Jurnal TEKNO
(Civil Engineeering, Elektrical Engineeering and Industrial Engineeering)
Vol. 19, No : 2, Oktober 2022 , p-ISSN:1907-5243, e-ISSN: 2655-8416

AGE BITUMEN REJUVENATION INCORPORATING REJUVENATORS

Wahyuni Wahab[1]
Fakultas Teknik, Program Studi Teknik Sipil Universitas Bina Darma[1]
email : wahyuni.wahab@binadarma.ac.id[1]

Abstrak

Abstract: To restore the performance of old bitumen which has been stiff and hard to become maltenes, it is necessary to add a rejuvenator to makes the old bitumen will soften and the performance of the bitumen will increase. This paper presents the results of physical property tests of aged bitumen incorporating rejuvenators. The physical property tests conducted were Penetration, Softening Point (SP), Viscosity (VIS), and Bending Beam Rheometer (BBR). The rejuvenator in the form of oil-based namely ceca base was added with the variation of 0.3%, 0.5%, 0.7%, and 1.0% from the weight of bitumen. The result shows that the penetration increase and viscosity decrease with the addition of the ceca base. While The SP and BBR tests show the inconsistent pattern

Abstrak : Untuk mengembalikan kinerja aspal lama yang kaku dan keras menjadi lebih baik, maka perlu ditambahkan bahan tambah peremajaan untuk meremajakan kembali aspal lama agar aspal lama menjadi lunak sehingga kinerja aspal meningkat. Penelitian ini menyajikan hasil uji sifat fisik aspal tua yang yang telah dilakukan peremajaan. Pengujian sifat fisik yang dilakukan adalah pengujian Penetrasi, Softening Point (SP), Viskositas (VIS), dan Bending Beam Rheometer (BBR). Peremajaan dilakukan dengan menambhakan bahan tambah berupa oil based yaitu ceca base yang ditambahkan dengan variasi 0,3%, 0,5%, 0,7%, dan 1,0% dari berat aspal. Adapun hasil peelitian menunjukkan bahwa penetrasi meningkat dan viskositas menurun dengan penambahan ceca base. Sedangkan uji SP dan BBR menunjukkan pola yang tidak konsisten

Keywords: *Recycled Bitumen, chemical addition, and ceca base.*

1. Introduction

Along with the development of the modern era, innovative technology from modern highways and convenient transportation

also continues growing. The capacity and capability of flexible pavement have to increase with the increase in traffic flow. There are several factors considered to raise the performance of the flexible pavement. To reduce the costs and materials used in the road construction, many research have been conducted on reclaimed asphalt pavement (RAP). Using RAP means reusing material from the milling and the destruction of old pavement. Some problems solved using this material such as reducing the use of virgin aggregates, eliminating landfill problems, saving non-renewable resources and reducing energy fuel consumption for processing and transporting materials [5].

According to Zaumanis et al [7], they compared the cost of providing asphaltmixtures containing RAP. Their research showed that new asphalt binder was the highest cost about $ 40 per ton, and then followed by an aggregate of $ 20 per ton. By using 50% of RAP, construction cost almost decreased from $ 70 to $ 50. It also supported by a previous study of using a RAP for about 20% and 50% could save the cost of construction from 14 % to 34% [3]

With the increasing of traffic flow, the capacity and capability of pavement also has to improve. Without the balancing of capability and load, the road damages could appear and gives disadvantages to many parties. However, reusing of aged bitumen will result the bitumen that stiffer than using the virgin bitumen, it will reduce Hot Mix Asphalt (HMA) performance and capability, so some additions is needed to be solved [2].

During the service life, the asphalt experience hardening and oxidation. Therefore, the aged bitumen becomes more rigid than fresh bitumen. It reduces the performance of hot mix asphalt (HMA). The rejuvenator or rejuvenating agent needed to restore the aged bitumen [6]. The rejuvenator contains maltenes constituents to increase balanced the composition of the binders lost during the service life. Rejuvenator also softens the aged bitumen and increase the resistance of mixed cracks [2].

In order to restore the performance of asphaltenes to maltenes, it is necessary add the rejuvenator in aged bitumen. The aged

bitumen would be soften and create broad-spectrum rejuvenation that replenishes the volatiles and dispersing oils while promoting adhesion [6]. Therefore, this paper presents the results of physical property tests of aged bitumen incorporating rejuvenators.

2. Materials And Test Methods

The research methodology describes the design of the research and procedures its operational framework, data acquiring sources, instrumentation used in the data analysis and research schedule. The procedures referred to Standard Specification American Society for Testing and Material (ASTM) and American Association of State Highway and Transportation Officials (AASHTO). All laboratory works performed at Transportation Laboratory and Chemical Laboratory, Universiti Teknologi Malaysia.

2.1 Materials

The reclaimed asphalt pavement (RAP) material was collected from the milling process at the Second link Highway, Johor Bahru, Malaysia. Based on the record, the road was constructed in 1997 with ACW 14 gradation. The thickness of wearing course was 50 mm. The fresh bitumen used was 60-70 PEN, which usually used as paving grade bitumen particularly in road construction and for the superior quality asphalt pavement. According to Klarkson and Isacsson [4] several types of bitumen used as rejuvenator, such as fresh bitumen, bitumen emulsion, cut backs and foam bitumen. The fresh bitumen addition in recycled bitumen used to soften the aged binder, but the addition of a rejuvenating agent also becomes a significant factor for homogeneity of the final binder result [1]. The selected rejuvenator was an oil-based rejuvenator namely cecabase. It was added into the aged bitumen with various percentages from the total weight of bitumen.

2.2 Methods

In this project, the method divided into 3 stages. The first stage was preparation of aged bitumen, the aged bitumen and aged aggregate separated by the ignition method or solvent extraction method that mentioned on ASTM and AASHTO standards. After the extraction, the distillation processes were conducted to produce aged bitumen from RAP. The second stage was blending process,60-70 PEN bitumen, aged bitumen and cecabase were blended to produce recycled bitumen. The final stage was evaluation of the recycled bitumen properties. The recycled bitumen was evaluated and compared with control bitumen.

2.2.1 Stage 1: Material Evaluation and Characterization

The first phase focused on preparing the material, the laboratory experimental of Stage 1 shown in this Figure 1.

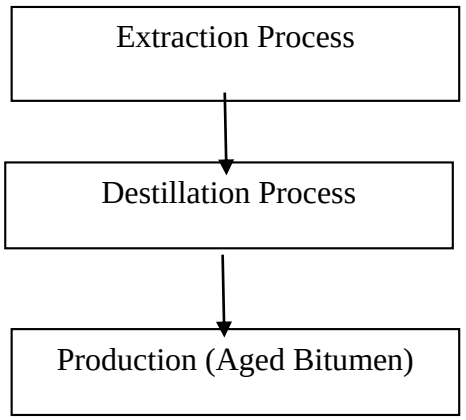

Figure 1. Stage 1 flowchart

a. Estraction Process

The extraction process represents removed the bitumen from the aggregates, this process held to get the aged

bitumen materials. This extraction process carried out based on ASTM D2172. The process started from loosening up the milling pavement and weight about 1200 gram, the material placed into the extractor bowl. Added the methylene chloride solvent into the loose material until the surface of the sample under the liquid put the filter paper on top of extractor bowl and screwed the funnel-clamp.

b. Destillation Process

The distillation is a process to get the residue from the extracted solution. To acquire the aged bitumen, It evaporated the menthelyne chloride and produced the aged bitumen.

2.2.2 Stage II: Blending Process

This stage carried out to produce the recycled bitumen. In this stage, the aged bitumen and cecabase mixed with the fresh bitumen (60-70 PEN), as shown in Figure 2.

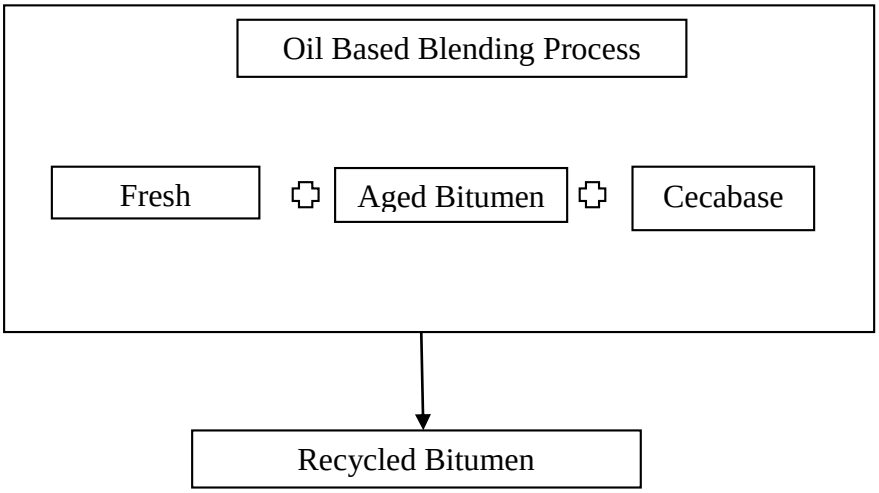

Figure 2. Blending process flow

The recycled bitumen consists of 60% fresh bitumen (60-70 PEN), 40% aged bitumen (extracted from RAP) and various

percentages of cecabase (0.3%, 0.5%, 0.7% and 1.0%) from the total recycled bitumen.

2.2.3 Stage III: Evaluation of Recycled Bitumen Properties

This stage divided into two parts which were physical and chemical property tests. Next, it compared the results with control bitumen. For the physical property test, the tests were a Penetration test, Softening Point (SP) test, Viscosity (VIS) test, and Bending Beam Rheometer (BBR) test.

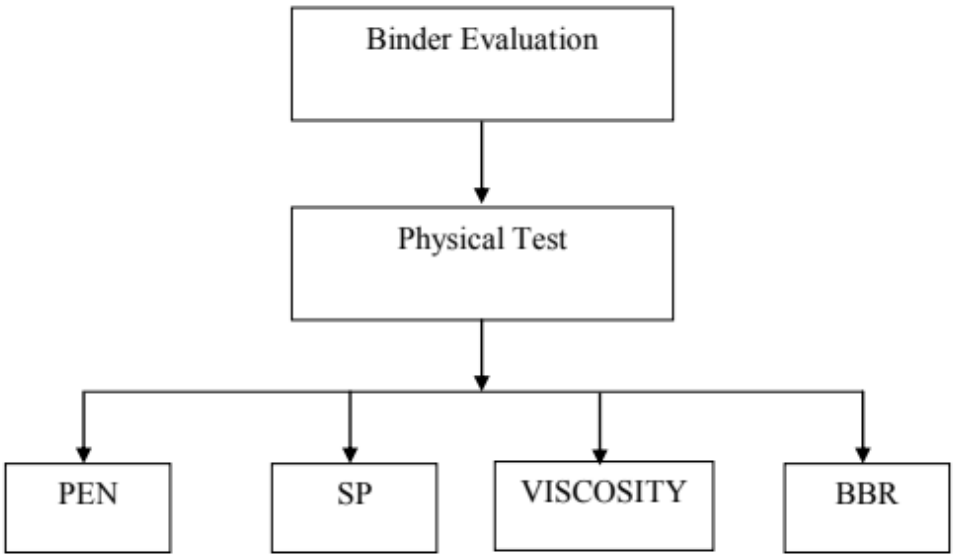

Figure 3. Physical property tests flowchart

3. Result and Discussion

The analysis and discussion performed on the data collected by the series of experimental works. The results were presented in the form of tables and graphs that shown below

3.1. Penetration Test

The penetration test results in Figure 4 shows that the hardness of the bitumen decreases along with the increasing of rejuvenator content. It also shows that the addition of 1.0% ceca base into the recycled bitumen gives the nearest value to 60-70 PEN bitumen as a control.

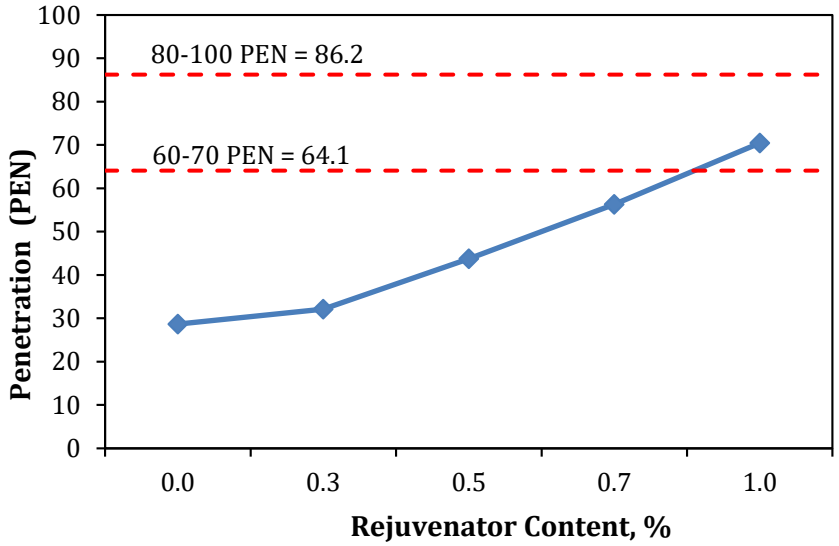

Figure 4. Penetration Tests Value

3.2 Softening Point Test

The results shown in Figure 5 show that the softening point decreased when cecabase was added by 0.3 and 0.5%, respectively. However, the softening point value again increased when cecabase was added to 0.7 and 1.0% respectively. As for the trend that is formed, the addition of 0.5 cecabase is the closest to the control line.

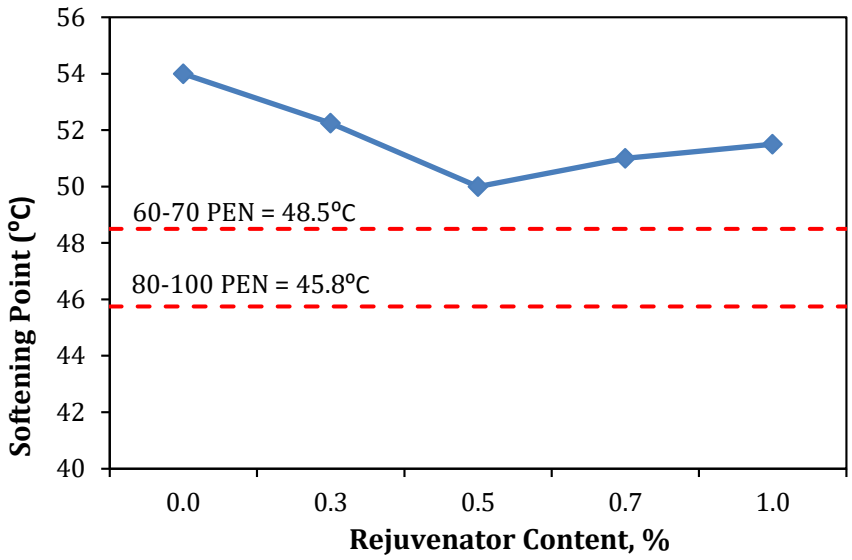

Figure 5. Softening Point Test Value

3.3 Viscosity Test

Figure 6 shows the viscosity test value at temperature 135°C with spindle no. 27 and 20 RPM rotation. The result shows that the addition of 0.7 and 0.1 % rejuvenator content give the nearest value to the fresh bitumen.

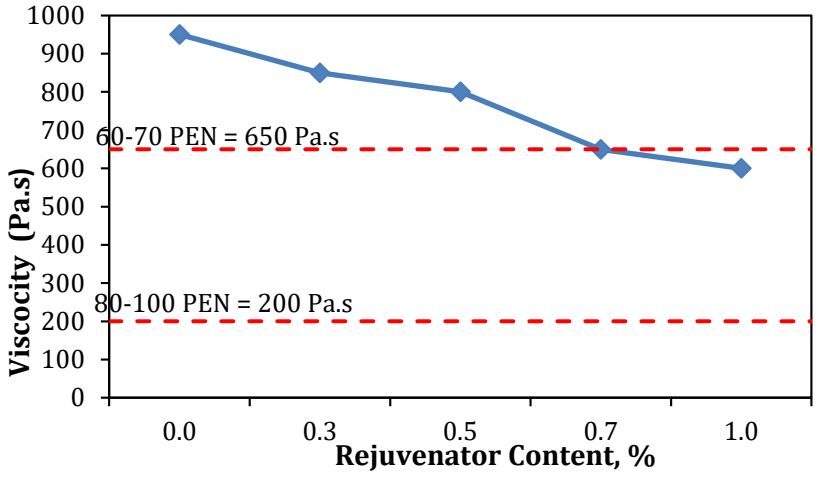

Figure 6. Viscosity Test Value at 135°C

Figure 7 shows the same viscosity test conducted at 165°C. It shows that at this temperature, the viscosity of all recycled bitumen is almost similar. It means that the addition of rejuvenator does not affect the bitumen viscosity at high temperature.

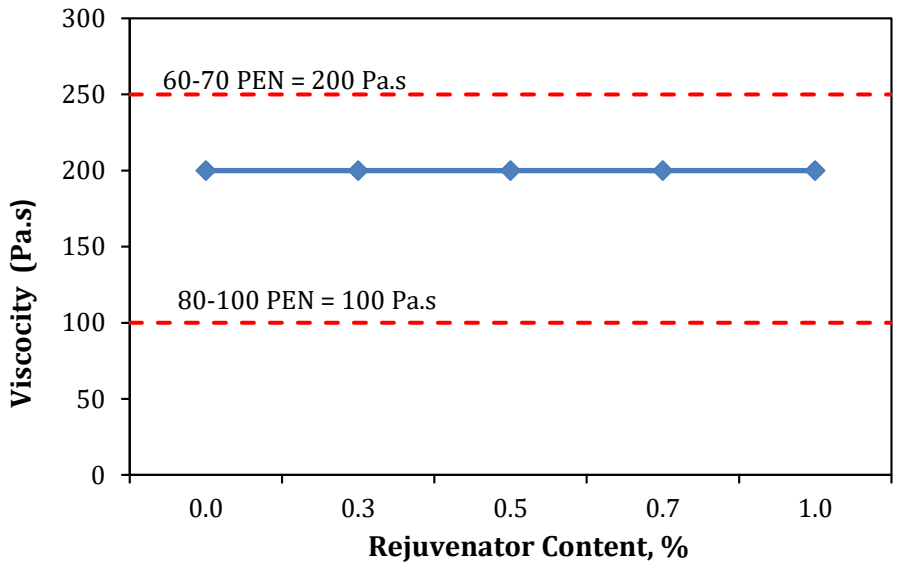

Figure 7. Viscosity Test Value at 165°C

3.1.4 Bending Beam Rheometer (BBR) Test Result

The Bending Beam Rheometer (BBR) test carried out during 250 seconds at -10^{0}C. The results show in Figures 8 and 8 for 60 seconds test length. For the m-value, inconsistent result was recorded. where m-value increases with additional of rejuvenator up to 0.5% but goes down at 0.7. It increases again at 1.0% of rejuvenator content. The additional at 0.5% of rejuvenator content is recommended because of them-value is identical to control bitumen (60-70 PEN).

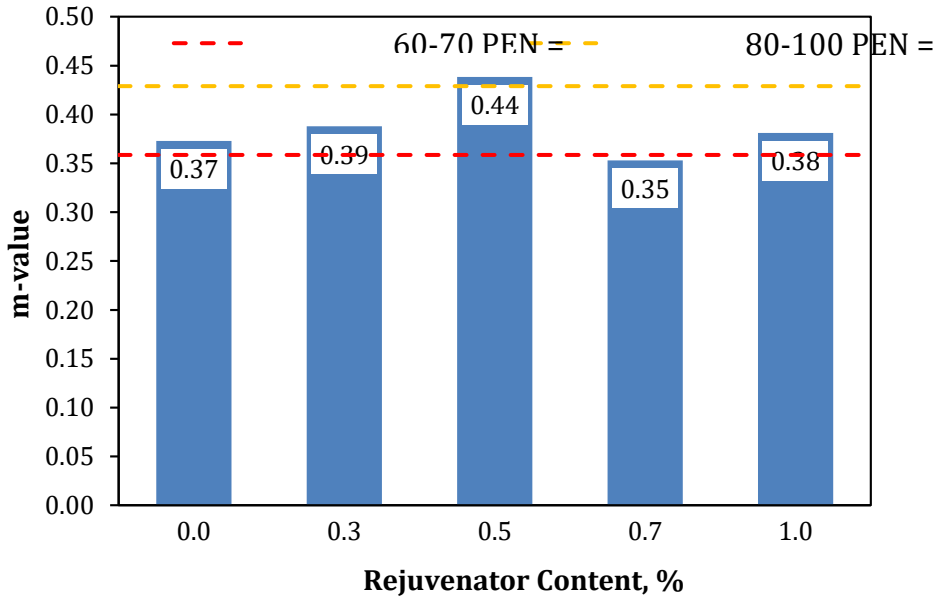

Figure 8. m-value of recycled bitumen incorporating rejuvenator content

Figure 9 shows another result obtained from BBR test. It is the stiffness of recycled bitumen. The stiffness shows contrast result but consistent with them-value. The stiffness at 0.5% rejuvenator content provides the nearest result to control bitumen (60-70 PEN).

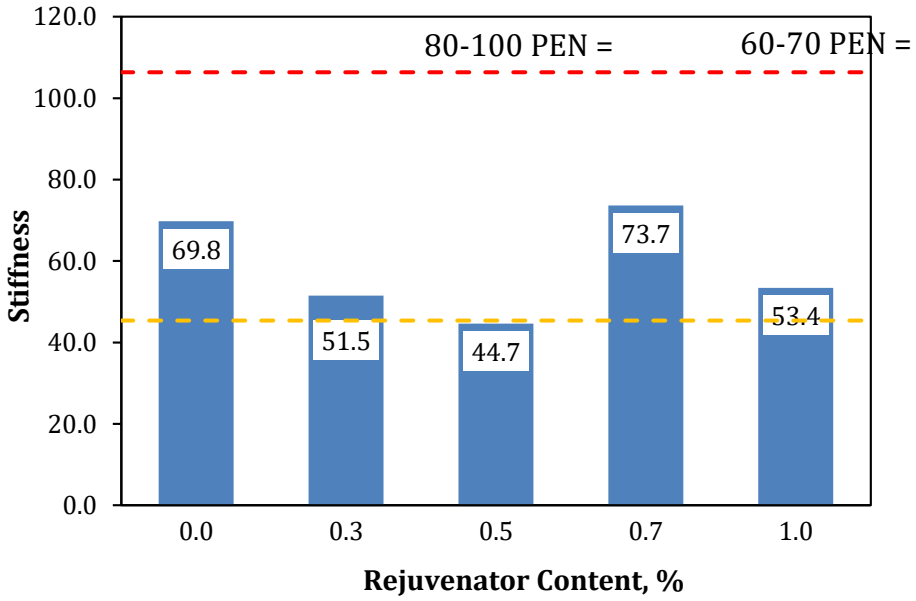

Figure 9. Stiffness of recycled bitumen incorporating rejuvenator content

4. Conclusions and Recommendations

This chapter presents the conclusion and recommendations based on the result obtained in this study. The conclusions and several recommendations for future research are proposed as follows.

4.1 Conclusions

Based on this study, the conclusions is along with the addition of the rejuvenator content, the penetration value was increasing. The softening point value result showed a pattern, where the temperature needed to soften the bitumen goes down from 0.0% to 0.5% and goes up when the rejuvenator added from 0.7% to 1.0%. The viscosity test result at 135^{o}C reflected that along with the increasing of rejuvenator content the viscosity value goes down, means the recycle bitumen became soften due to the rejuvenators. Therefore, the recycled bitumen viscosity showed the same result at

165^{o}C. It means the rejuvenator did not have a significant impact on recycled bitumen at 165^{o}C temperature. The Bending Beam Rheometer (BBR) test result showed the inconstant value.

4.2 Recommendation

Based on this study, the recommendations as follows:

(a) More variation of the rejuvenator type and content to reflect and complete the pattern.

(b) Other related chemical tests can be considered to figure out the relationship between the physical and chemical properties.

References

[1] Baghaee Moghaddam, T. and Baaj, H. (2016) 'The use of rejuvenating agents in production of recycled hot mix asphalt: A systematic review', Construction and Building Materials. Elsevier Ltd, 114, pp. 805–816. doi: 10.1016/j.conbuildmat.2016.04.015.

[2] Dinh, B. H., Park, D. W. and Le, T. H. M. (2018) 'Effect of rejuvenators on the crack healing performance of recycled asphalt pavement by induction heating', Construction and Building Materials. Elsevier Ltd, 164, pp. 246–254. doi: 10.1016/j.conbuildmat.2017.12.193.

[3] Kandhal, P. S. and Mallick, R. B. (1997) 'Pavement Recycling Guidelines for State and Local Governments: Participant's Reference Book', Fhwa-Sa-98-042, (December), p. 301. Available at: https://www.fhwa.dot.gov/pavement/recycling/98042/.

[4] Karlsson, R. and Isacsson, U. (2003) 'Application of FTIR-ATR to Characterization of Bitumen Rejuvenator Diffusion', Journal of Materials in Civil Engineering, 15(2), pp. 157–165. doi: 10.1061/(ASCE)0899-1561(2003)15:2(157).

[5] Ongel, A. and Hugener, M. (2015) 'Impact of rejuvenators on aging properties of bitumen', Construction and Building Materials. Elsevier Ltd, 94, pp. 467–474. doi: 10.1016/j.conbuildmat.2015.07.030.

[6] Zargar, M. et al. (2012) 'Investigation of the possibility of using waste cooking oil as a rejuvenating agent for aged bitumen', Journal of Hazardous Materials. Elsevier B.V., 233–234, pp. 254–258. doi: 10.1016/j.jhazmat.2012.06.021.

[7] Zaumanis, M. et al. (2014) 'Influence of six rejuvenators on the performance properties of Reclaimed Asphalt Pavement (RAP) binder and 100% recycled asphalt mixtures', Computers and Chemical Engineering. Elsevier Ltd, 71, pp. 538–550. doi: 10.1016/j.conbuildmat.2014.08.073.