, for example a C2 SMR (90 day compressive strength range between 2 and 10 MPa) is allowed up to and including the binder course in footways but is not permitted above subbase level in a Type 0 carriageway (Figure 5).

<table>
<thead>
<tr>
<th>Structural Material for Reinstatement (SMR)</th>
<th>Minimum layer thickness and compressive strength requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer</td>
<td>Road Type</td>
</tr>
<tr>
<td>Combined Binder Course &amp; Sub-base</td>
<td>NP</td>
</tr>
<tr>
<td>Base (Roadbase)</td>
<td>NP</td>
</tr>
<tr>
<td>Base (Roadbase) &amp; Sub-base</td>
<td>NP</td>
</tr>
<tr>
<td>Sub-base &amp; or below</td>
<td>150 mm</td>
</tr>
</tbody>
</table>

**Figure 5** Minimum layer thickness and permitted use of SMR extracted from the SROH.

**Notes:**
NP = no permitted for that combination of layer and road type, C2 = 90 day compressive strength between 2 and 10 MPa and C4 = 90 day compressive strength between 4 and 10 MPa.

4.3 **Surround to apparatus**

According to the SROH, Class E, (unacceptable excavated materials), and materials that contain particles greater than 37.5 mm nominal size, shall not be used as surround to the apparatus. Suitable fine granular fill, including recycled aggregates, or an ARM may be used for the entire surround to apparatus, or any part thereof, (in accordance with Appendix A9 HAUC, 2002).

4.4 **Backfill**

Imported and excavated material for backfill is classified Class A to E (section 3.1). Classes A to D which fulfil the SROH requirements (Appendix A1 HAUC, 2002), are acceptable for use and should be compacted in accordance with Appendix A8, HAUC (2002).

The classes of backfill materials are open to the use of recycled materials and specific provision is given for certain secondary aggregates, such as slag, fly ash (also known as pulverized fuel ash), clinker and furnace bottom ash, which are noted as being able to achieve satisfactory performance, despite not meeting certain aggregate requirements. ARM’s may also be used for the entire backfill layer, or any part thereof (in accordance with Appendix A9 HAUC, 2002).

Material used for backfill shall pass through a 75 mm BS sieve and for trenches less than 150 mm wide the material shall pass through a 37.5 mm BS sieve. In addition, frost susceptible material shall not be used within 450 mm of a road surface, unless frost susceptible material already exists at that level, in which case approval may be sought. Good compaction of backfill is vital for ensuring long-term performance of the reinstatement.

Clegg hammer – in situ test of compaction
4.5  Subbase

The function of a subbase layer is to spread the load from traffic and the upper layers. Therefore, it must be placed and compacted to a high standard, so that the reinstatement has a long life. Good methods of construction include;

- applying the correct number of compaction passes
- checking subbase surface is to the correct tolerance
- checking for defects (contamination, loose material and so on)

Care must be taken to ensure that natural drainage is not adversely affected. Advice on the selection of suitable materials should be sought if site conditions indicate adverse drainage conditions. In certain circumstances, the use of hydraulically bound materials can have potential long term benefits over unbound equivalents.

Permitted options for subbase in a flexible pavement are given in Appendix A1 HAUC (2002). Furthermore, the thickness of subbase layer may be reduced, provided that the thickness of the bituminous binder course is increased proportionately (in accordance with S6.3.3. HAUC, 2002).

Permitted options for subbase in a rigid road are given in Appendix A5 HAUC, 2002. Where such a subbase layer exists, a similar or equivalent material shall be laid to match the existing thickness subject to a minimum thickness of 150 mm.

ARMs may be laid to the top of subbase level, in accordance with Appendix A9, regardless of whether or not the existing subbase is a bound material, for both flexible and rigid pavements. Similarly, a CBM3 subbase of 150 mm thickness may be used in small excavations and narrow trenches regardless of whether the existing subbase is cement bound, for both flexible and rigid pavements. Where this option is utilised, the base material shall also be a bound material.

Recycled aggregates are permitted as a constituent of subbase layers if the material complies with the SHW. For further information refer to the aggregain specifier (http://www.aggregain.org.uk/specifier).

4.6  Upper layers

Reinstatement of the upper pavement layers, depends on the design of the road, footway, footpath or cycle track. However, the final as laid profile must comply with the performance requirements of SROH. Permitted options for base course within a flexible pavement are given in SROH Appendix A4 subject to the exceptions listed in sections S6.3.2 (CBM3 in Flexible and Composite Roads) and S6.3.3 (Base Equivalence). ARMs may be laid to the top of base level, in accordance with SROH Appendix A9, regardless of whether the existing base is a bound material.

Recycled aggregates are permitted as a constituent of any upper pavement layer if the material complies with the SHW. For further information refer to the aggregain specifier (http://www.aggregain.org.uk/specifier).

For rigid pavement construction a concrete slab replaces the base and binder course, and often the surface course too. Permitted options for permanent concrete slab reinstatement are given in the SROH Appendix A5.

4.7  Summary of material applications

4.7.1  Foamed concrete

Foamed concrete can be used:

- At any position within the surround to apparatus and/or backfill as the entire layer or combined with any other backfill materials, in any proportion, within any reinstatement*
- As subbase within any reinstatement
- As a combined subbase and base layer in Road Types 1, 2, 3, and 4
- As a combined subbase and binder course, within any reinstatement in footways, footpaths and cycle tracks

* Practical guidelines on the use of foamed concrete (especially as a pipe surround) are contained in the Practical Guide to Streetworks (HAUC, 2006).
### 4.7.2 Unbound and hydraulically bound materials

A summary of the unbound and hydraulically bound material (other than foamed concrete) applications is contained within Figure 6, along with an indication of the required mechanical performance, in terms of compressive strength ($R_c$ in MPa) or CBR (%).

<table>
<thead>
<tr>
<th>Application</th>
<th>Material type</th>
<th>Product</th>
<th>Mechanical performance</th>
<th>Re-use</th>
<th>Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined binder course and subbase</td>
<td>H</td>
<td>SMR</td>
<td>90 day $R_c$ 2 to 10 MPa (footway, footpath or cycle track only)</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Base</td>
<td>H</td>
<td>SMR</td>
<td>90 day $R_c$ 2 to 10 MPa (Road type 3 and 4 only)</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Base &amp; subbase</td>
<td>H</td>
<td>SMR</td>
<td>90 day $R_c$ 2 to 10 MPa or $R_c$ 4 to 10 MPa (dependent on road type)</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Subbase</td>
<td>H</td>
<td>SMR</td>
<td>90 day $R_c$ 2 to 10 MPa</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Class S)</td>
<td>Soaked CBR &gt;30%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U</td>
<td>GSB 1</td>
<td>Equates to a CBR &gt;30%</td>
<td>Y</td>
</tr>
<tr>
<td>Backfill</td>
<td>U or H</td>
<td>SMR</td>
<td>90 day $R_c$ 2 to 10 MPa</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type S)</td>
<td>Soaked CBR &gt;30%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class A - graded granular</td>
<td>&gt;15% CBR</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type A)</td>
<td>Soaked CBR 15 to 30%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class B - granular</td>
<td>7 to 15% CBR</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type B)</td>
<td>Soaked CBR 7 to 15%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class C - cohesive/granular</td>
<td>4 to 7% CBR</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type C)</td>
<td>Soaked CBR 4 to 7%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class D - cohesive</td>
<td>2 to 4% CBR</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type D)</td>
<td>Soaked CBR 2 to 4%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>Pipe bedding and surround</td>
<td>H</td>
<td>SMF (Type S)</td>
<td>Soaked CBR &gt;30%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type A)</td>
<td>Soaked CBR 15 to 30%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type B)</td>
<td>Soaked CBR 7 to 15%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type C)</td>
<td>Soaked CBR 4 to 7%</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMF (Type D)</td>
<td>Soaked CBR 2 to 4%</td>
<td>-</td>
<td>Y</td>
</tr>
</tbody>
</table>

**Figure 6** Overview of materials and permitted applications (SROH).

Key: U = unbound materials, H = hydraulically bound materials. Note: Specific reference should be made to the SROH to ensure compliance.

Recycled aggregates are permitted in all the applications.

Re-use of materials is only applicable to unbound materials. A key issue with on-site re-use is the identification of materials (specifically in terms of compliance with the specification). This can only be fully achieved by undertaking laboratory testing. A practical option is to downgrade an excavated material based upon on-site assessment, for example Class A down to Class B and SHW Type 1 down to Class A (HAUC, 2006). Larger projects may justify an initial phase of investigation to confirm re-use options.

Frequently asked questions (section 5) and sources of further information (section 6) are included to further assist practitioners.
Frequently asked questions regarding the terminology and use of recycled and hydraulically bound materials are addressed in the following section.

5.0 Frequently asked questions

5.1 Why should I encourage recycling in trench reinstatement works

There are clear benefits to be gained from using recycled products in highways, as well as economic, environmental and social contributions to sustainable development. These benefits include:

- quality and performance which is at least comparable with those of primary options
- reduction in the need for raw materials
- reduction in materials going to landfill
- potential reduction in local and regional haulage (especially in urban areas where hub recycling schemes capable of handling trench arising can be sustained)

5.2 What are recycled aggregates?

For trenching works, the term recycled aggregates includes three main groups:

- selected trench arisings suitable for re-use
- processed and/or treated trench arisings made suitable for re-use
- recycled aggregates from other sources, other than trench works, such as recycled concrete aggregate from demolition works

Recycled aggregates have specific provision within the SROH, and they have been fully incorporated into the SHW and its accompanying guidance (design manual for roads and bridges HD35), and they are fully covered by European harmonised material and testing standards. The quality protocol for the production of aggregates from inert waste should be followed to ensure a uniform control process and to demonstrate recovery from waste. (WRAP, 2004, 2005c and 2005d).

5.3 What are stabilised materials?

Stabilised materials are grouped under the hydraulically bound materials family. Stabilisation infers a level of durability above which would be expected from the untreated material. It is achieved by the addition of percentage of various hydraulic binders to materials (typically soils). In particular, the addition of lime to a fine grained soil initiates several reactions, which are grouped into the following three stages: -

- Improvement – drying out by absorption and evaporation, results in the reduction in the soil moisture content
- Modification – physico-chemical reactions between the lime and clay minerals occurs within a few days and changes the soil's plasticity.
- Stabilisation – long-term hydraulic reactions occur within the material and result in increased long term durability and performance

5.4 What are alternative reinstatement materials (ARMs)?

Alternative Reinstatement Materials (ARMs) includes new or alternative materials which have been developed for use in highway construction and maintenance. Many of these materials have a long history of use across all categories of roads and various other pavement applications, but do not yet have specific provision within the HAUC Specification (2002). This lack of specific recognition or provision means that ARMs are often trialled prior to full approval.

ARMs are categorised by the HAUC Specification (2002) into two groups defining the application of the material:

- Structural Materials for Reinstatements (SMRs)
- Stabilised Materials for Fills (SMFs)
5.5 Where can recycled aggregates be used?

Recycled aggregates have a proven track record within asphalt, concrete, hydraulically bound and unbound materials. Specific provision for their use are included both within the specification for the reinstatement of openings in highways (HAUC 2002) and the specification for highway works, with additional guidance given in the design manual for roads and bridges (HD35).

Significantly, the recently introduced European standards for aggregates mean that materials are not discriminated on the basis of source. The focus is on fitness for purpose rather than origin of the resource.

5.6 Are these recycled materials inferior?

No. Fitness for purpose is ensured by compliance with the specification, testing and design. Any material that complies with the specification can, therefore, be used. Certain materials may be specifically prohibited, but these can include both natural and recycled sources.

To ensure a quality assured product, the quality protocol set out by WRAP (2004, 2005c and 2005d) outlines a uniform control process for producers, from selecting inert waste and processing the material to producing a quality managed recycled aggregate that is no longer classified as waste. The protocol seeks to ensure that recovered aggregates meet the quality and conformity requirements for European standards for aggregates.

5.7 What specifications can be applied to hydraulically bound materials (including stabilised soils)?

Detailed information on the specification of hydraulically bound materials is provided in the specification for highway works series 600 and 800:

- Series 600 covers stabilised capping is based upon British Standards (BS) for stabilised soils
- Series 800 is based upon European harmonised standards (BS ENs) and covers aggregate based hydraulically bound mixtures and stabilised soils for subbase and base applications

Associated guidance is signposted in section 6.

5.8 Do hydraulically bound materials harm nearby trees?

No, there is no impact on the surrounding environment where soil stabilisation has been carried out and water courses have not been affected in the past (Britpave, 2006). In fact this process has been adapted to treat contaminated sites (known as solidification). However, hydraulically bound materials are not a satisfactory growing medium; the bound matrix is densely compacted which impedes root penetration and reduces permeability and nutrient availability necessary to support plant growth. Therefore, hydraulically bound materials may not be suitable in close proximity to trees, i.e. within the ‘Precautionary Area’ (NJUG 10). This guidance is simply based upon the mechanical properties of the material.

The use of hydraulically bound materials may actually be considered advantageous in certain areas where roots are problematic (exploiting trenches and damaged pipes as pathways of least resistance). In such circumstances the hydraulically bound materials may serve as a root barrier, protecting the underground services.

5.9 Are the applications containing recycled aggregates more susceptible to poor workmanship?

No, recycled aggregates are permitted providing they meet the relevant performance criteria for each construction layer, ensuring the material will perform as well as conventional materials. Clause 710 of the SHW and the content of all foreign materials (including wood, plastic and metal) shall not exceed 1% by mass. Therefore, they should not be more susceptible to poor workmanship than their conventional counterpart.
5.10 Are the hydraulically bound materials more susceptible to poor workmanship?

No, these materials should be produced to a quality protocol, handled by trained staff and have test certificates provided to ensure compliance with the specification. Additional confidence in processing and mixing is recognised with quality controlled off-site recycled materials.

5.11 Where can I find out more information about recycled aggregates and their application?

The WRAP AggRegain website (www.aggregain.org.uk) has numerous case studies, technical information and guidance on the specification of recycled materials and products.
Numerous technical reports, guidance documents and web based information sources are available to guide practitioners.

6.0 Further information


BRITPAVE, 2004. Stabilised soils as sub-base or base for roads and other pavements. Technical Data Sheet BP/08. (www.soilstabilisation.org.uk)


Faragher E. 2005. CBEM3 Recycling pilot materials and technical aspects (Unpublished report for Northern Gas Networks and Advantica)


Highways Agency Interim Advice Notes 73/06 Design guidance for road pavement foundations (draft HD 25) (This note does not form part of the DMRB or the MCHW)


Highways Agency. Design Manual for Roads and Bridges, Volume 4 Section 1 Part 6 (HA 74/00) Geotechnics and drainage. Earthworks. Treatment of fill and capping materials using either lime or cement or both


National Joint Utilities Group, 1995, Guidelines for the Planning, Installation and Maintenance of Undertaker Services in Proximity to Trees. NJUG Publication 10


WRAP, 2005a, Identifying opportunities for recycling of excavated spoil from utility works within local authority areas, and promoting the use of recycled materials through good practice in procurement. WRAP Oxon (www.wrap.org.uk)

WRAP, 2005b. Recycled roads a step by step guide to local authority procurement. WRAP Oxon (www.wrap.org.uk)

