Increased Stability of Rubber-Modified Asphalt Mixtures to Swelling, Expansion and Rebound Effect during Post-Compaction

Authors : Fernando Martinez Soto, Gaetano Di Mino

Abstract : The application of rubber into bituminous mixtures requires attention and care during mixing and compaction. Rubber modifies the properties because it reacts in the internal structure of bitumen at high temperatures changing the performance of the mixture (interaction process of solvents with binder-rubber aggregate). The main change is the increasing of the viscosity and elasticity of the binder due to the larger sizes of the rubber particles by dry process but, this positive effect is counteracted by short mixing times, compared to wet technology, and due to the transport processes, curing time and post-compaction of the mixtures. Therefore, negative effects as swelling of rubber particles, rebounding effect of the specimens and thermal changes by different expansion of the structure inside the mixtures, can change the mechanical properties of the rubberized blends. Based on the dry technology, different asphalt-rubber binders using devulcanized or natural rubber (truck and bus tread rubber), have served to demonstrate these effects and how to solve them into two dense-gap graded rubber modified asphalt concrete mixes (RUMAC) to enhance the stability, workability and durability of the compacted samples by Superpave gyratory compactor method. This paper specifies the procedures developed in the Department of Civil Engineering of the University of Palermo during September 2016 to March 2017, for characterizing the post-compaction and mix-stability of the one conventional mixture (hot mix asphalt without rubber) and two gap-graded rubberized asphalt mixes according granulometry for rail sub-ballast layers with nominal size of Ø22.4mm of aggregates according European standard. Thus, the main purpose of this laboratory research is the application of ambient ground rubber from scrap tires processed at conventional temperature (20ºC) inside hot bituminous mixtures (160-220ºC) as a substitute for 1.5%, 2% and 3% by weight of the total aggregates (3.2%, 4.2% and, 6.2% respectively by volumetric part of the limestone aggregates of bulk density equal to 2.81g/cm^3) considered, not as a part of the asphalt binder. The reference bituminous mixture was designed with 4% of binder and ± 3% of air voids, manufactured for a conventional bitumen B50/70 at 160ºC-145ºC mix-compaction temperatures to guarantee the workability of the mixes. The proportions of rubber proposed are #60-40% for mixtures with 1.5 to 2% of rubber and, #20-80% for mixture with 3% of rubber (as example, a 60% of Ø0.4-2mm and 40% of Ø2-4mm). The temperature of the asphalt cement is between 160-180 ºC for mixing and 145-160 ºC for compaction, according to the optimal values for viscosity using Brookfield viscometer and 'ring and ball' - penetration tests. These crumb rubber particles act as a rubber-aggregate into the mixture, varying sizes between 0.4mm to 2mm in a first fraction, and 2-4mm as second proportion. Ambient ground rubber with a specific gravity of 1.154g/cm^3 is used. The rubber is free of loose fabric, wire, and other contaminants. It was found optimal results in real beams and cylindrical specimens with each HMA mixture reducing the swelling effect. Different factors as temperature, particle sizes of rubber, number of cycles and pressures of compaction that affect the interaction process are explained.

Keywords : crumb-rubber, gyratory compactor, rebounding effect, superpave mix-design, swelling, sub-ballast railway
Conference Title : ICRT 2017 : International Conference on Rail Transportation
Conference Location : Rome, Italy
Conference Dates : July 17-18, 2017