ABSTRACT: Highway maintenance and new construction works carried out by Local Authorities present many opportunities for recycling, both through reuse of arisings and by utilizing locally available recycled and secondary aggregates. This can be cost effective and give excellent technical performance as well as meeting environmental objectives such as reduced consumption of primary aggregates and reduced emissions of CO₂. Recycling is most likely to be successful when the client is fully committed to the process and all the stakeholders are involved from an early stage. Hampshire County Council is fully committed to sustainability and has set up a partnership for highway maintenance with Raynesway Construction Southern Ltd and Foster Yeoman Limited that pioneers a natural resource management approach. This is illustrated by four case studies that demonstrate an innovative approach to recycling in unbound applications, footways, bituminous base and binder courses, surface dressings and concrete.

KEY WORDS: Recycling, Local Authorities, partnering, pavements, footways, foamed bitumen, earthworks

1. INTRODUCTION

In England, County Councils are responsible for the maintenance of public highways with the exception of trunk roads and motorways. This covers a wide range of situations, from lightly trafficked roads in rural areas and housing estates to major principal roads (‘A’ roads) that are very heavily trafficked and connect with the trunk road and motorway network. Highway maintenance covers a wide range of operations, from patching and surface dressing to complete reconstruction of life-expired carriageways. The County Councils are also involved in new construction, from ensuring that new roads in housing and industrial estates are constructed in accordance with the Local Authorities adoption specifications to major schemes such as bypasses. County Councils are thus in a very powerful position to influence the amount of recycling and the use of recycled and secondary aggregates in highway maintenance and new construction in their areas.

Hampshire is a county on the south coast of England, roughly half way between the east and west ends of the country. It has a population of 1,240,000 and covers an area of 367,680 hectares, making it one of the largest
non-metropolitan or “shire” counties in England [1]. Most of the county is within 1-2 hours of London by main-line rail services or motorways. The major cities of Southampton and Portsmouth, on the south coast, are not part of the county. The county is partly rural but many areas are heavily developed, particularly around the principal towns of Winchester and Basingstoke.

Hampshire County Council is responsible for maintaining more than 6,000 miles of road and a similar length of footways. The maintenance of Hampshire’s road network is carried out to ensure that the highways are safe and that the public can use them without obstruction. The Hampshire Highways Group, a branch of the County Council’s Environment Department, carries this out in accordance with set policies. Hampshire has been in the forefront of developing a systematic approach to the maintenance and management of the highway network and was influential in the development of the Local Authorities Association’s Highway Maintenance Code of Good Practice [2].

Hampshire County Council has a firm commitment to sustainability. Aim 2 of the Council’s Corporate Strategy is to protect the environment by promoting the principles of environmental sustainability. Sustainable development implies the following principles which can be adopted for highway maintenance operations:

- A reduction in the consumption of natural resources, including energy. Non renewable resources should be substituted with renewable resources.
- Waste should be reduced.
- Waste should be reused or recycled.
- Biodiversity should be preserved or enhanced.
- Valuable natural and physical assets and amenities should be preserved and protected.

These principles are embodied in a formal council policy which states that Hampshire County Council, as the Highway Authority, shall consider environmental factors whenever designing a maintenance scheme or planning a maintenance operation. The choice of materials and processes that preserve or enhance the environment should have due regard to the health and safety of the road user [3]. This policy drives the actions of the Hampshire Highways Group and clearly favours recycling and the use of recycled and secondary aggregates provided this does not adversely affect the performance or safety of the highway network.

As part of its commitment to sustainability, Hampshire County Council signed a Public Service Agreement (PSA) with the Government in April 2002 covering the period up to March 2005. The Public Service Agreement requires Hampshire County Council to achieve more demanding performance targets than would otherwise be expected. One of the targets was to recycle an additional 40,000 tonnes per annum of household, commercial and industrial waste through development of a natural resource management approach. Highway maintenance and new construction were identified as key areas which could contribute significantly to meeting this target.

The delivery of highway maintenance services in Hampshire is achieved through a partnership between the County Council, Raynesway Construction Southern Ltd (RCS) and Foster Yeoman Limited. The partnership has a number of benefits including a shared feeling of project ownership, agreed priorities and common goals by all the stakeholders. Stable relationships are developed between the partners, which generates and stimulates strategic thinking. The arrangement allows efficiencies in programming by linking project clusters to project partners. It enables the development of new materials and specifications, with input and advice from the Environment Agency where necessary. The project has the following sustainability related objectives:

- Identify opportunities for changing working practices on highway maintenance to optimize reuse and recycling of construction waste;
- Reduce construction waste and use recycled and secondary aggregates;
- Draw on each other’s strengths for the mutual benefit of the partners and the people of Hampshire.

The benefits of this approach and the ways in which recycling can be used in Local Authority highway works are illustrated by the following case studies, which cover new construction as well as maintenance. TRL has been involved through a Partners in Innovation project funded by the Department of Trade and Industry to optimize resource usage in a defined geographic area. Part of this project involved a series of research and demonstration
projects involving the use of recycled and secondary aggregates in a variety of applications that illustrate how their potential can be achieved and how obstacles can be overcome.

2. DEMONSTRATION PROJECTS

2.1 A325 Major maintenance scheme at Alice Holt
This project is a major maintenance scheme contracted out for Hampshire County Council. The project is a three phase operation with Raynesway Construction Southern being involved at present in phase two, which involves the stabilisation of the A325 near Alice Holt in the north east of the county, over a distance of about 1.8 km. There are three sections of road requiring stabilisation of the embankment. The first section is 300 m long on one side of the road; the second section is 150m long on both sides of the road and the third section is 400 m long on one side of the road.

The embankment is currently made up of poor quality clay at a slope of 45°. The embankment has been dug out in benches of 0.5 m. The excavated material was replaced with selected granular fill (see Figure 1). The embankment ranges from 0.8m to 5.0m in height and the works required a total of 21,000 tonnes of imported fill. The new embankment was built at a shallower slope of 1:3. The imported fill was supplied by recycled aggregates derived from the processing of construction and demolition waste, thus avoiding the use of primary aggregates. The recycled aggregates are permitted constituents as general fill and capping in the UK Specification for Highway Works [4]. The specification called for Class 6F5 selected granular fill, which is normally used as a coarse grained capping layer, rather than Class 1A general granular fill. This was to ensure that a well graded granular material with a high angle of internal friction was used. The recycled aggregates meet this specification and performed as well as primary aggregates. The works were carried out from September 2004 to January 2005, and the free-draining nature of the recycled aggregates meant that it was possible to work the materials in these conditions. This would not have been possible with locally available sands and gravels, which were susceptible to moisture.

In addition to the technical benefits of using recycled aggregates, there were cost savings due to reduced haulage compared to primary aggregates, and environmental benefits from this and reduced use of natural resources.

![Figure 1. Schematic section of the embankment reconstruction at Alice Holt](image-url)
2.2 B3047 Martyr Worthy footway works

One of the ways in which the partnership have been pursuing sustainable construction methods is by the use of cold-mix recycled asphalt with foamed bitumen binder, commonly known as ‘foamix’. This has a number of advantages over conventional hot-mix asphalt in sustainability terms. By using recycled asphalt, or other recycled and secondary aggregates, it saves the use of primary aggregates. As it is mixed and laid cold it saves energy in the manufacturing process, and hence emissions of CO₂. It is also safer than hot-mix asphalt, and is 100% recyclable in the future.

RCS have been using foamix in a number of different applications throughout the county. They expect to have used approximately 12,000 tonnes by the end of the PSA in March 2005. They spent time during the summer months experimenting and trying different applications. Foamix has been used in footpaths, road maintenance and on individual’s driveways. They have found that the foamix works well if laid in dry conditions but doesn’t work so well if laid in wet weather. The foamix remains stable once it has been laid for a couple of days before rain but it is better if a sealing layer is put on top. Foamix has performed well and RCS are growing in confidence in using it in a variety of different applications. They have been using the foamix a lot in haunching applications all over the county. It has been used as an alternative to the sub base, base and binder courses of roads and footways. By using a single layer of foamix instead of separate sub-base and base layers, overall savings in the thickness of the road pavement, and hence materials used, can be made as illustrated for a minor road on Figure 2.

Footway works offer a number of opportunities to try out new techniques and materials in relatively low risk situations, especially in rural areas. The project considered here, on the B3047 in a rural area, is being undertaken as part of the term maintenance programme. It is trying to push the boundaries towards a new way of using foamix in footways with a surface dressing laid straight on top of the foamix instead of a full surface course.

The existing footway surfacing was removed along with any plant/ root damaged/ contaminated sub-base. The footway was overgrown and significant clearing was required prior to work starting. The total length of the footway which has been constructed is 711 m. The footway was constructed to allow for a 0.08 m foamix layer. The foamix was also used to repair any areas where damaged sub-base had been removed. The total quantity used was 100m³ for the surface layer and 50 m³ for repairing the sub-base. The works were carried out in November and December 2004.

One of the major concerns the contractors had was that when the foamix is laid it generally doesn’t have a really smooth finish, so if the surface dressing is laid on top the overall finish might not be as smooth as with a normal
surface course, and this might result in ponding of water. However, the scheme proved very successful, with the quality of the finished surface being comparable with that of conventional construction.

### 2.3 Reuse of surface dressing chippings

In surface dressing operations on highways, there are always some surplus unused materials. After the surface dressing has been laid, further surplus material is generated as sweepings of loose material from the road surface. In Hampshire there are a number of remote sites where unused surface dressing chippings have been stockpiled for a number of years. These sites are now receiving post surface dressing sweepings as well as the unused material. The surface dressing sweepings would previously have been sent to landfill or used on farmers’ tracks. In 2003 these stockpiles were estimated to be in excess of 4,000 tonnes.

Hampshire County Council and Road Maintenance Service Ltd wanted to find a use for the excess surface dressing chippings and sweepings. The material came in a range of sizes including 6mm, 10mm and 14mm. The material was required to be screened before it would be suitable for use. Road Maintenance Services suggested that a dry screening process be used to remove the majority of contaminants. The screened material would then be lightly coated with bitumen to bind the high dust content of the resulting material to the aggregate, thus reducing the dust problem. This process was trialed at their depot in Cheshire. The material was screened, coated with bitumen and laid successfully.

In the 2004 season (May to August), these recycled coated chippings were used at 33 sites across Hampshire. In all, 1,613 tonnes of 10mm material and 1,554 tonnes of 6 mm material were laid using either a 10/6 mm racked in dressing or 10/6mm double dressing specification.

The resistance to skidding of aggregates used in surface dressings is measured by a test called the Polished Stone Value (PSV) test. The required value of PSV for any site depends on a number of factors, including the anticipated traffic load and the geometry of the road; the higher the PSV, the greater the skid resistance. Due to the mix of chippings prior to the screening process, the Polished Stone Value (PSV) of the resultant material could only be assumed as 60 PSV for the 10 mm and 55 PSV for the 6 mm chippings. As a number of the sites where the material was to be laid required a PSV of 65 the use of the recycled material needed to be carefully managed. In some cases where double dressings were being used, it was possible to coordinate use of the 10 mm recycled chippings as the first application, with the 6 mm layer being a 65 PSV primary aggregate. The recycled material did not perform any differently when being laid to the equivalent primary material.

To date all sites treated using the recycled chippings are performing well. Monitoring is continuing every 6 months, particularly related to the overall skidding resistance on site where a higher PSV primary chipping was used. Following the overall success of the trials, preparations are underway for a similar programme in 2005.

Cost savings of over £28,000 were obtained by using the recycled materials, largely because of the long haulage distance of the equivalent primary material and the surface dressing sweepings having no initial value. The use of the locally sourced recycled surface dressing sweepings saves nationally on the amount of road haulage, with associated savings in fuel and emissions of CO2.

### 2.4 Bar End Household Waste Recycling Centre, Winchester

As well as being responsible for highways, Hampshire County Council is responsible for the disposal of the waste produced by the 1.24 million residents of the county, and is eager to exceed government targets for recycling as part of its corporate commitment to sustainability. Part of this strategy is the provision of household waste recycling centres (HWRC) throughout the county. In 2000 it was decided that a site would be needed for a new HWRC to serve the Winchester area. The chosen site at Bar End was owned by the County Council.

The Waste Management Group in the Environment Department of the Council made it clear to the Engineering Consultancy Group that the project was to be a demonstration project for sustainable construction techniques. This included using recycled and secondary aggregates in the construction where practicable. The designer therefore specified the materials that were permitted and the method of treatment for site won materials to allow
them to be used within the permanent works. There was close liaison between the Waste Management Group, Engineering Consultancy, Hampshire Highways Group, Raynesway Construction Southern Ltd and Foster Yeoman to generate ideas for maximizing the use of recycled and secondary aggregates in the construction of the HWRC and the access road to it. Other bodies, such as the Environment Agency and Onyx Environmental Group Plc, were involved as the plan for the site was developed. This was then followed through in the development of specifications and method statements to enable the ideas to be implemented.

As well as maximising the use of recycled aggregates, the site incorporates a number of other sustainability features. These include a sustainable urban drainage system (SUDS) that will take all the runoff from the site and the access road. All the runoff will be allowed to infiltrate into the ground through swales and a balancing pond with storage capacity for the 1 in 100 year storm.

The form of the HWRC is a circular concrete slab as the lower level, on which the containers for the recycled materials will be placed, with concrete retaining walls rising to an upper level where cars will park and from where materials can be placed in the containers. There will be a one-way road system for cars around this upper level. The access road runs for 300 m from the end of the public road at the edge of Bar End Industrial Estate to the HWRC. The existing access road is to be regraded and widened, giving a composite structure (Figure 3). It is on sloping ground and required a sheet pile retaining wall on the downslope side for the first 100 m from the public road. A schematic cross section through the access road is shown on Figure 3.

The existing structures, car park and access road on the site were demolished, crushed and screened and stored on site for use in the new works. The cut-and-fill balance was designed so that as much of the sub-base of the existing car park as possible could be used as recycled aggregate in the new works. The resulting recycled aggregates and recycled asphalt were used as capping, unbound sub-base and backfill to the concrete retaining wall of the HWRC and the retaining wall for the access road. Recycled aggregates are permitted for all these applications in the UK Specification for Highway Works. The materials available on site were not sufficient for all the aggregate requirements for the works, so recycled aggregates and recycled railway track ballast were imported to make up the quantities.

![Figure 3. Schematic cross section of access road showing use of recycled aggregates (not to scale)](image-url)
A combined bituminous base and binder course was used for the access road and the flexible carriageway around the HWRC. This was made using cold recycled aggregates and foamed bitumen as the binder (‘foamix’). In this case the coarse aggregate was matured and processed Incinerator Bottom Ash Aggregate (IBAA) from a nearby waste-to-energy plant at Chineham, operated by Onyx Environmental Group Plc. Within Hampshire three new incinerators are to be built by the end of 2005. This will result in approximately 100,000 tonnes of Incinerator Bottom Ash (IBA) arising within the county which needs to be managed. A small scale trial with IBAA as aggregate in asphalt had been carried out in Hampshire in 2003, and there are examples of the use of IBAA in asphalt from elsewhere in the UK [5] and overseas.

The method statement for the use of IBAA in foamix was written in conjunction with Foster Yeoman and was based on the experience of Hampshire County Council and Foster Yeoman with foamix in a number of highway maintenance and new works projects, and the small trial with IBAA in 2003. The design is based on existing guidance on the use of foamed bitumen in the Specification for Highway Works and recent design guidance for cold recycled bituminous materials produced by TRL as TRL Report 611 [6]. It was important that the IBAA was matured and processed before being used in the foamix, as unweathered IBA has a very high pH and detrimental environmental and mechanical characteristics. These can be avoided by allowing the material to mature for several weeks and processing it to remove impurities before use. Onyx stockpiled 1,200 tonnes of IBA at the Rainham Marshes landfill site in Essex. The IBA was weathered for at least three months and testing was undertaken to ensure the quality of the ash. Onyx processed the IBA to remove impurities, screened and graded the material to ensure the correct size and quality for use in the foamix as IBAA. The processed IBAA was delivered to the Foster Yeoman depot at Micheldever (Figure 2) and mixed with the other ingredients to form the foamix used in the base and binder course of the access road. The foamix was placed successfully in two 75 mm layers.

The use of foamix containing IBAA was an issue of concern to the Environment Agency, because a ditch at the edge of the site leads to the River Itchen which is a candidate Special Area of Conservation under the Habitats Regulation and therefore has a high level of protection. The Environment Agency required further investigation to be carried out to identify the risks, if any, of using the IBAA within the foamix. TRL carried out a qualitative risk analysis to identify any risks that the use of IBAA at the site might cause. It was found that the risk of the IBAA causing harm to human health or the environment was very low. A programme of leaching tests and environmental monitoring was agreed by all parties to ensure that the use of IBAA in foamix did not pose any risk to the environment.

The extensive testing of the IBAA prior to use, preconditioning and the mixing into the foamix meant that the IBAA was no longer classed as a controlled waste by the Environment Agency. The Bar End site was not therefore considered to require a Waste Management License or exemption to receive the Foamix.

A further use of recycled aggregates in a high value application was in the concrete base slab for the HWRC. The concrete is fibre reinforced to prevent shrinkage cracking and incorporated 15% recycled aggregates as the coarse aggregate in the concrete. The concrete has a compressive strength of c25/30 and a maximum aggregate size of 20mm.

The works were carried out between June and December 2004, with the foamix being placed in November and the site being opened to the public in December. The recycled aggregates were found to be easy to handle and performed well in all applications. It is intended that the successful use of IBAA in the base and binder course will enable the wider use of this material in similar applications across the county in the future. This will enable a beneficial end use to be established for this very significant stream of material, and preserve reserves of primary aggregates that would otherwise be used for these applications.

The project illustrates how the use of recycled and secondary aggregates can be maximised when the client provides a clear brief, the designer actively specifies alternative materials, the contractor presses his suppliers to provide the required materials and the client and contractors site staff work together to achieve a satisfactory quality of construction.
3. LOGISTICS

The success of the natural resource management approach adopted by Hampshire County Council, Raynesway Construction Southern and Foster Yeoman would not have been possible without the provision of adequate facilities for storing and processing materials. The network of storage sites for surface dressing materials has already been discussed in Section 2.3. Two other types of facilities are essential to the success of the programme.

There are two segregation plants, at Alton and Petersfield. These are waste transfer stations, which were set up to receive arisings from highway works. The materials are sorted into categories such as concrete, asphalt, granular material and clay, so that they can be reused for the highest value applications. The materials are stockpiled until sufficient volumes are available for reuse. They are then sent to nearby recycling centres for processing to meet the appropriate specification requirements and are reused in further works.

There are also two asphalt plants, at Botley in the south of the county, near the large urban areas of Portsmouth and Southampton, and at Micheldever in the centre of the county. Foster Yeoman has set up a mobile foamix plant at the Micheldever depot that can process arisings from across the county. For example, asphalt planings from the A325 maintenance scheme at Alice Holt were sent to the Micheldever plant for processing into foamix for use elsewhere in the county. As well as recycled asphalt, the plant can handle a number of other recycled and secondary aggregates. The IBAA used at Bar End was made into foamix at the Micheldever plant.

The overall flows of material in highway maintenance works in Hampshire are illustrated in the Figure 4, which shows the materials that can be counted towards the PSA target of 40,000 tonnes per annum. There have been significant savings in construction and demolition waste sent to landfill as a result of the natural resource management approach adopted by Hampshire County Council, but the official figure has not yet been confirmed.

Figure 4. Simplified flows of material in highway maintenance works in Hampshire
4. CONCLUSIONS

The case studies illustrate how recycling and the use of recycled and secondary aggregates can be maximized in Local Authority highway maintenance and new construction works. A number of factors are critical for the success of this in Hampshire:

- There has to be a clear lead and commitment from the client. In this case it arises from Hampshire County Council’s corporate objectives, which include an aim to protect the environment through the promotion of the principles of environmental sustainability. This has been worked through in the context of highway maintenance and drives the day-to-day activities in the county.
- There has to be early involvement of all the key stakeholders, including contractors and suppliers. Hampshire County Council has enabled this through the partnership it has set up with Raynesway Construction Southern and Foster Yeoman for highway maintenance. However, it is possible to achieve this early input under other contractual arrangements.
- All parties have to be fully committed to the project and work as a team sharing common goals. In this environment innovation can flourish and new methods and materials can be developed and trialed.
- Logistical arrangements have to be made and facilities provided to enable arisings to be processed and reused in the highest value applications. In Hampshire, this involved setting up segregation plants, establishing relationships with a recycling contractor and establishing a foamix plant in the county.
- Opportunities should be sought to take advantage of locally available recycled and secondary aggregates. In Hampshire this involved use of recycled aggregates and railway track ballast in unbound applications and exploring the potential of a large material stream of IBAA for use in bound applications.
- Most applications involving recycling and the use of recycled and secondary aggregates are already covered by the UK Specification for Highway Works and design guides such as TRL Report 611 [6]. However, to take advantage of locally available materials it may be necessary to develop new methods and specifications, such as for the use of IBAA in the base and binder course at Bar End.
- Significant cost savings can be made by this approach, as well as environmental benefits of reducing consumption of primary aggregates, reducing haulage and associated fuel use and reducing energy use and CO₂ emissions by the use of cold mix asphalt processes such as foamix.

County Councils are particularly well placed to drive increased recycling because the scale of their operations is sufficiently large to give them the opportunities to pursue these options and to justify the initial effort needed to set up the systems to make the approach work in practice. In this respect Hampshire is an exemplar local authority, and the approach Hampshire has adopted could usefully be followed by other local authorities in similar positions. The effort that has been put in has more than amply been repaid by visible improvements in the sustainability of its highway operations, which in turn reflects the concerns of residents and government for a more sustainable future, and by cost savings.

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