Procedia Engineering

Volume 143, 2016, Pages 26–33

Advances in Transportation Geotechnics 3 . The 3rd International Conference on Transportation Geotechnics (ICTG 2016)

Hydrophobic Polymer Additive for Stabilization of Aggregates in Local Government Roads

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Abstract

In Australia, the road network is extensive and consists chiefly of unbound granular material overlain by a thin layer of asphalt. With trafficking and adverse environmental conditions, roads may become unserviceable quite quickly. So there is a need to re-condition granular roads through in-situ recycling to achieve the sustainability goals of re-use of materials and reduction of greenhouse gases by minimizing transport of materials. Bitumen, in the form of either cold emulsion or foamed bitumen, has been used for this purpose quite successfully, but there exist situations where it is too expensive for the road authority, given the nature of the road, or bitumen may not be suitable if plastic fines exist in the pavement material. Environmental conditions such as poor drainage of primarily flat land may also have local government looking for alternative treatments. Hydrophobic dry powder polymers (DPP) mixed with lime can serve to provide an improved road base quickly at relatively low cost. Unfortunately the literature on polymer additives in aggregates is quite limited and so research has commenced with the aid of local government agencies in Adelaide, South Australia. In this paper a field trial and laboratory investigation are presented on the comparative engineering properties of treated and untreated aggregates from a road trial. Testing has included hydraulic conductivity, large column capillary rise tests and repeated loading triaxial testing. Performance of the road sections will be monitored in the coming years through La Croix Deflectograph testing.

Keywords: Dry powder polymer, resilient modulus, permanent strain, La Croix Deflectograph

1 Introduction

For many years the recycling of road material has been practised on a relatively small scale. In Australia, due to the increasing shortage of suitable landfill sites and the spiralling cost of tipping fees at landfills, considerable effort is being put into utilizing waste products, such as recycled concrete aggregate and masonry [1] and in-situ recycling of road aggregate. The degraded in-situ pavement material is marginal and therefore requires some improvement with additives before placing it again.

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Selection and peer-review under responsibility of the Scientific Programme Committee of ICTG 2016

doi:10.1016/j.proeng.2016.06.004

The variability of the in-situ material may affect the reliability of the prediction of its in-service performance. Additives used in recycling projects are primarily used to modify aggregates; the soil is mixed with another substance (a stabilizer or additive) to improve one of its properties, such as strength or moisture susceptibility [2].

1.1 Stabilization

Ideally, aggregates used in road pavements need acceptable workability, strength, durability, volume stability, wear resistance, and water resistance [3] to withstand the local conditions. Occasionally, materials with these properties can be sourced from the degraded aggregates on site, after the addition of additives or stabilizers to improve the factors that led to the failures (e.g. inadequate strength or poor water resistance).

The stabilization of material can be performed by a number of different methods, such as re-compaction, drainage, improved grading by adding missing particle sizes, or addition of binders or moisture inhibitors (stabilizers). The choice of the stabilizer depends on the reason for stabilization. Stabilizers can include cement, bitumen, other granular material and polymers [4]. With the low level of bitumen additive which is generally used [5], only polymers provide significant resistance to moisture ingress. Moisture is a major contributing factor to the distress of roads. Graded aggregates and subgrades can lose much of their strength and stiffness if they absorb excessive moisture [6].

1.2 Dry Powdered Polymers (DPP)

Dry Powdered Polymers consists of a hydrophobic wax coating on some form of carrier, such as flyash and may include lime. Rodway [7] suggested that polymer stabilization is ideal for treatment of poor quality, clayey gravel that loses considerable strength when it is wet up while in service, since the stabilizer acts to waterproof the stabilized aggregate. Austroads [8] suggests that polymers are also applicable to sandy aggregates of little or no plasticity. A DPP manufacturer whose product has been used throughout Australia is Polyroad. Lime is applied with the DPP according to the plasticity of the fines. The primary objective of the polymer treatment is water resistance as the treated material becomes hydrophobic. With this water resistance, the strength and flexibility of the base course of the road can be maintained, although it may not be at a particularly high level.

The Polyroad approach to selecting the stabilizing product is, if the Plastic Index of the fines (PI) is less than 12%, use Polyroad PR.21L. The percent of DPP in PR.21L is 1.5% by mass; 2 parts polymer to 1 part lime. However, if the PI is greater than 12, PR.11L is preferred (DPP 1% by mass, 1 part polymer to 1 part lime). A capillary rise test, similar to that suggested by Standards Australia [9] is used to evaluate the suitability of the treatment. Specimens of the treated material, are cured after preparing at 100% Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) for Modified Proctor compaction. Specimens are tested after drying back to 80% and 60% of OMC. A maximum capillary rise of 25% over a 24 hour period is acceptable, without any swelling.

Poli from the South Australian road authority, DPTI, [10] evaluated material treated with PolyRoad PR21L. The DPP and lime was added to a blended aggregate of 75% stream gravel and 25% base gravel. Tests reported by Poli included plasticity index, grading, water absorption, swell, capillary rise and repeated load triaxial testing or RLTT. The RLTT was conducted to the Austroad [11] RLTT protocol on stabilized soil prepared at different moisture states and compacted to 98% of MDD (Modified Proctor compaction). Poli [10] concluded that the addition of dry powder polymer with lime was beneficial. Permanent strain was reduced and the resilient modulus of the Polyroad treated material was not sensitive to the initial moisture content of prepared specimens.

In another study, Wightwick [12] investigated the suction developed in his DPP treated samples as the moisture content changed, through determination of soil water characteristic curves (or SWCC) The hydrophobic nature of treated aggregates could be seen in the shifts of the SWCC between the non-stabilized and stabilized materials, which should provide benefits of strength and stiffness.