Pilot application of modified asphalt mixture with End of Life Tires (ELTs) and Reclaimed Asphalt Pavement (RAP)

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Abstract
The accumulation of huge quantities of waste tires is an environmental concern worldwide. There have been several studies on recycling of end-of-life tires, since these cannot be reused and are no longer accepted in landfills (Directive EU 31/99). Used tires are usually recycled for material recovery or used as tire-derived fuel (TDF) for energy recovery due to their high calorific value. Nevertheless, there is one application of End of Life Tires (ELTs) that is less common in Greece and this is the modification of asphalt mixture by crumb rubber from mechanical granulation of ELTs, which improves road properties.

This study, aims to investigate the properties of a pilot's demonstration road pavement such as skid resistance, rutting (wheel bolts) and noising. During the pilot demonstration, pavements with modified asphalt and crumb tires and asphalt mixtures with participation of Reclaimed Asphalt Pavement (in percentage 30% and 50 %) and of ELTs crumb were applied, to substitute the coarse asphalt mixture. The pilot application of road pavement was conducted in Aspropyrgos, Greece. The results were compared to the conventional asphalt mixture, the modified rubber mixture and the modified rubber with different RAP percentages and they are very promising.

The assessment of the environmental impact was investigated under the following scenarios: a) conventional asphalt mixture, b) modified asphalt and crumb tires mixture, c) modified asphalt, crumb tires and 30% RAP mixture and d) modified asphalt, crumb tires and 50% RAP mixture. The environmental impact of the four considered applications was analysed by means of the life cycle simulation software SimaPro.

Introduction

The population growth and the social-economic increase, create a continuous increase on the demand of vehicles and, thus to high discards of vehicles. According to Formela *et al* (2022) 1000 million of End of Life Tires (ELTs) are released to environment every year and the predictions show an increase to 1200 million in year 2030. Despite landfill of tires is forbidden in the EU from 2003 (2006 for shredded tires), it is still a practiced ELTs option in many countries. Other ELTs practices are the recycling for new raw material, the reuse as construction material and for energy recovery. The disposal of ELTs has considerable environmental importance, since huge space is required for landfilling, whilst ELTs have poor biodegradability and are easy in combustion (Torretta. 2015).

Data given from the European Tire and Rubber Manufacturers Association (ETRMA) shows that the vast majority of ELTs are recycled for the production of crumb rubber. In 2019, the 95% of ELTs was treated for material recycling and energy recovery. The recycled material is an important resource for industries such as construction, automotive and cement (ETRMA, 2021).

According to Mohajerani et al. (2020) the addition of ELTs improve the performance of asphalt pavement, either by the dry or wet method of modified asphalt mixture production. In this study, the physical and mechanical properties of modified asphalt mixture with participation of RAP and ELTs in a pilot road application was investigated.

Material and Methods

With the completion of tests for the suitable ELTs percentage, mixture asphalt, ELTs and RAP samples by wet method were produced in a special industrial production unit. For the pilot demonstration, asphalt paving total length 500m was carried out in Aspropyrgos, Greece.

Four different types of asphalt mixture were paved. In particular, 100 m laid out with conventional asphalt, 150 m with asphalt and ELTs mixture, 100m with asphalt, ELTs and RAP in 30% mixture and finally 150m of asphalt, ELTs and RAP in 50% mixture. The noising measurements were carried out according to ISO 11819:1 2001 with sound meters NTi XL2 and Bruel & Kjaer 2250.

The determination of skid resistance was carried out according to standard BS 7941-2:2000 with a Grip Tester (Findlay Irvine) equipment. Measurements accomplished in both directions of the same road. The rutting (wheel bolts) carried out according to standard ASTM E2133-03, with a Walking Profiler equipment.

Finally, the determination of spraying was carried out from visual observation of photo frames, but only for the conventional asphalt and the mixture of asphalt, ELTs and RAP in 30% percentage.

The physical and mechanical properties were estimated after 4 months and 8 months from the road asphalt paving.

The environmental impact of greenhouse gas emissions for the modified asphalt mixture pavements was determined by means of the life cycle simulation software SimaPro.

Results and Discussion

The modified asphalt with ELTs participation performed the lowest results in noising test for all the vehicle types, whilst the modified mixtures with RAP in 30% and 50% percentage addition performed similar noise results as the conventional asphalt. Especially, the participation of ELTs in asphalt mixtures reduced the noise level in both measurement periods. The highest level noise of a passenger vehicle (moving at upwards direction) in modifies asphalt with ELTs addition reached at 64 dB, whilst passenger vehicles level noise reached at 72dB to the other asphalt mixtures. There was a difference of 8dB between these measurements. The same difference of 8dB between the asphalt mixtures measurements were also presented at downwards direction moving, for both passenger and truck vehicles.

In skid resistance tests, in both road directions, the modified asphalt with ELTs crumb had the best performance. Modified asphalt had grid number values between 0,35 to 0,47 instead of the other mixtures with RAP and conventional asphalt which performed values between 0,29 to 0,44, as illustrated in Figure 1.

Finally, there was no difference in modified asphalt pavement in rutting at the two periods of measurements. There was deterioration of rutting in second period measurement for the conventional asphalt.

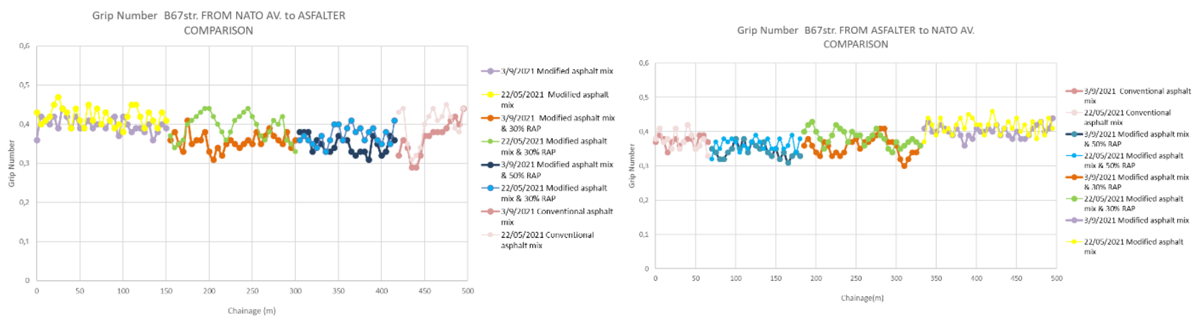

Figure 1. Skid Resistance Results.

Conclusions

In this research, the results are promising for the participation of ELTs crumb in asphalt mixture. Moreover, two waste streams could be utilized. The first one is the ELTs stream, which could increase the recycling percentage of ELTs as raw material production with consequent environmental benefits. The other one is the RAP stream, which could also increase the percentage of RAP participation in asphalt over 20%.

No environmental benefit is obtained by using modified asphalt with crumb ELTs compared to conventional asphalt. However, the applications of asphalt, crumb ELTs and RAP in 30% and 50% percentage, were more efficient. The first could reduce greenhouse gas emissions from 7% to 23% and the second one up to 48%.

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