Field Validation of High Content Recycled Asphalt Concrete Mixtures with Accelerated Pavement Testing

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ABSTRACT

This paper describes the experimental efforts to validate the use of high percentage of reclaimed asphalt pavement (RAP) in base and surface courses using accelerated pavement testing (APT). The evaluation comprised two mixtures optimized in the laboratory with 75% RAP (base course) and 60% RAP (surface course). For the APT, test tracks with real scale pavements were constructed using the mixtures with RAP and the equivalent standard mixtures without RAP as control subjects. The full-scale traffic simulator MLS10 was used to load the test tracks until failure, replicating years of traffic in just a couple of months. Results showed that the pavements with high RAP content showed earlier and denser surface cracking than their equivalent control section pavements. Pumping of fines from the unbound subbase course was also evident. For the same temperature and loading, pavements with RAP showed higher elastic strains. Besides, rutting was deeper in the pavements with RAP as a consequence of the loss of subbase support produced by pumping induced voids. These findings evidence the need of further optimization of the RAP mixtures to enhance their field performance. Further, the results endorse the use of APT as validation tool for a field evaluation of laboratory results.

Keywords: reclaimed asphalt pavement (RAP), accelerated pavement testing (APT), performance of asphalt pavements, traffic simulation

1. BACKGROUND

Reclaimed asphalt pavement (RAP) is one of the most frequently used recycled materials in road constructions. The name RAP is given to the material removed through a milling of a pavement due to, for example, resurfacing or reconstruction of a pavement. RAP is generally a granular material containing aggregates coated to some extent with asphalt binder. This material is usually transported to a storage site and stockpiled. Later, it might be mixed with fresh aggregates and a binder in different proportions to enhance its properties. Additives might be also used as rejuvenator agents. Afterwards, the resulting mixture can be transported to the construction site, placed, and compacted to form a new pavement layer. Ideally, sustainable pavements should have the highest possible amount of RAP without compromising their field performance. Therefore, the design of mixtures with high percentage of RAP content has been an important research topic for several decades [1-3].

An extensive Swiss laboratory research project revealed that optimized mixtures containing high percentage of local RAP can reach similar mechanical properties as standard hot mix asphalt in terms of permanent deformation, stiffness and fatigue, even after aging in the laboratory [4-8]. Hence, according to these results, high content RAP mixtures might be used as paving material following an appropriate mix design. However, this conclusion was based uniquely on laboratory experiments, and there is a certain uncertainty regarding the field performance especially since in the laboratory, scale issues like mixture production, transport and compaction can be only partially simulated. Furthermore, the simulation of traffic loading conditions and the influence of the climatic can be only roughly achieved in the laboratory. The construction of test sections to verify laboratory results was considered an expensive and time consuming option to validate the obtained results. Therefore, accelerated pavement testing (APT) was evaluated as the costly-effective fast alternative for a safe implementation of the research results.

2. OBJECTIVES AND EXPERIMENTAL APPROACH

The objective of the present work was to benchmark the performance of the designed mixtures with RAP (test subjects) against the same mixtures without RAP (control subjects) using APT. To that end, two standard mixtures were selected:

- A surface course mixture AC11S (according to the Swiss standard [9])
- A base course mixture ACT22S (according to the Swiss standard [9])

In the first case, the test object mixture was prepared with 60% of RAP and adding the rejuvenator BRW from Grisard Bitumen AG (Basel, Switzerland) [10]. The second mixture was prepared 75% of RAP and the same rejuvenator.

Two pavements structures containing the RAP mixtures were constructed at real scale. The same pavements without RAP were built in parallel to be used as control sections, making a total of four different pavement structures. The full-scale traffic load simulator MLS10 was used to load the pavements (see Figure 1). This device has a loading length of 4.2m can apply up to 6000 load cycles per hour using truck tires [11-12]. In this work, the machine was used with super single tires and a load of 65kN applied in a channelized fashion. For this experiment, a reduced tire speed of 18km/h was used.

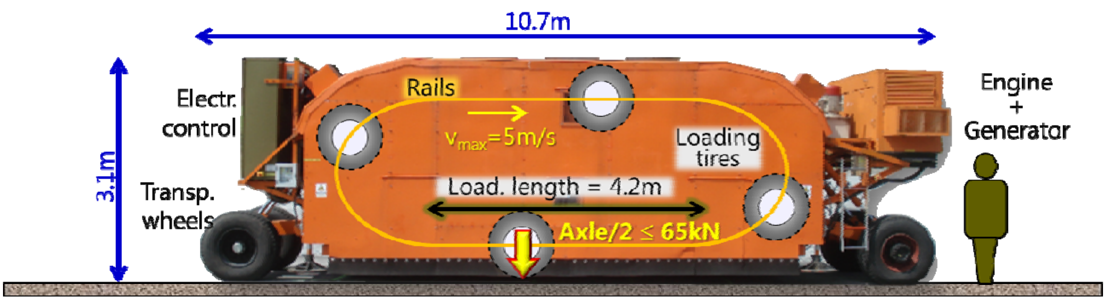

FIGURE 1 View of the traffic load simulator MLS10

The experimental setup was designed taking into account the limited length of the loading path of the MLS10 (4.2m). Since the experiment was carried out in an outdoor facility, it was not possible to control the climatic conditions. Therefore, in order to avoid possible bias in the results due to, for example, different loading temperatures, it was necessary to load the test and control sections at the same time. As a result, two of the four pavements were loaded simultaneously, making two loading locations. The location 1 included the base course mixtures ACT22S, whereas the location 2 comprised the surface course mixtures AC11S. A schema of the pavements constructed for the APT including their material and thickness is presented in Figure 2. Figure 3 shows a view of the test site.

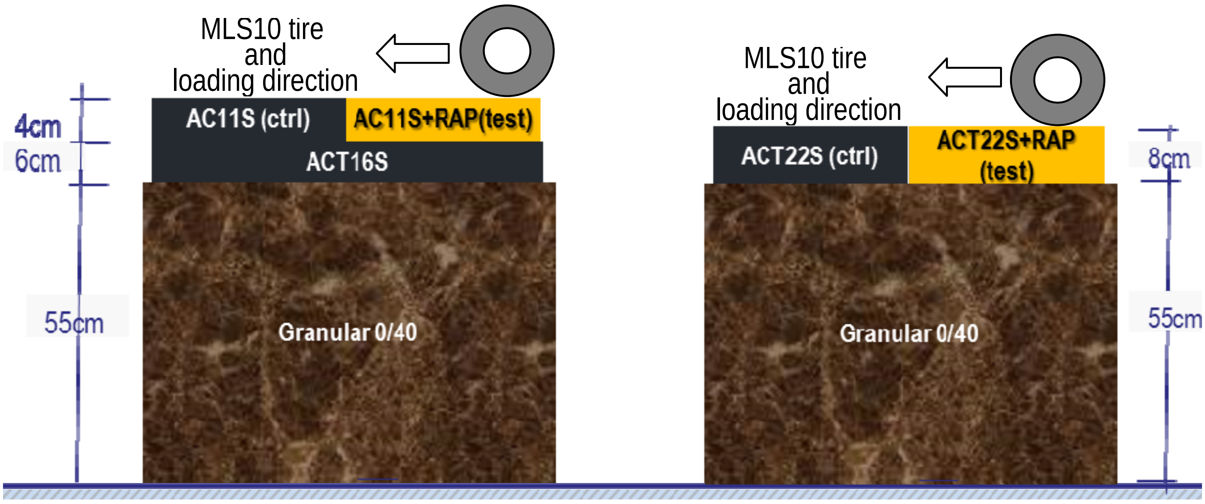

FIGURE 2 Schema of the test setup.

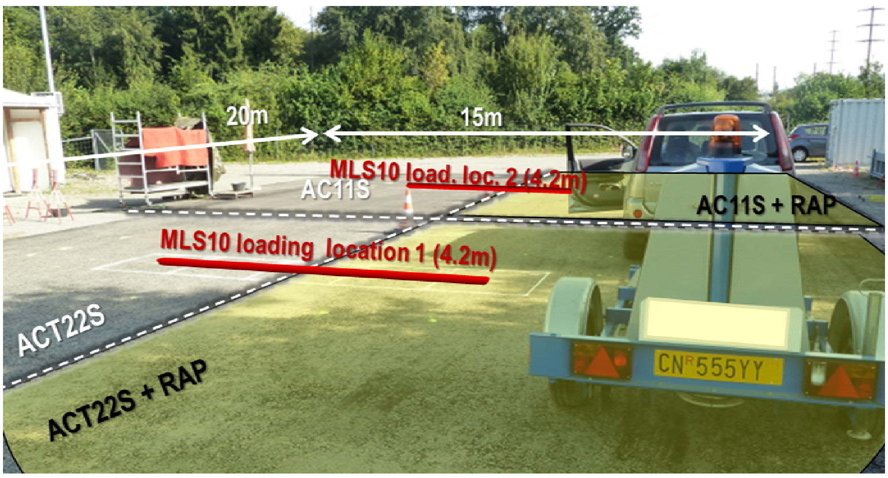

FIGURE 3 Panoramic view of the pavements and loading locations (in red)

The extension of the tests was planned until reaching one or both pavement’s failure. In order to do an evaluation of the pavement response and performance, several measurements and inspections were carried out:

- Visual assessment of the pavement surface looking for crack initiation

- Measurements of the pavement deformation with a profilometer in order to evaluate the rutting performance
- Strain monitoring using embedded strain-gauges to observe the pavements’ stiffness behaviour under loading. The temperature of the pavements was also measured continuously with thermocouples embedded in the pavement.

Finally, cores were taken to evaluate the volumetric and mechanical properties of the materials once the MLS10 loading finished.

3. TEST DEVELOPMENT

Location 1 was loaded with a total of 400’000 MLS10 load applications. Since the thickness of the pavements at locations 2 was bigger, a total of 600’000 load applications were necessary to reach the failure of one of the pavements

4. RESULTS

4.1 Crack development

The pavements were scanned regularly to detect crack formation. New cracks were marked with colour and a photographically documented. Figure 4 shows the pictures of the surface in loading location 1 through the course of the loading phase, with emphasis on fist observation of cracks on each pavement. The control section is shown in the upper side of the pictures, whereas the pavement with RAP is in the bottom part. A chart showing the crack development vs. the number of accumulated MLS10 loading is on the right part of Figure 4.

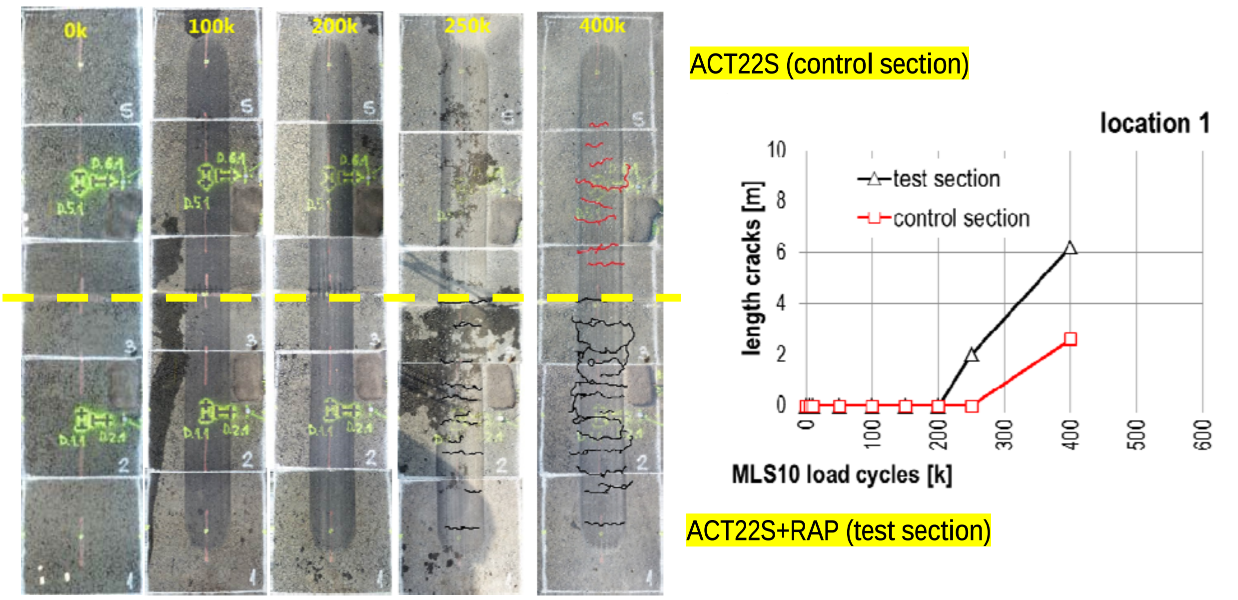

FIGURE 4 Picture of the cracks progression in loading location 1.

The first transversal cracks were observed with RAP pavement after 250000 load cycles After finishing the tests, the test section was densely populated with cracks, whereas the control section presented only a few transversal cracks.

Figure 5 shows the crack's development of loading location 2, where the AC11S was built.

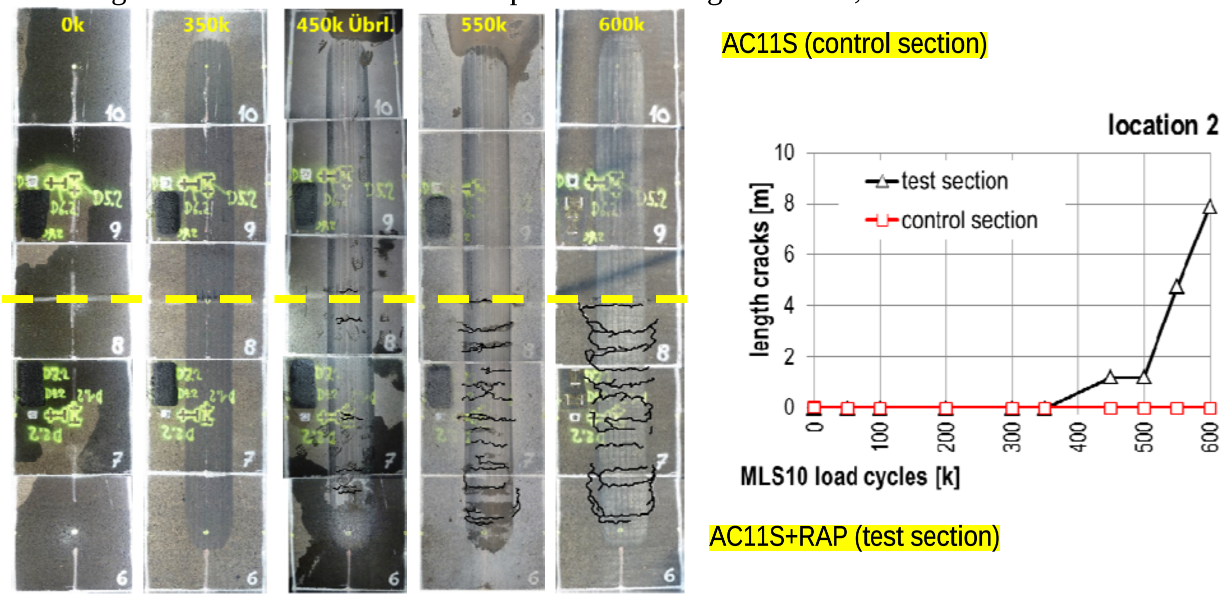

FIGURE 5 Panorama of the pavements and loading locations (in red)

In this case, the fist cracks were discovered at the test section following the 450'000 load cycles interruption. These distresses progressed into a dense pattern of transversal cracks at the end of the tests. However, in the control section no crack was observed.

4.2 Rutting performance

Rutting depth in all section, calculated as the difference between the highest upward peak in the profile and the averaged rut depth under the tire, is depicted in Figure 6. At location 1, the rutting performance in both test section and control section is similar, only after 250000 load cycles the rutting of the test section is slightly higher than in the control section. A similar phenomenon is observable in locations 2, where higher rutting is observed in the RAP material after 300000 load applications. This is coincident with the observation of the first cracks. Therefore, the higher rutting observed in the test sections can be attributed to voids in the unbound base layer produced by the loose of fines due to pumping through the cracks. The pumping of fines was observed on the surface of the pavement and by the fact that the cracks observed in cores through the entire thickness of the pavement (Figure 7).

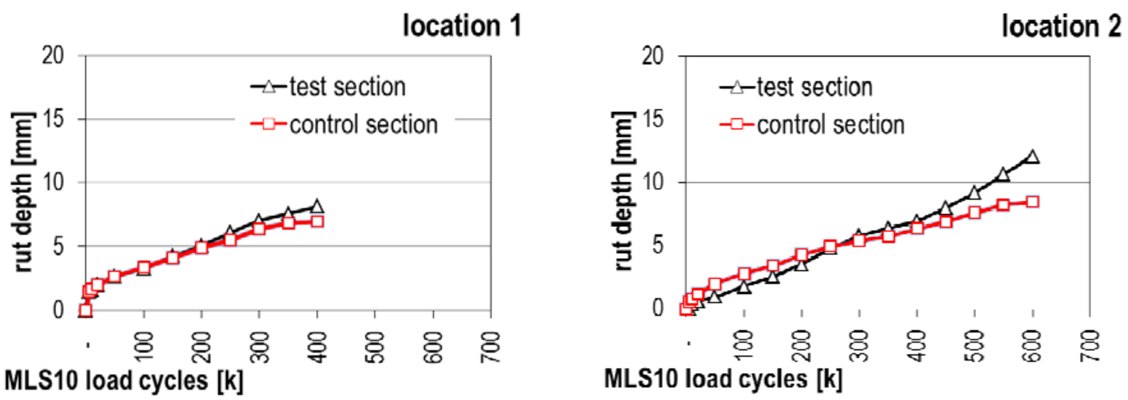

FIGURE 6 Rutting developments in location 1(left) and location 2(right)

FIGURE 7 Formation of "volcanos" of fine material (left), superficial dirt (center) and bottom-up cracks (right) that confirms the pumping effect

4. CONCLUSIONS

In this work, a validation experiment with the MLS10 to evaluate the field performance of high percentage RAP mixtures is presented. The results show that the mixtures with RAP, showed worse performance than the control mixtures without RAP, as cracking manifested earlier and in a greater extent. This effect also affected the rutting performance of the tested sections. Therefore, although the promising laboratory results obtained previous to the validation, it is recommended a revision of the mixture design in view of increasing the cracking resistance. It is believed that the poor field performance of the high percentage RAP mixtures is due to an inadequate blending of the old binder, the new binder and the rejuvenating agent produced in the asphalt plant. Therefore it is recommended that future research should focus on a better blending of the binders. On the other hand, these findings endorse the use of APT as validation tool for laboratory results and encourage further research of high percentage RAP mixtures.

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