

Pavement Structure for Low-capacity Roads with Different Recycled Materials Utilization

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Summary

In road construction various recycling techniques are well-known and long-term developed worldwide. Commonly recyclable materials, known as reclaimed asphalt pavement, are used. These materials are gained during the pavement rehabilitation process. In some cases further secondary granular materials are used, e.g. masonry or concrete recyclable material (MRM or CRM) coming from demolition works. Utilization of recyclable materials in pavement structure is specified in Czech Republic by technical requirements, focusing above all on recycled asphalt pavement (RAP), lesser then on other granular materials especially for the sub-base layers. The trend is to use recyclable materials in one structural layer of the pavement.

Authors are introducing experimental design of an alternative pavement structure, where the recyclable materials are used in protection layer, sub-base and/or binder course all at once, eventually in wearing course as well. The main techniques are: MRM reinforced by synthetic fibres and cold recycling technique with RAP, bituminous emulsion (or foam bitumen) and cement as combined binder. Pavement rehabilitation techniques based on cold processes are from the environmental and economic point of view without any doubt of benefit. The paper summarizes the present laboratory experience with these techniques and comments results of experimental tests of odd structural materials and the pavement structure with both materials. Strength properties as well as stiffness and cohesion of two layers made by different technique is introduced and discussed.

Keywords: masonry recyclable material, cold recycling mix, strength characteristics, shear test.

1. Introduction

Application of recycled materials in the building industry is essential for sustainable development of a country. In the Czech Republic, the use of primary sources and materials is becoming unbearable from both the economical and environmental perspective and so there is an effort to seek the possibility in re-use of those building materials whose live-span has been exceeded. At present, the mostly recycled materials in the Czech Republic come from the recycled waste of bricks, concrete, asphalt, unsorted construction waste, various types of aggregates and soil. All these materials can be grouped in so called recycled aggregates (RA).

In case of concrete or masonry waste the combination of recycled construction waste, fibres and suitable binder creates an unusual fibre concrete; new composite, which offers a wide field of possible use in construction industry. Within the scope of the experimental measurements selected mechanical and physical characteristics will be discussed later in this paper. These characteristics are crucial for intended applications, while the amount of tests conducted allows statistical

evaluation of the obtained results. In case of reclaimed asphalt pavement several recycling techniques are used for more than three decades. Originally RAP was introduced in limited amount to a new asphalt mix later the hot in-place recycling has been developed commonly with two most important cold recycling techniques using bituminous emulsion or foamed bitumen as a binder. These bituminous binders are often combined with hydraulic binders like cement or lime hydrated to improve the rigidity and bearing capacity of final mix.

2. Experimental program

Basic mechanical-physical characteristics of recycled concretes were measured and compared with characteristics of normal concretes. A series of laboratory trials were carried out to establish the practical viability of using (C&DW) material as replacement for virgin aggregates. In a mixture proportion the amount of cement was reduced from the calculated content to the minimum value set in the standard ČSN EN 206-1 for Portland fly-ash cement CEM II/B – V 32,5R. Recycled aggregates consisted in 100 % content of natural aggregates. Unclean brick and concrete rubble were shattered in recycling company. To improve the performance of the concrete polypropylene fibres (FORTA FERRO) have been used too. In order to minimize cost and optimize dosage of fibres portion of 0,5 % and 1% of volume content has been determined and assessed.

For cold recycling mixes the experimental work has been divided into several sets of tested mixes, with bituminous emulsion and combinations of reclaimed material and cement content. Simultaneously in some mixes reclaimed asphalt has been combined with aggregates which have been classified by the producers as waste material (quarry Košťálov) or waste filler. In the case of waste filler which constitutes a by-product of crushed aggregate production, the original mineral (rhyolite) has greenish dark grey colour and is very fine-grained <0.09 mm, compact with black chlorite accumulations.

Specimens produced from cement with masonry recyclable material as well as from cold recycling asphalt mixes were at first tested separately to gain sufficient experimental data on the behaviour of these materials. In the second part of the research special twin-layer specimens have been prepared consisting of MRM concrete with total thickness about 80 mm and cold recycling asphalt mix with average thickness 45-50 mm. For the preparation of these joined specimens which simulated simple two layer pavement system primarily block concrete specimens (300x150x100 mm) have been produced from which cylindrical core specimens were drilled. The upper base of these core specimens was furnished with tack coat (special emulsion has been used) to secure sufficient adhesion between concrete and cold recycling mix. The specimens were then inserted in gyratory compactor moulds for preparing the second layer. For compaction gyratory compactor has been identified as the most suitable equipment applying 30 gyrations with static load of 600 kPa.

3. Conclusions

Based on a large series of acquired experimental results on different characteristics of the tested material, it can be judged on the behaviour of both composites. Certain differences were found between the samples with recycled masonry aggregate and recycled concrete aggregate, the samples with different amount of fibres and even between the particular experimental methods. In case of cold recycling asphalt mixes a positive effect of waste filler or small-sized aggregates could be confirmed. The new findings from the experiments with recycled aggregated will be used for definition of the not yet existing standards and provisions related to recycling of structures in the Czech Republic. Results are presented from the laboratory test results showing how C&DW materials can be recycled and experiment testify that utilization of recycled concrete with fibres or cold recycling asphalt in every-day life is possible and more it is useful without special admixtures. However, the use of recycled aggregate is possible only for that with acceptable grading in the range of 0-32 mm on account of a technology simplification. Suitable technology of construction material recycling could be considered an easy alternative for future applications. The recycling of this waste will reduce environmental damages caused by incorrect disposal, extend the useful life of landfills and preserve finite natural resources. The combination of both described techniques can be in addition an interesting and economic solution for low-capacity roads.