The effect of mineralogy and grain size of fine aggregate and different macro textures on the durability of the RCCP surface under abrasion conditions

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ABSTRACT

The roller-compacted concrete pavement (RCCP) surface is almost smooth and without texture due to the vibrating rollers in the construction process. The lack of texturing causes a decrease in skid resistance in RCCP. For this purpose, different scenarios were proposed to create surface texture at micro and macro levels and provide the necessary friction. To provide friction at micro-scale, siliceous and calcareous sand and a combination of 50-50 of them with broken and natural aggregate shape was used in the construction of 8 RCCP mixing designs. In addition, in order to provide macro-texture, each of the eight mixing designs was texturing by methods such as seeding (three cases), stamping (two cases), and brooming (two cases). The purpose of this paper is to investigate the durability of various micro and macro textures created on RCCP surfaces by the simulation method proposed in the ASTM C 944 standard. The results showed that different textures have almost the same abrasion resistance. Among these, the seeding texture with the grain size of 4.75-9.5 mm has the weakest, and the stamp texture of 4 x 4 cm has the most durable abrasion resistance. Changes in abrasion resistance were associated with more changes in the mixing design. This means that crushed silica sand had the highest and natural lime sand had the lowest abrasion resistance. The results demonstrated that the combination of calcareous and siliceous materials improves abrasion resistance. In this regard, the higher the fracture rates of combined sand, the better the abrasion resistance.

KEYWORDS

Rolled compacted concrete pavement, abrasion resistance, Micro-texture, Macro-texture, optimum mix proportion

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Introduction

In roller compacted concrete pavements, due to the impact of the concrete surface with the roller, the macrotexture is greatly reduced, and therefore this type of pavement is not recommended for high-speed roadways. Therefore, in this research, we try to increase the frictional resistance of such mixtures in different ways so that this type of concrete can be used in high-speed roads. Skid resistance in concrete pavements is affected by the micro/macro textures of the pavement. The micro-texture is related to the properties of the materials in the mortar phase and the macrotexture depends on different methods of surface polishing and texture creation [1]. Abrasion resistance of the surface of roller-compacted concrete pavement makes it possible to use this type of pavement without a layer of secondary asphalt on highways and freeways at speeds above 60 km/h. Hassanupour considers the improvement of surface properties in the method of turning and grooving by diamond drill heads. It also suggests this method for repairing RCCP and ordinary concrete pavements [2].

From the study of different sources, it can be concluded that the simultaneous study of the abrasion resistance of micro/macro textures, which play an essential role in improving the skid resistance of roller-compacted concrete surfaces, can be considered as an innovation of this research. In addition, the study of macro textures created on laboratory samples, in addition to showing the ability to perform in field conditions to some extent, can be considered as other innovations in this research in choosing the appropriate texture in terms of durability against simulated traffic abrasion. Finally, proposing an optimal mixing design for roller compacted concrete to achieve proper abrasion resistance can be another innovation of this research.

Materials and experimental methodology

To provide friction at micro-scale, siliceous and calcareous sand and a combination of 50-50 of them with broken and natural aggregate shape was used in the construction of 8 RCCP mixing designs. In addition, in order to provide macro-texture, each of the eight mixing designs was texturing by methods such as seeding (three cases), stamping (two cases), and brooming (two cases). The purpose of this paper is to investigate the durability of various micro and macro textures created on RCCP surfaces by the simulation method proposed in the ASTM C 944 standard.

Results and discussion

As can be seen from Figure 1, the abrasion resistance of different textures is slightly different. Among the different textures, the seeding texture with the 4.75-9.5 mm chip size is the weakest, and the 4 x 4 cm stamping texture is known as the strongest texture. Therefore, it seems that the texture selected for the execution is 4 x 4 cm, which is the least troublesome and comfortable texture in terms of execution technique.

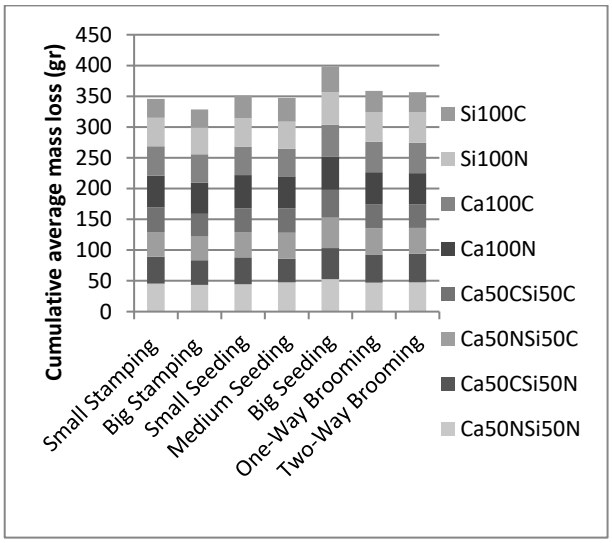

Figure 1. abrasion resistance of different macro textuers, regardless of their mixing designs

To comprehensively study the abrasion resistance of different mixing designs, regardless of their texture, Figure 2 is presented.

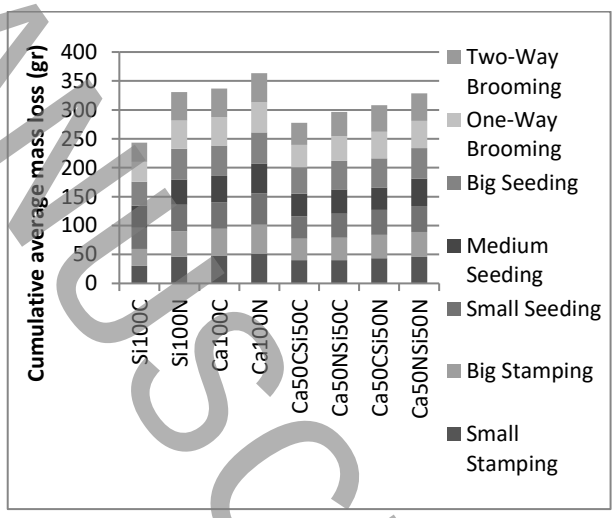

Figure 2. abrasion resistance of different mixing designs, regardless of their texture

Based on the results obtained in Figure 2, the mix design containing crushed silica sand has maximum abrasion resistance and the design containing natural calcareous sand has minimum abrasion resistance.

Based on the results observed in this study, by combining calcareous and siliceous sand with different fracture percentages, the abrasion resistance was improved compared to non-combined mixing designs except for broken silica sand. Accordingly, the higher the fracture rate, the higher the abrasion resistance. The results showed that if the fracture percentage of the two types of sand is the same and equal to 50% if we use broken siliceous sand instead of broken calcareous sand, the abrasion resistance would be higher. The results showed that if we have to choose sand to be made from broken limestone and natural silica, it would be very economical to choose broken sand due to the relatively high cost of natural silica sand and the rarity of this type of sand, although if we can Mix the two to get a better effect.

Conclusion

The purpose of this study is to investigate the reliability of micro-textures over time under heavy traffic. Creating an abrasion resistive texture can definitely ensure good skid resistance during operation. Based on this, to increase the macro and micro-texture of the pavement surface, texturing techniques and using different fine aggregate materials with different origin and fracture percentages were used, respectively. Based on this, the results showed that:

1. Apart from mixtures made with crushed silica sand, mixtures made by combining different sands have higher density, flexural and compressive strength than mixtures made with one type of sand. In general, the combination of aggregates with different sizes and shapes will lead to better strength performance, including compressive strength and flexural strength, due to the proper interaction.

2. Different macro textures have almost the same abrasion resistance. Among these, the seeding macro texture with the grain size of 4.75-9.5 mm has the weakest abrasion resistance, and the texture of 4 x 4 cm has the lowest abrasion resistance.

3. Crushed silica sand had the highest abrasion resistance and natural lime sand had the lowest abrasion resistance.

4. The results showed that except for broken silica sand, which provided the best abrasion resistance, the combination of calcareous materials (broken or rounded) and natural silica together improves the abrasion resistance of the mixture compared to mixtures made with each of these three types of sand. Also, among the mixtures made with composite sands, it can be concluded that the higher the fracture rate of the composite materials, the better the abrasion resistance will be.

5. It can be concluded that the abrasion resistance of the concrete samples is sensitive to the change of fine-grained materials, their fracture percentage, and different sand compositions and has many changes. it can be seen that the type of macrotexture may be able to improve friction, but will not have much effect on the abrasion resistance of concrete pavement. Therefore, it can be claimed that the simulation of traffic flow wears subject to ASTM C 944 standard on RCCP depends more on the design of the concrete mix than the shape of the texture created on it. This is important because it is possible to improve the skid resistance problem of RCCP by creating different textures on the surface of the RCCP and to ensure that long-term traffic flow affects the macrotexture if appropriate materials are used in concrete construction. It will not have much reliability on concrete pavement abrasion resistance.

6. To achieve an optimal mixing plan, considering economic issues such as the price of natural and broken materials in the market, it can be concluded that, if only the maximum abrasion resistance is considered, the use of broken silica sand (Si50C) to make concrete in Is a priority. Nevertheless, if the goal is to achieve a good abrasion resistance and at the same time an economic plan, it seems that the combination of round calcareous sand and broken silica (Ca50NSi50C) seems to be a reasonable option.

References

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