

THE MAXIMISATION OF THE USE OF RECLAIMED ASPHALT PAVEMENT (RAP) IN THE GREEK CONSTRUCTION INDUSTRY

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The use of secondary and recycled materials in the construction industry has become an essential method to implement sustainable development in the construction industry. The use of asphalt planings, which is derived from the replacement of deteriorated road pavements, as an alternative construction material to build reclaimed asphalt pavement (RAP) converts waste into an asset. Its use contributes to the global objective of sustainable development through protection of the environment by prudent use of natural resources. Notwithstanding the benefits, the progress in using RAP has been relatively slow in many countries. Several barriers inhibit the use of RAP to a varying degree across the globe. Literature has provided evidence that the effects of these barriers are influenced by technical and non-technical environmental factors which vary from country to country. The use of RAP in the Greek construction industry is very low; this paper therefore aims at identifying the barriers inhibiting the use of RAP in Greece and to establish how they are affected by the environmental factors identified in literature. The collection of data was based on the critical appraisal of the literature and the use of structured interviews with key stakeholders in Greece. The paper made recommendations on how the level of recycling of asphalt planings could be improved in the Greek construction industry.

Keywords: recycling, reclaimed asphalt pavement, sustainability.

INTRODUCTION

The aim of this paper is to identify the barriers that inhibit the use of reclaimed asphalt pavement (RAP) in the Greek construction industry and to establish how they are affected by the environmental factors identified in literature. The research was based upon literature review and results of structured and semi-structured interviews with selected practitioners from both the public and the private sectors in Greece, done as part of an ongoing research aimed at developing a model to assist highway authorities in Greece in promoting highway construction in an optimum sustainable way.

The paper starts with a brief review of literature on the state of the art of using RAP and other road recycling techniques. It also identifies the issues and barriers that exist in other countries and discusses the advancement of knowledge about the technical and economical feasibility of recycling RAP. Raw data and information from relevant

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statistics and the interviews are presented and conclusions are drawn about the potential of using RAP in highway projects in Greece.

USING RAP AS A SUSTAINABLE CONSTRUCTION MATERIAL

The concept of sustainable development applied to construction involves a commitment to minimisation of waste, maximisation of recycling and the use of alternative materials. A way to achieve sustainable construction is by using recycled and secondary aggregates instead of primary aggregates. In road construction, asphalt pavements are traditionally built by using natural resources including aggregates and binders. These resources are limited and therefore recycling of asphalt after the road surface service-life is important for sustainable development. Recycling of asphalt pavements in its present form evolved around the mid-1970s in the USA. In some European countries reuse of reclaimed asphalt started more than 30 years ago. For countries such as the Netherlands, Germany and Denmark the major driving forces have been, the limited landfill capacity and reduction of adequate mineral resources (Schimmoller *et al.*, 2000); however there are several European countries where the level of recycling of asphalt pavements is still very low (E.A.P.A., 2008a).

According to the European Standard for Reclaimed Asphalt (EN 13108 -8) (B.S.I., 2005) reclaimed asphalt pavement (RAP) is defined as ‘asphalt reclaimed by milling of asphalt road layers, by crushing of slabs ripped up from asphalt pavements or lumps from asphalt slabs and asphalt from reject and surplus production’. The reasons for, and advantages from, using recycled aggregates, were summarised by Carswell *et al.* (2005) in the following points:

- the use of already existing materials, the elimination of disposal problems and the conservation of natural resources (quarries and land for tip sites);
- major energy savings, including those related to avoiding processing of additional virgin material and the potential for reduced haulage of materials with associated reduction in energy emissions and congestion;
- a cost reduction with respect to other conventional methods of restoring former properties of the road.

In addition to the above environmental and economic benefits, there are social benefits also derive from in-situ recycling of asphalt pavements, such as the reduction of inconvenience due to the traffic and the reduction of nuisance due to the faster completion of the project.

Road recycling techniques

There are three types of applications for bituminous planings (Winter and Henderson, 2001):

1. Low Utility applications, i.e. general fill;
2. Intermediate Utility applications, i.e. capping layer or sub-base in road construction;
3. High Utility applications, i.e. hot and cold recycled bituminous materials.

The first two are the most commonly used types; however, the third is more sophisticated and has greater sustainability performance.

The High Utility recycling processes can be divided into two major methods: hot and cold techniques (Coventry *et al.*, 1999). These can be further sub-divided into in-situ or central plant recycling (ex-situ). In-situ recycling allows the reclaimed material to be incorporated directly back into the new asphalt pavement under construction or

maintenance. Central plant recycling consists in removing the material from the site to a plant located elsewhere which recycles the reclaimed asphalt in order to re-use it either on the original project or on other projects. Ex-situ recycling can process materials from all bituminous layers, and not just wearing course (White, 1992). The different recycling techniques are summarised in Table 1.

Table 1: Road recycling techniques, source: (Coventry *et al.*, 1999)

Location	Hot	Cold
In-situ – Shallow (wearing course maintenance to a depth of around 20 mm)	Remix and/or repave	Retread
In-situ – Deep (maintenance to a depth of up to 350 mm)		Deep – in-situ
Off site	Central plant hot recycling (CPHR)	Central plant cold recycling (CPCR)

Feasibility of using RAP

Laboratory and site tests have proved that the mixes containing RAP have satisfactory performance and in some cases even better than the ones using only virgin materials. From the work carried out by Byrne (2005) the conclusions concerning the performance of RAP mixes were that the optimum percentage of RAP in the mixes for the basecourse was 30%, for the roadbase 15% and for the wearing course 7.5%. Widyatmoko (2008) laboratory assessment of the feasibility of utilising RAP in wearing course and base course found that the overall performance level of the specimens containing RAP was at least similar to, or better than, that of conventional asphalt materials. Carswell *et al.* (2005) stress the need to recycle thin surfacing systems as part of efforts to promote sustainability within road construction because of the quantity of relatively scarce aggregates with high skid-resistance properties within the layer. The findings of their research demonstrated that 10% RAP can be easily added to new materials without affecting grading.

Apart of the unquestionable environmental benefits of using RAP, there must be economic benefits for the industry to use it. Several studies have proved the cost effectiveness and the economic feasibility of using RAP in highway construction and maintenance. A cost benefit analysis carried out by Byrne (2005) supported the viability of using RAP in highway maintenance. The savings were calculated and offset against the cost of modifying the existing plant. There were also financial benefits as a result of the reduced pavement thickness.

Other key issues that must be considered in establishing the feasibility of using RAP are the type of asphalt plant and method of adding the RAP because both have an influence on the levels of RAP that can be added to a new surface-mix. For batch mix plants the potential to add RAP varies from 5% to 50% depending upon the method of RAP addition to the mix. For continuous drum mix plants, the process lends itself to RAP addition and levels of 25-40% were claimed by the manufacturers. In the USA this system has been developed further to a double barrel where additions of 50-60% were claimed possible by the manufacturers.

Overall, it is essential that the whole-life value of a project is evaluated before it is decided whether is cost effective to use RAP or not. Reid and Chandler (2001) stress that when comparing recycling with conventional treatments, it is important to ensure that a fair comparison is being made. Statistics and research on the technical and economic aspects on the subject prove that there is considerable potentiality in using RAP as an alternative material in highway maintenance. The potentiality varies

depending on: the type of asphalt plant, the type of road pavement to be constructed and method of adding the RAP. It remains to find the appropriate model and methodology for each country not only to maximise the recycling of RAP, but also to increase the quantities recycled in intermediate and high utility applications.

Issues and barriers

Notwithstanding the benefits, the progress in using RAP in highway maintenance has been relatively slow. Barriers in using RAP have been already identified and many countries endeavour to overcome them. Most of these barriers are non-technical, and mainly consist of providing reassurance to clients and regulators and ensuring that materials are handled properly in line with quality protocols (W.R.A.P., 2005).

In the UK, the Transport Research Laboratory (TRL) published a guidance document on increasing the amount of recycling and use of alternative materials in transport infrastructure renewal works (Reid and Chandler, 2001). The report identified ten main issues that were potential barriers to the use of recycled and secondary aggregates, provided a summarised guidance and recommended actions for the main groups of stakeholders. A later report of the TRL (Reid *et al.*, 2006) identified the progress that had been done so far on these issues and recommended further actions. E.A.P.A. (2008a) also provided further guidance and recommendations for governments and public authorities on these issues concerning the use of RAP.

The issues and barriers and their respective guidance and recommendations are summarised in the following sub-sections:

Specifications

A reason given for the limited amount of recycling was that existing specifications did not encourage the use of new recycling methods or emerging alternative materials (Reid and Chandler, 2001). The authorities responsible for specifications have to be sure that the recycled materials and methods will give satisfactory performance. This normally requires trials under controlled conditions to build up a body of experience on the use of the materials and methods, which takes time to accumulate. The British Standards Institution adopted the new European Standard EN 13108-8:2005 from the 1st of January 2008 (B.S.I., 2005). Therefore, specifications are not a barrier to the use of RAP anymore in the UK.

Test methods

Harmonised European Standards for aggregates, introduced in the UK in 2004, cover all aggregates, whatever their origin, and require the same tests to be carried out on them (Reid *et al.*, 2006, E.A.P.A., 2008a). Therefore test methods are not a barrier to the use of RAP.

Reliability and quality control

One of the perceived obstacles with the use of alternative materials has been their variability and the presence of deleterious components. The perception of recycled and secondary aggregates as highly variable and of low quality has changed fairly in the UK, particularly with public sector clients such as local authorities, as a result of government initiatives on sustainability and increased experience of their satisfactory use (Reid *et al.*, 2006). These issues have been addressed by introducing quality control systems to demonstrate that the materials have been processed to remove impurities and that the properties lie in a defined band which is suitable for the proposed application.

Environmental concerns

According to the European Standard EN 13108-8 (B.S.I., 2005), reclaimed asphalt may not contain tar. Most contaminants are unlikely to be a concern since RAP is used in cement bound or bitumen bound form, as the exposure to percolating water is greatly reduced. The leaching behaviour of asphalt containing RAP is not different from asphalt produced with virgin materials. Asphalt with or without RAP does meet the most onerous requirements in Europe with regard to leaching (E.A.P.A., 2008a).

Waste regulations including waste management licensing

A major issue that affects the use of RAP derives from the definition of waste based on the Article 1(1)(a) of the Waste Framework Directive (2006/12/EC), (EU, 2006) that 'waste are materials for which the generator has no further use for own purpose of production, transformation or consumption, and which he discards or is required to discard'. Apart of the legal debate about the interpretation of "discard", a further complication is that material, which has been subject to a specialist recovery operation, may no longer be classified as a waste but as a product (Reid and Chandler, 2001). As it is stressed by Reid *et al.* (2006), the subject of waste management regulation and its interaction with the use of recycled aggregates remains a complex one, and further developments may occur in the future.

Conditions of contract

The forms of contract under which road maintenance works are carried out can have a significant influence on the extent of recycling and the use of RAP. Reid *et al.* (2006) concluded that although partnering is a good way to encourage recycling, it is not essential. Recycling can be carried out under most forms of contracts. What is essential is a clear lead from the client and commitment from all parties.

Planning

The planning system interacts with recycling because planning permission is normally required for sites for the production of recycled and secondary aggregates. Reid *et al.* (2006) argue that planning permissions will continue to be an issue of critical importance for the use of recycled and secondary aggregates; however, the planning system, as well as being a barrier to recycling, can also act as an enabling agent.

Supply and demand

Matching supply and demand remains one of the most difficult aspects of recycling, particularly ensuring a continuing supply of high quality materials. Reid *et al.* (2006) explain how partnering is one way of ensuring that supply and demand issues are addressed. The provision of adequate sites, not only for reprocessing materials but also for storing them, is important for recycling in activities such as highway maintenance, where there is a continuous supply of arisings from different sites that require to be processed and are then used on other sites. This can be a particular problem in urban areas, where it can be difficult to provide sites with sufficient storage space because of high prices and pressure of land use.

Economics

The economic factors are crucial for the use of RAP. Its use will be limited if it is, or is perceived to be, more expensive than primary aggregates, however sustainable its use might be (Reid *et al.*, 2006). The UK government has acted to adjust the economic balance in favour of recycling by means of the landfill tax and the aggregates levy. Reid and Chandler (2001) underpin that costing of the projects should be on a global rather than on a individual basis, because the surplus material generated on one project can be utilised on the next. That way the savings can be significant.

Lack of awareness

The main barrier to recycling is widely cited as conservatism and a lack of awareness among highway engineers (W.R.A.P., 2004). There has been considerable progress in addressing the problem of lack of information in the UK, especially among construction professionals and major clients. Where progress has been less marked is in the SME (Small and Middle Enterprises) sector.

THE USE OF RAP IN GREEK INDUSTRY

Current situation

After a major change in the local administration in Greece in 2010, the existing municipalities were unified into larger organisations becoming highway authorities for the local road network and also planning authorities. Managers and highway engineers have to face new challenges and responsibilities concerning road construction and maintenance, construction, demolition and excavation (CDandE) waste management and recycling under the recent organisational change.

Moussiopoulos *et al.* (2007) suggests that Greece is not a typical “recycling country”, especially in regards to the recycling of CDandE waste. Recycling has not yet been established as a waste management practice and uncontrolled dumping of CDandE waste is the most common practice.

Figures from statistics of the European Asphalt Pavement Association (E.A.P.A., 2008b) gave a picture about the Greek road construction industry. Some basic conclusions drawn from these figures were as follows:

- There was an increasing trend in the production of Hot Mix Asphalt (HMA) in Greece during the years 1993-2008.
- There was no production of Mastic Asphalt, Porous Asphalt, Cold Bituminous Mixes, Stone Mastic Asphalt or any other special type of bitumen mix, except of some small quantities of Asphalt Concrete for very thin layers (BBTM).
- There was no production of Warm Mix Asphalt.
- Greece is the only country from the ones referred in the report with no figures for any type of recycling.
- The owners of Asphalt Plants are also contractors of highway projects. The relatively high figure of 250 implies that the majority are SMEs.
- There were no Plants fit for hot recycling.
- Some of these Plants were operated and owned by the road administrations and/or municipalities.

Following the above conclusions, a series of selected structured and semi-structured interviews were undertaken in April 2010 in the city of Thessaloniki, in order to explore the situation in Greece about the potential of using RAP, the perception of the barriers that inhibit its use and general points of view from different perspectives. There were interviews with eight selected professionals involved in highway maintenance: four from the Municipality of Thessaloniki (i.e.: the head of the Department of Highway Construction, the manager of the Division of Implementation, a former supervisor of the asphalt plant of the Municipality, and the current supervisor); the chairman of a developmental agency, who was also a councillor in a neighbouring municipality; the owner of an asphalt plant, who was also acting as a contractor for road maintenance projects; a supervisor of a recycling plant; and a professor of the University of Thessaloniki, who is a specialist in asphalt mixtures.

During the first part of the interview the interviewees were asked to answer on specific questions about the use of RAP: e.g.: how their organisation responded so far; what was the potentiality of recycling; was there adequate infrastructure; and also to give their general point of view. The second part was about filling out an opinion questionnaire based on a rating scale of importance about the impact of the ten major issues and barriers identified previously on recycling. Although the above results were based on a relatively small sample, some primary conclusions could be extracted. According to the answers, the prominent issues were the lack of Greek specifications and the lack of awareness. Other significant issues were the economic factors.

The Issues and Barriers in using RAP in Greece

The recently conducted major organisational change resulting from the merging smaller Municipalities clearly gives the new bigger Municipalities the opportunity to adopt a more sustainable model of highway maintenance. In public sector agencies, Crawford *et al.* (2003) have revealed the experience from Australia the difficulties that can arise when attempting to apply 'standard' project management practices in complex, multi-stakeholder environments, especially where organisational change projects are involved. Their findings have clearly demonstrated that successful implementation of strategic change by projects requires a flexible process grounded in shared professional experience. Systems thinking in general and particularly Soft Systems Methodology (SSM) (Checkland and Scholes, 1996, Checkland, 1999) were found to offer a rich source of theoretical and model-based contributions to inform development of project management practice in these contexts. SSM provides a technique for "seeing" the proposed scheme from a number of perspectives: the councillors; local residents; contractors; plant owners; practitioners; experts; etc. Use of SSM brings to the fore the range of likely responses to, say, a public consultation and provided a framework for this research.

According to the findings of this research, the main issues and barriers that have to be overcome in order to maximise the use of RAP in the Greek construction industry can be categorised into legal, economic, social and technical issues:

Legal issues

The legal framework for waste recovery in Greece began to take shape in 2001 with the adoption of the Law 2939/2001. With this Law, Greece transposed the Directive 94/62/EC on packaging and packaging waste. The principal objective of this Law was, 'the establishment of measures that for the management of packaging are targeted at reuse or recovery of their waste'. In June 2010, the Law 2939/2001 was superseded by the new Law 3854/2010 which incorporated the CDandE waste management. The liability of the CDandE waste producers for their obligations under the Law was covered by the Joint Ministerial Decision (JMD) 36259/1757/E103 signed on the 23 August 2010. This JMD was meant to act as a disincentive to the dumping of materials and in favour of recycling. It also set targets for reusing, recycling and reclaiming of CDandE waste.

The gaps in the legal framework, the inconsistency of the governmental policy and the lack of specifications were identified from the interviewees as the major barriers that inhibit the use of RAP. However, the interviews were conducted prior to the signing of the JMD 36259/1757/E103 which seems to cover some of these gaps and since then some asphalt plants have started to use RAP.

Economic issues

The price/performance ratio of asphalt containing RAP must be at least comparable with a traditional material. The market of RAP is influenced by the availability and price of primary aggregates, the cost of landfill and the transport costs (E.A.P.A., 2008a). In Greece there is high availability of primary lime stone aggregates in relatively low prices. On the other hand, the existing landfills cannot accept asphalt planings. This situation led to uncontrollable dumping.

Social issues

An issue that came out after the interview with the owner of the recycled plant was the strong opposition of the local community against the operation of that plant, which caused a year of delay. The higher levels of dust and noise associated with recycling plants can cause strong NIMBY (Not in My Back Yard) syndromes. Clearly, there is a need to improve the technology to mitigate the noise and dust constraints, which should be followed by effective sensitisation of locals of the benefits of these approaches to sustainable development.

Technical issues

There were concerns about the existing infrastructure, the available recycling techniques and the technological feasibility of using RAP, expressed mainly on behalf of the public sector professionals but evidently, these issues had to do rather with the lack of awareness than the lack of available technological solutions and therefore they should not be addressed as technical issues.

Recommendations and actions for overcoming the barriers

Developments over recent years have encouraged an increasing number of local authorities in the UK to use recycled content in highways maintenance. The introduction of the landfill tax and the aggregates levy, new recycling techniques, new technical specifications and standards encourage recycling. In general terms, if Greece is to catch up with UK, similar actions must be taken by the Greek Government. The highway authorities in Greece have to set strategic objectives and procurement policy which show commitment to the principles of sustainable construction generally and particularly, they have to incorporate into their strategy targets for recycling CDandE waste, such as RAP. These targets will have to contribute to the relevant national targets set by the government. In order to achieve this on the strategic level, strategic/corporate objectives about reducing waste and maximising recycling in highway works have to be created, stated in tender documents and corresponding key performance indicators (KPIs) have to be used for contract management and evaluation of the results for alignment with the strategic objectives. The procurement strategy should provide positive conditions for delivering the strategic objectives of the authority and encourage contractors and suppliers to invest in plant and suitably trained staff; thus, longer-term contract routes are needed, preferably with a partnering arrangement. These procurement routes will facilitate the increased use of recycled materials in general.

Some of the critical actions for the success of the use of RAP in Greece are:

- There has to be a clear lead and commitment from the client and coordination with other recycling initiatives. This arises from the corporate objectives.
- There has to be early involvement of all key stakeholders, including contractors and suppliers. This can be enabled through a partnering arrangement.

- Logistical arrangements have to be made, e.g. storage depots and recycling plant. This could involve segregation plants and establishing relationships with a recycling contractor according to the Law 3854/2010. The possibility of operating a cold recycling plant has also to be examined.
- Modern specifications, design guides and quality protocols should be used. Where there are no Greek specifications, the EN specifications should be used.
- To stimulate recycling, contracts should encourage recycling and the use of recycled materials. Legislative and contractual demands for recycling can provide the drivers for the industry to invest in asphalt plants that can accommodate RAP in their mixes.

The enlarged local government organisations have greater power to pursue sustainable strategies such as the use of RAP. The partnering arrangements that many local authorities in the UK employ for highway maintenance contracts could be used as guidance for the new municipalities in Greece. The maximisation of using RAP in highway construction and maintenance in Greece can be achieved through a clear national waste management strategy. This has to be specified with the relevant legislation and a consistent policy. The government has also to encourage sustainable procurement strategies. The highway authorities, both governmental agencies and local authorities will have to set corporate strategies and procurement policies in line with the national strategy in order to contribute to the national targets on recycling CDandE waste and eventually turning waste such as asphalt planings into valuable asset by recycling them back to asphalt pavements.

CONCLUSIONS

The aim of this research has been to identify the barriers inhibiting the use of RAP in the Greek construction industry and to establish how they are affected by the generic environmental factors identified in literature. In order to achieve this aim it has been necessary to review and analyse literature on the subject and obtain information from professionals in key positions in the highway construction industry using qualitative research techniques. The outcome of this initial research is the background information that will form the basis for a further research aimed at developing a model to assist the existing and newly created municipalities to promote highway construction and maintenance in a sustainable manner.

The literature review identified the recycling techniques that are currently used worldwide in road construction and maintenance. It also identified the technical and economical feasibility and the general issues and barriers that inhibit the use of RAP in other countries. These issues were discussed with practitioners from both the public and private sectors through structured and semi-structured interviews in order to identify the key issues to be considered as the main barriers in Greece.

According to the research findings, in order to maximise the use of RAP in Greece the highway authorities have to set strategic objectives strongly connected with the national targets for recycling of CDandE waste and particularly RAP. Their procurement policy will have to follow this strategy. During the bidding and the construction processes the achievement must be evaluated against the targets and the KPIs. Procurement routes that include long-term relationships and continuous improvement targets need to be encouraged, as these will facilitate the increased use of recycled materials. This policy should form the linkage between the strategic objectives of the authority and the materials, practices and processes used in an ongoing way on the highway construction.

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