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Study on Road Construction and Rehabilitation

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ABSTRACT

This paper explains the cold in-situ re-use process and examines its benefits compared to other methods of rehabilitating and upgrading road pavements. Also covered are the engineering properties that can be expected when road building materials are treated with the various stabilizing agents. Recommendations are given for the choice of the most cost-effective stabilizing agent depending upon a number of variables.

APPLICATIONS OF COLD IN-SITU RE-USE

A wide variety of applications of the cold in place recycling process is possible. In broad terms, road pavements can be recycled to depths of as little as 100mm, up to depths in excess of 300mm. Three typical variations are given below, but the process is by no means limited to these specific applications.

Upgrading of unsurfaced roads Unsurfaced roads cause problems during the dry season when vehicles moving along them cause clouds of dust during the dry season, while in the wet season they become unpleasantly muddy, and dangerously slippery. Maintenance of the gravel wearing course is on-going, with regular grading being required to maintain the roads' riding quality.

From time to time it is necessary to replenish the gravel wearing course, using borrow pits located along the routes. Besides the cost of the excavating, loading, hauling and placing the gravel on a regular basis, there is an adverse impact on the environment, as with time the borrow pits grow bigger and bigger, becoming eyesores and causing soil erosion.

The cold in place recycling process offers an economical means of upgrading these roads. By strengthening them using this process, and providing them with a durable blacktopped surface, the dust and mud problems are eliminated. Besides this, studies carried out in many countries show that economic benefits can be expected in the longer term, due to a substantial reduction in maintenance costs.

The upgrading of un surfaced, lightly trafficked rural and village roads can be carried out very cost-effectively by recycling 10cm to 12cm of the existing gravel wearing Cold in place recycling: A relevant process for road rehabilitation and upgrading Lewis AJN et al - 7 - CAPSA'99 course with either bitumen emulsion or foamed bitumen, and then applying a thin surface treatment such as a chip seal or bituminous slurry seal.

Recycling thin asphalt pavement layers

Pavements where the distress is caused by aging of the asphalt layers can be effectively rehabilitated by recycling a relatively thin layer. This type of distress can be identified by cracking and surface degradation that occurs without severe rutting.

The minimum depth of this type of recycling is usually around 80mm and the recycling is carried out with the addition of bitumen emulsion, followed by the application of a hot-mix asphalt surfacing.

In order to improve the gradation of the milled asphalt, so as to ensure good compaction, it is often necessary to spread a layer of crusher dust onto the surface of the existing pavement prior to recycling so that it mixes with the asphalt during the recycling process.

Structural strengthening by deep recycling
Modern recycling machines are capable of recycling tough pavements consisting of thick layers of hot-mixed asphalt. The complete process is normally carried out in a single pass, significantly cutting construction time and reducing traffic congestion. Very little new material, if any, has to be brought in; the process recycles and strengthens the material in the pavement of the existing road in a single operation. The thick layer that can be recycled using modern recycling machines means that it is possible not only to rectify superficial asphalt aging problems described above, but is also to be able to address weaknesses that occur deeper in the pavement. These can normally be identified by the presence of severe deformation and rutting, which occur together with cracking and potholing.

Recycled layer thicknesses in excess of 300mm, using cement alone, or combinations of cement and bitumen emulsion or foamed bitumen, are commonplace. Obviously the use of heavy vibratory rollers is essential to ensure proper compaction of thick recycled layers. Vibratory rollers with a static mass of at least 17 tons are recommended when thick layers are recycled. The roller should be equipped with variable amplitude and frequency control; initial passes should be carried out with a high amplitude/low frequency setting while final compaction should be achieved by carrying out further passes with a high frequency/low amplitude setting.
In the case of very heavily trafficked roads it is normally necessary to strength the pavement further by paving one or more layers of hot-mixed asphalt on top of the recycled layer.

CHOICE OF STABILISING AGENTS
The principal reasons for the treatment of recycled materials with stabilizing agents are: ·
To improve strength and hence the structural capacity of the pavement without the need to import additional material to increase pavement thickness; Cold in place recycling: A relevant process for road rehabilitation and upgrading to enhance durability so as to ensure the long-term performance of the pavement; and To improve resistance to moisture.

The choice of the most effective stabilizing agent for a particular application depends on several factors, the principals of which are: Price. The relative costs of the stabilizing agent; Availability. The ease with which the stabilizing agent can be resourced; Acceptability. Certain stabilizing agents are often more acceptable locally. The local experience that has been gained with a particular product often has a large influence as regards its acceptability; and Material type. Different stabilizing agents are more effective with certain types of aggregate than others.
In the following tables the advantages and disadvantages of the various stabilising agents covered previously in this paper are compared:

CEMENT:

ADVANTAGES	DISADVANTAGES
Easy to apply as a powder or slurry. Normally less expensive than bitumen or emulsion. Improves material's resistance to moisture.	Shrinkage cracking can be a problem. Cracking can, however, be substantially reduced by careful mix design – keeping cement content as low as possible and keeping the moisture content on the low side.

BITUMEN EMULSION:

ADVANTAGES	DISADVANTAGES
Easy to apply - the emulsion is sprayed directly into the recycler's mixing chamber. Emulsion treatment produces a flexible, fatigue resistant layer that is not prone to cracking. Once fully cured, emulsion treated material is resistant to the ingress of moisture.	Usually more expensive than cement or foamed bitumen. Emulsion must be formulated to be compatible with the recycled material, with a suitable "break" time to enable proper mixing and compaction. Emulsion treatment can be a problem when in situ moisture contents are high – the addition of the emulsion will push the moisture content well above optimum resulting in heaving of the recycled layer.

COMBINATION OF BITUMEN EMULSION AND CEMENT:

ADVANTAGES	DISADVANTAGES
The cement can be injected as a slurry together with the emulsion into the recycler's mixing chamber. Alternatively it can be applied as a powder, and the emulsion sprayed by itself into the mixing chamber. The cement/emulsion combination produces higher strengths, cures quicker, and is more resistant to water than emulsion alone. If properly designed it is not prone to shrinkage cracking.	More expensive than either cement or emulsion alone. Also more expensive than foamed bitumen. The emulsion must be formulated to have a suitable "break" time when it is mixed together with the recycled material and the cement. Premature breaking of the emulsion when it comes into contact with the cement will cause problems with unsatisfactory mixing and "balling" - correct formulation of the emulsion is essential.

FOAMED BITUMEN:

ADVANTAGES	DISADVANTAGES
Easy application - the foamed bitumen is sprayed directly into the recycler's mixing chamber. Foamed bitumen treated material forms a flexible layer with good fatigue properties that is not prone to shrinkage cracking. It is resistant to the ingress of water. Usually less	Requires a supply of hot (180o C) bitumen. For foamed bitumen treatment, the material should have between 5% and 15% passing the 75 micron sieve size. If this is not the case, the grading should be rectified by importing and spreading a layer of suitably graded

expensive than bitumen emulsion or a combination of emulsion and cement. Additional water is not added to the recycled material, as is the case when emulsion is used. Rapid strength gain - the road can be trafficked immediately after compaction is complete.	aggregate over the layer to be recycled.

FOAMED BITUMEN AND CEMENT:

ADVANTAGES	DISADVANTAGES
When a low percentage of cement (1% to 2%) is used in combination with foamed bitumen, it improves the strength of the recycled material significantly. In addition, material treated with this combination will have an even higher resistance to water compared to foamed bitumen alone. Less expensive than a combination of bitumen emulsion and cement.	It has the same bitumen temperature and aggregate grading requirements as foamed bitumen. It is more expensive than foamed bitumen alone.

TYPICAL PROPERTIES OF STABILISED MATERIALS

Typical properties of the materials treated with the five varieties/combinations of stabilizing agents discussed in the previous tables are summarized in the table below. These properties are based on tests carried out on well-graded crushed aggregates. It will be noted that some tests are not applicable to all stabilizer types, for instance unconfined compressive strength testing is not considered applicable for evaluating bituminous treated materials.

Except in the case of cement stabilized materials, these properties are based on tests carried out on Marshall Specimens compacted by applying 75 blows of a standard Marshall hammer per face. Specimens are cured by leaving the mples in their moulds for 24 hours at ambient temperature before extracting and then curing them in a forced draft oven for 72 hours at 60⁰ C. All testing is carried out at a temperature 25⁰C.

The unconfined compressive strength and indirect tensile strength testing for cement stabilized materials is carried out on cylindrical specimens (150mm diameter x 125mm length), compacted to 100% Mod. AASHTO density and damp cured at an elevated temperature of 70⁰ C to 75⁰ C for 24 hours.

CONCLUSIONS

The development of powerful, efficient, recycling machines has made it possible for a variety of pavement recycling applications to be considered, ranging from unsurfaced, lightly trafficked rural roads to busy highways and city streets.

The process allows a wide selection of stabilizing agents to be employed to strengthen the pavement without having to import additional material to thicken it, as well as to enhance durability and improve its resistance to moisture.

Cost savings in excess of 20% are normally achieved, compared to the use of other more conventional methods for rehabilitating and upgrading roads. There is no doubt that the rapid growth of cold in place recycling throughout the world is evidence of the cost-effectiveness of this process.

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